Sitek *Process Solutions*

"Supplier of High Quality Semiconductor Manufacturing Equipment"

Tencor P-20
Long Scan Profiler

Operation Manual

Sitek Process Solutions

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Ellipsometers
Gaertner L116 and L117
Plasmos
Rudolph Auto EL II
Rudolph EL III
Rudolph Auto EL IV

Etchers
Applied Materials 8110, 8120, 8130
Applied Materials 8310
Applied Materials 8320
Applied Materials 8330 metal etcher
Branson/IPC 2000 etcher
Branson/IPC 2100 P etcher/stripper
Branson/IPC 3100 and 3100 LP, 12"
Branson/IPC 4000 Dual Barrel
Drytek Drie-102 etcher
Drytek 202 oxide etcher
Gasonics Aura 1000 & 2000 strippers
Gasonics Aura 2001 etcher
LAM Rainbow 4500
LAM 480, 490
LAM 580 oxide etchers
LAM 590 etchers
LAM 690 aluminum etcher, 5"
LFE 1002 PFS/PDE/PDS etcher
exposure
Plasmatherm 640 Hex etcher RIE
Plasmatherm PK-2410 Parallel plate
Plasmatherm PK 2430 and PD-2480 RIE
Plasmatherm AMPS 300E RIE
Technics RIE 80, 800, 8000
Tegal 421 plasmaline
Tegal 415 plasma etcher
Tegal 701 poly etcher
Tegal 703 oxide etcher
Tegal 801 & 803 etchers
Tegal 900E etcher
Tegal 901 etcher
Tegal 903 etcher 5"
Tegal 915 Barrel Etcher
Tegal 1511E

Evaporators
Airco-Temescal FC 1800 E-beam evaporator
Airco-Temescal FC-2500 E-beam
Airco-Temescal VES-2500 Filament
Airco Temescal FC 3200 Filament evaporator
Balzer 510 Filament evaporator
CHA MARK 50 E-beam evaporator
CHA SE 600 evaporator
CHA 1000 E-beam evaporator
Davis and Wilder 10-SC 2836 Filament
Varian 3118 Filament evaporator
Varian 3120 E-beam evaporator
Varian 3125 E-beam evaporator

Furnaces
ASM Diffusion Furnaces
Bruce BDF4 Furnace
Tempress 4 stacks
SVG/Thermco 4300 4-stack w/TMX 9001 controller
Thermco MB-71, 80 & 81 Mini-Brutes
Thermco TMX 9000 furnaces
Thermco TMX 9001 4 stack, 5 & 6"

Ion Implanters
Eaton Nova 10-80 implanters
Eaton Nova 10-160 high current implanters
Eaton Nova 3204/3206 implanter
Varian CF4 and DF4 implanter
Varian CF5 and DF5 implanter
Varian 350D implanter 4, 5 & 6"
Varian CF 3000 implanter
Varian 120XP

Leak Detectors
Leybold Hereaus Ultratest F line leak
Triotech G-203 gross leak detector
Leybold Hereaus U100 helium-turbo
Triotech 4001-1A-2 fine leak detector
Varian 936-60
Veeco MS-Series

Mask Aligners
Canon MPA 500 FAB
Cannon PLA 500F aligners
Canon PLA 501F and FA aligners
Canon 521 FA
Canon FPA-1550 MI G-line
KARL SUSS MA56 3" aligner
KARL SUSS MA54 4" GaAs
KARL SUSS MJB-3 aligners
KARL SUSS MJB 55 aligners
Kasper 2001 aligners: 3 or 4"
Perkin-Elmer 240/241 mask aligners
Perkin-Elmer 340/341 mask aligners
Perkin-Elmer 552HT
Perkin-Elmer 600HT, 660HT

Ovens
Blue M's
IMTEC Star 2000 vapor prime oven
Yield eng. LP III vapor prime ovens

Photoresist Tracks & Strippers
DNS tracks
FSI: Atlas, Jupiter and Saturn
Fusion M 126 deep UV flood
Fusion M 150 deep UV flood exposure
Headway D single head spinner
MTI MultiFabs
MTI FlexiFabs
MTI OmniChuck single track coater
MTI Target Track
Semitool ST, S and F Series SRD's
Semix
Solitec Developer
Solitec 4
SVG 8100, 8600 & 8800 Series

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Probers

Electroglas 1034X wafer prober
Electroglas 1034X-6 prober, Opt D
Electroglas 2001X probers
Micromanipulator 6000 and 6200
Pacific Western Probe II
R&K 260 and 300 probe stations
R&K 670 Semi Auto prober
Signatone S450 Semi-Auto with motorized stage/micozoom probes
Signatone S 250 sub-micron analytical prober
Teledyne TAC PR-100 prober
Teledyne TAC PR-53 prober
Wentworth MP900 Probe Station

Reactors

AG Associates RTP systems (210, 410, 4100, 8108)

Applied Materials 2100, 3300, & P5000 System
Applied Materials 7800 and 7810 RP/RPX
ASM PECVD

Wafer & Mask Inspection

Aeronca WIS-150 and WIS-200
Estek WIS-600, 800, 8000, 850, 8500
Nanometrics Nanoline III CD measure
Nanometrics Nanoline IV CD measure
Nanometrics Nanoline V CD measure
Nanometrics Nanoline 50 CD measure
Nanometrics Nanospec AFT 174, 180, 181, 200 & 210

Nikon Optistation 2A & 3A
OSI Microvision VLS-1 CD measure
CSI Microvision VLS-201 inspection station
Tencor Surfscans 100, 164, 4000, 4500, 5000, 5500, 6200, 7000

Wafer & Mask Scrubbers

Kasper 4500 scrubbers
MTI 6300S scrubber

MTI 6700 mask scrubber
MTI Multifab and Flexifab scrubbers
Solitec 1100 scrubber
Solitec 5110 SJ scrubber
SVG 8020 SSC scrubber
SVG 8120 SSC scrubber
SVG 8620 SSC scrubber
Ultratech 602 mask cleaner
Ultratech 603 mask cleaner

Wafer Steppers

GCA 6300 stepper, 5x
GCA 8000 stepper, 5x
GCA 8500 in-line stepper, 5x
Nikon I and G-line steppers
Ultratech 900 standard field stepper
Ultratech 1000 standard
Ultratech 1000 wide field

Wafer Testing

ADE 6033, 6034 and 6035 microsense thickness gauges
Magnetron M700 and 750 4-point probe
MDC CV plotters
Sloan Dektak IA and IIA profilometers
Tencor Alpha step 100 profilometers
Tencor Alpha step 200 profilometer
Tencor 100 and 160 Surfscan
Veeco FPP 100, 5000 4-point probes

Sputtering Systems

Balzer BAK 600 sputtering system
Balzer LLS 801 sputtering system
Balzer BA 510 sputtering system
CPA 9900 and 9930 sputtering system
CPA 9980 sputtering system
MRC 603 sputtering/vertical-load lock
MRC 643 sputtering system
MRC 902M sputtering system
MRC 903A and 903M sputtering

MRC 942-A-2 CTI cryo
MCR 943 3 target in-line sputtering
Perkin-Elmer 2400 and 2400-8L sputtering system
Perkin-Elmer 4400
Perkin-Elmer 4410
Perkin-Elmer 4450
ULVAC MCH-9000
Varian 3120 sputtering systems
Varian 3180 sputtering systems
Varian 3190 sputtering systems
Varian 3290

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Tencor® P-20
Long Scan Profiler

Operations

Tencor

Software Version 2.31
FOR CLEAN ROOM USE CLASS 100 ONLY

Text Only: #271632-27 Rev. E 8/95
Text & Binder: #251127-27

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PATENTS

This instrument is protected under the following patent: 4,752,898.

REVISION LOG

This manual includes new features for software version 2.31 of the P-20 Long Scan Profiler. The following is a brief summary of these changes:

- **Chapter 2, "Basic Skills"**

  The following keys have been implemented to enhance the keyboard:

  THETA, XY, LOAD, START, STOP, FAST Z ⇑ , FAST Z ⇓ , SLOW Z ∨, VAC, OPTIC MAG ∧, OPTIC MAG ∨

- **Chapter 10, "Wafer Stress Application Option"**

  The Tencor P-20 Wafer Stress application now enables you to calculate the stress in a deposited film by measuring the wafer deflection or curvature that the stress induces on the substrate.

- **Chapter 11, "Signal Light Tower Option"**

  The current implementation of the Signal Light Tower available in the current release of the Tencor P-20 allows you to specify custom definition corresponding to specific instrument states. This approach involves some relatively simple hardware and new Profiler software which translates instrument statues into commands to the new hardware.

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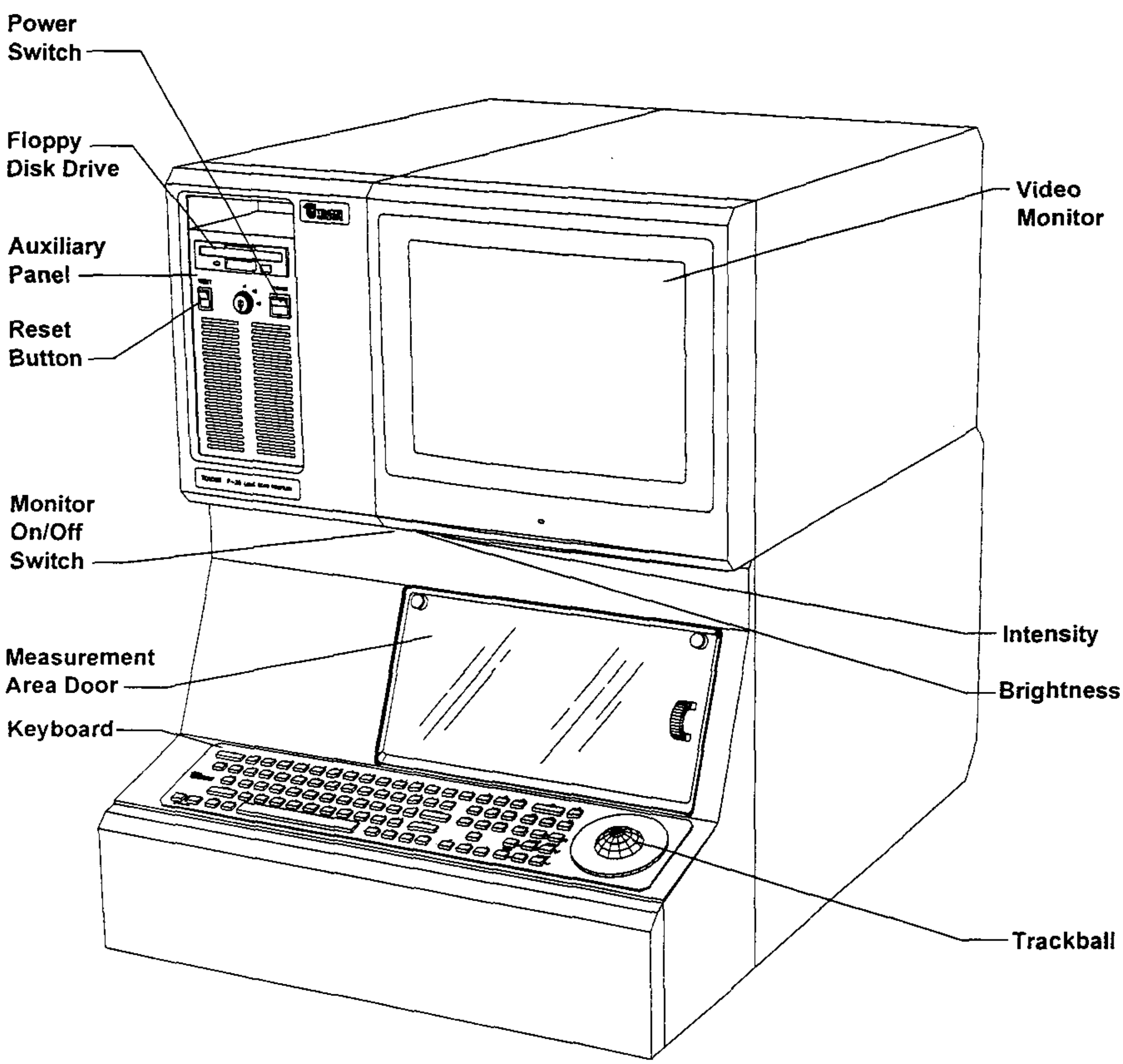


Figure 1-1 Tencor P-20 Long Scan Profiler

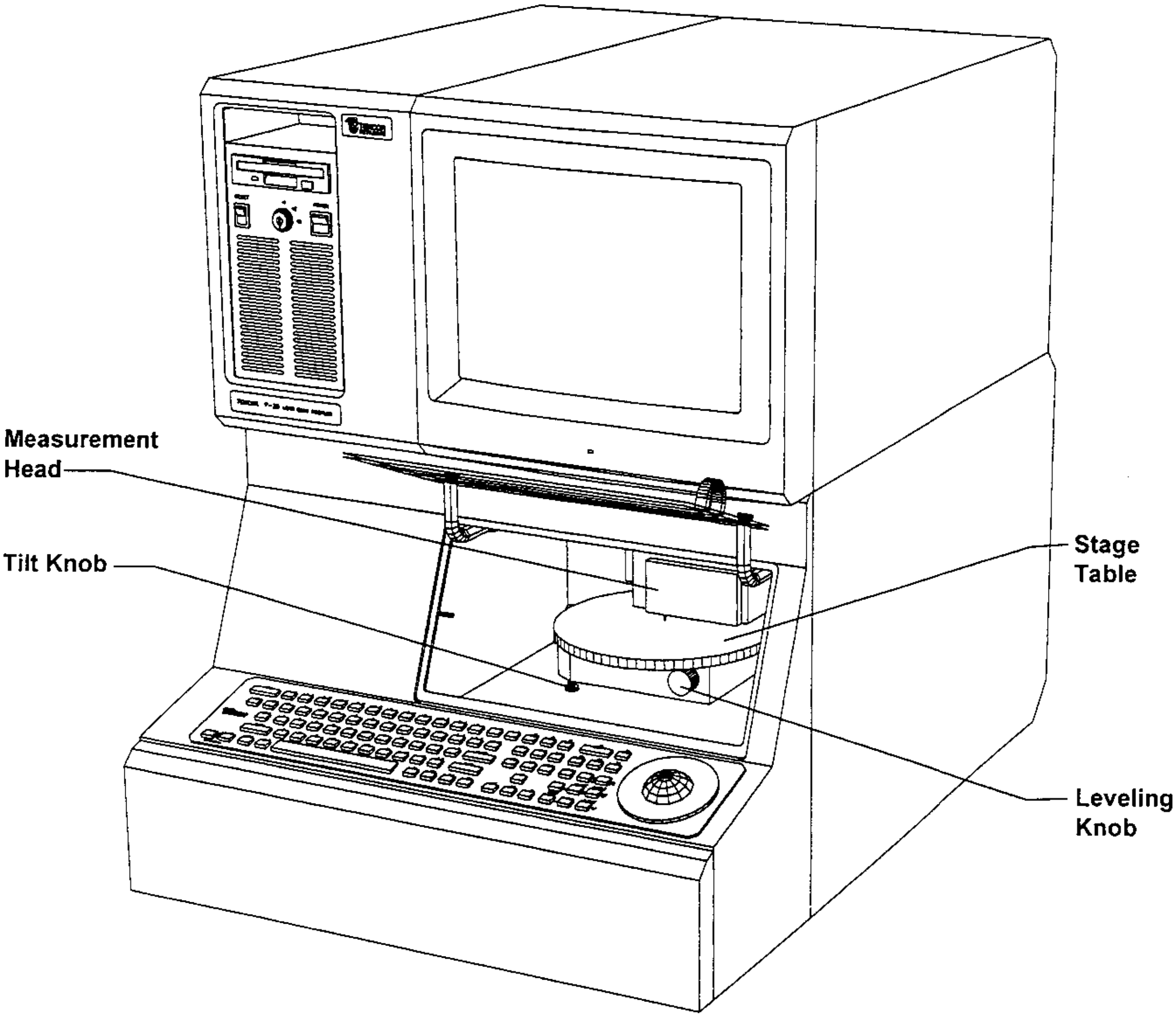


Figure 1-2 Measurement Area of the Tencor P-20 Long Scan Profiler

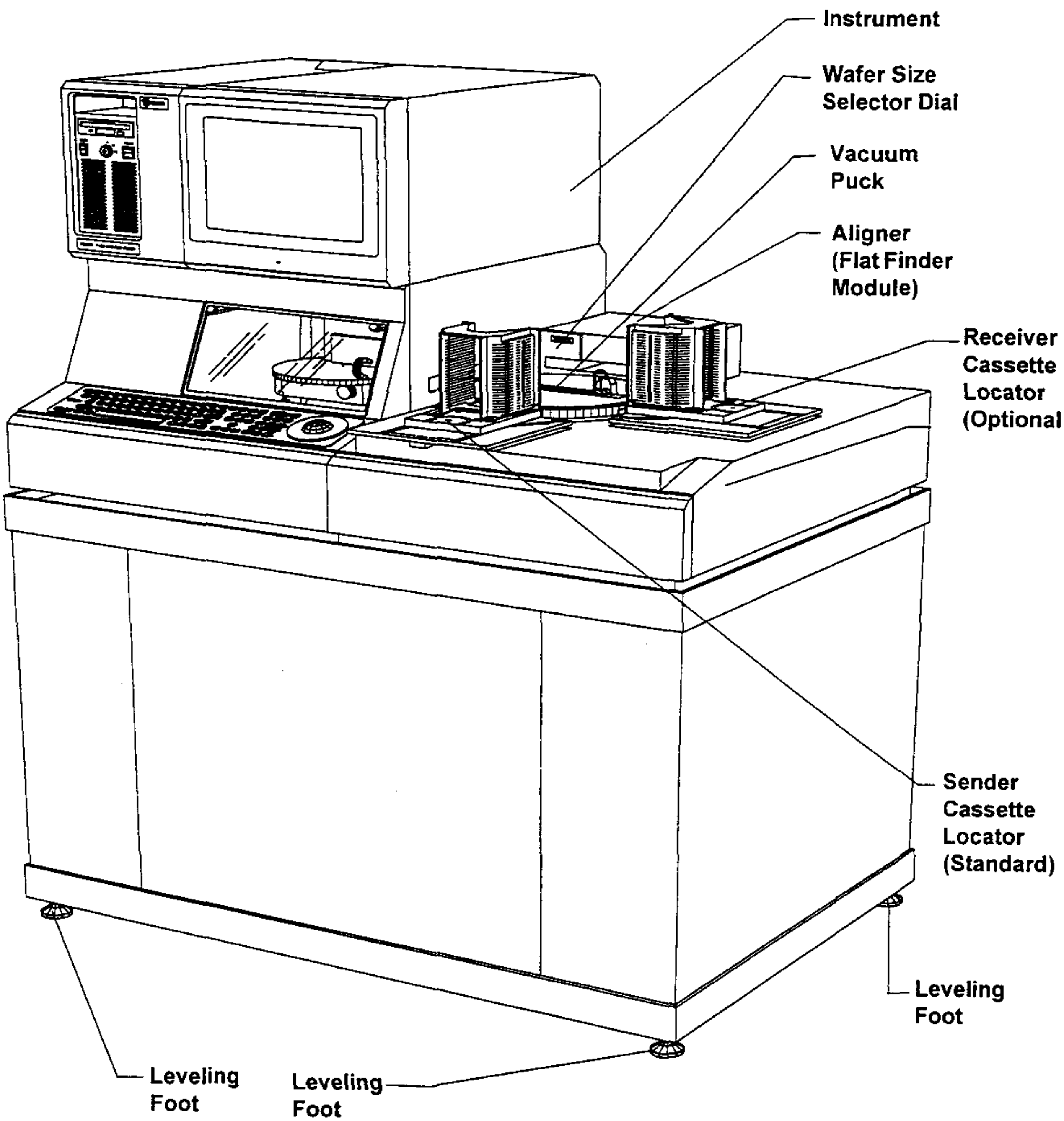


Figure 1-3 Tencor P-20h Long Scan Profiler with Wafer Handler

1 INTRODUCTION

1.1 ABOUT THIS MANUAL

This manual describes in detail the operation of the Tencor P-20 Long Scan Profiler. It is intended as a tutorial and a general operating guide for individuals who will use the P-20 to inspect and analyze sample surfaces.

This manual consists of the following chapters:

- Chapter 1, "Introduction," discusses how to use the manual, terminology used, and an overview of the instrument and its features.
- Chapter 2, "Basic Skills," provides information on starting the instrument and a description and overview of the controls and the measuring software.
- Chapter 3, "Getting Started," is a brief tutorial on how to load and measure a sample.
- Chapter 4, "Recipes," provides detailed information on creating, editing, copying, and saving profile recipes.
- Chapter 5, "Profiling," provides detailed information on loading samples, locating sample features, and collecting data from the sample surface.
- Chapter 6, "Analyzing Scan Data," discusses analysis of the sample data, as well as editing and saving the data.
- Chapter 7, "Sequencing," covers creating, editing, and saving sequence programs.
- Chapter 8, "Using the Database," discusses deleting, printing, reviewing, exporting, and importing of Scan and Sequence recipes and data.
- Chapter 9, "GEM/SECS Option," discusses the optional GEM/SECS interface.
- Chapter 10, "Wafer Stress Application Option, " discusses how to calculate the stress in a deposited film.
- Chapter 11, "Signal Light Tower Option, " discusses custom definition corresponding to specific instrument states.

A glossary and an index are also provided at the end of this manual.

1.2 RELATED MANUALS

Tencor Instruments also provides the *Tencor P-20 Long Scan Profiler Reference Manual,* a reference guide covering installation, maintenance, calibration, configuration, and operational theory of the instrument, and the *Tencor P-20 SECS Interface Manual,* a reference guide covering the implementation of the GEM/SECS Option.

1.3 INSTRUMENT FEATURES OVERVIEW

The Tencor P-20 Long Scan Profiler is a computerized, highly sensitive surface profiler that measures roughness, waviness, step height, and other surface characteristics in a variety of applications. It features the ability to measure micro-roughness with up to 0.5Å (0.002 µin.) resolution over short distances as well as waviness over a full, 210-mm (8.2-in.) scan. The built-in PC computing power offers precise, automatic measurement capability with the convenience and ease of use of Microsoft Windows-based software control and data analysis.

The Tencor P-20 can profile a variety of materials, including

- Magnetic disks
- Semiconductor wafers
- Precision-machined and polished surfaces
- Ceramics for micro-electronics
- Glass for flat panel displays
- Optical surfaces

The instrument is available in two basic configurations: the manual P-20 and the automatic wafer handler P-20h. Additional hardware and software options can be added. Contact Tencor Instruments about availability.

The Tencor P-20 provides the following features:

- Precise measurement of the surface typography of finely textured disks at sub-angstrom vertical resolution.
- Measurement of vertical features ranging from under 100Å (0.4 µin.) to approximately 0.3 mm (11 mils), with a vertical resolution of 0.5, 2, or 10Å (or 1, 10, or 50Å with the optional Extended Range MicroHead).
- An unlimited number of data points per profile guarantee that the horizontal resolution is generally limited by the stylus radius and not by the number of data points.
- Measurements can be taken in either metric or English units, which are selectable independently for horizontal and vertical parameters.
- Measurement of many roughness and waviness parameters, with user-selectable cutoff filters to isolate roughness and waviness.
- Ability to fit and level a scan, allowing accurate step height measurements on curved surfaces.
- Ability to detect the edge or apex of a profile feature, allowing automated data analysis relative to the feature.
- Ability to divide a length in a single scan into segments, as in the OD-to-OD profile of a disk with a central hole.

- Ability to repeat a scan up to ten times and automatically calculate the average, thereby minimizing the effects of environmental noise on measurements.
- Ability to automatically execute an unlimited number of scans in a sequence.
- Automatic positioning on the sample surface to within a few microns in X and Y.
- Precision mode, allowing precise location of small features and deskew coordinates for automatic operation.
- Built-in, 80486-DX 33 MHz PC-compatible computer with 210 MB of disk storage.
- Application software running in the Microsoft Windows environment.
- Accommodation of samples up to 355 mm (14 in.) wide, 57.2 mm (2.25 in.) thick, and 2.2 kg (5 lb) in weight.

1.4 HARDWARE FEATURES AND OPTIONS

Processor

The processor is an 80486DX-33 MHz controller that runs MS-DOS and Windows. It is PC compatible.

Screen

The 36-cm (14-in.) VGA video monitor displays the Tencor P-20 program, including a magnified sample video image. The sample image has high resolution and contrast and can be zoomed to an image ratio of 4:1.

Keyboard

The system is equipped with an operator's keyboard built into the front panel for full instrument operation. The keyboard has a full set of standard AT keys, as well as some instrument-specific control keys.

The keyboard also has a trackball control device for fast cursor movement, stage and measurement head motion control, and convenient menu option selection. The trackball and keyboard can be used interchangeably for these functions.

Data Disk System

The inboard 210-MB hard disk contains the Tencor P-20 program and provides storage of scan recipes, sequences, and data. A 3.5-in. (1.4-MB) disk drive enables data and recipes to be stored on floppy diskettes.

MicroHead Low Moment Measurement Head

The MicroHead permits highly accurate profiling of surface topography with minimal stylus contact force. The innovative stylus arm design has a very low moment of inertia, so it is much less susceptible to environmental noise. This allows the instrument to operate effectively at stylus forces that are more than 10x lower than achievable with the standard measurement head. At higher force settings, the MicroHead can either take scans at higher speeds for a given stylus force, or take scans with greatly reduced noise. The MicroHead also allows greater precision in identifying peaks and valleys on the surface with vertical repeatability typically at 6Å (1σ) with 0.5Å resolution.

The MicroHead also features an undistorted top-down view, facilitating precise stylus alignment and allowing accurate video calibration and pattern recognition. User-interchangeable lenses provide magnification from 185 to 1200x in two ranges. Features as small as 10 x 10 μm are easily positioned and scanned.

Extended Range Measurement Head (Optional)

The Extended Range MicroHead, offers most of the capabilities of the MicroHead with an extended vertical range. Stylus forces range from 0.5 to 45 mg; vertical ranges are ±6.55, ±65.5, and ±325 μm; vertical repeatability is typically 10Å (1σ) with 1Å resolution.

Motorized Level and Rotation (Optional)

The Motorized Level and Rotation Option enables

- Automatic mechanical leveling of the sample. (The standard unit provides electronic leveling of the traces.)
- Programmable sample rotation using a motorized rotary stage. (The standard feature is a high-precision manual stage.) The motorized option enables programmed θ-position repeatability at 4 in. from the center of 4 μm (0.16 mil).

This option is available only at the time of initial factory installation.

Hard Disk Locator (Optional)

A disk locator is available for holding hard disks on the sample stage. The locator adjusts to fit 48-, 65-, and 95-mm disks.

Wafer and Square Sample Precision Locators (Optional)

Wafer and square sample precision locators are available to enable exact positioning of a sample relative to a fixed reference point. Locators are available for the following sample sizes: 3, 4, 5, 6, and 8 in. See Appendix D, "Precision Locators," in the *Tencor P-12 Reference* manual for graphic representations of the available locators.

Wafer Handler (P-20h)

The wafer handler automatically transports wafers in and out of the instrument. The handler consists of a robotic mechanism with a vacuum puck mounted on a turntable, two cassette locators (one standard, one optional), and an aligner. If you are using both cassette locators, the standard cassette locator functions as the sender and the optional cassette locator functions as the receiver.

The vacuum puck picks up and transports the wafers, the cassette locators hold the cassettes of wafers, and the aligner orients the wafers in the X, Y, and θ positions as desired.

The handler can load wafers in four sizes: 100 mm (4 in.), 125 mm (5 in.), 150 mm (6 in.), and 200 mm (8 in.).

Vacuum Sample Hold-Down

The vacuum hold-down enables a sample to be held securely in the center of the stage and is available with the manual and motorized rotary stages.

Printer Port

A parallel port accommodates a compatible printer. Any printer supported by Microsoft Windows can be used with the Tencor P-20 software.

ESD Ground Jack

A standard banana jack for an ESD wrist strap (1-MΩ resistance minimum) is provided for use with static-sensitive devices. See Figure 1-1 for the location of the jack.

1.5 SOFTWARE FEATURES AND OPTIONS

Operating Environment

The Tencor P-20 runs in the Microsoft Windows 3.1 environment on the MS-DOS 6.2.x operating system.

Database Manager

This feature provides enhanced organizational capabilities for storing, managing, and exporting your P-12 measurement recipes and data.

Automatic Sequencing

The Sequence feature allows you to write a *sequence program* for the instrument so that you can combine up to 300 recipes and artifact locations into a sequence. A sequence program links scan recipes with stage locations to automatically take repetitive measurements, greatly enhancing the productivity of the P-12 instrument.

Wafer Stress Application (Optional)

The Tencor P-20 Wafer Stress application Option enables you to calculate the stress in a deposited film by measuring the wafer deflection or curvature that the stress induces on the substrate.

Signal Light Tower (Optional)

The Signal Light Tower Option allows you to specify custom definition corresponding to specific instrument states. This approach involves some relatively simple hardware and new Profiler software which translates instrument statues into commands to the new hardware.

GEM/SECS (Optional)

The GEM/SECS Option allows the uploading of scan measurement data to a host computer. The capability also supports Alarms, Data Collection, Equipment States, Error Messages, Initialization, Clock, and process program upload and download. See the *Tencor P-20 SECS Interface Manual* for more information on the GEM/SECS Option.

Pattern Recognition (Optional)

The Pattern Recognition Option can be used to enhance the capabilities of the Sequence Option. Automated deskew alignment minimizes operator intervention in sequences, improving throughput.

1.6 HOW TO USE THIS MANUAL

To get the most out of this manual, first-time users should proceed sequentially from Chapter 1 through Chapter 3 to get an overview of the instrument and its operation.

The remaining chapters provide a more thorough look at the concepts introduced in these first three chapters.

1.7 CONVENTIONS USED IN THIS MANUAL

This manual uses typographic formatting and symbols to distinguish between explanations, procedures, notes, cautions, and so on. This manual also uses many specialized terms that might be new to you. These conventions are described in this section.

1.7.1 TYPOGRAPHIC FORMATTING

Keep these conventions in mind when reading the manual.

Term	**Meaning**
abc...xyz	Italics are used to identify information you type using the operator keypad or the computer keyboard.
CD D:\DATA	Messages and examples appear in bold text.
LOAD	The keys or buttons you must press are indicated by small, capitalized letters.
ALT + S	When you see several keys divided by plus signs, hold down the first key while pressing the remaining key(s). For instance, hold down ALT while pressing S.
File menu Scan window	Menus and windows are shown with initial capital letters.
Direction field	The term *field* is used to identify the location of areas on dialog boxes where you can type data. The actual field name or description usually appears in the window next to the location where data is entered. Some fields are for display purposes only and do not accept data.
[<] [>] [^] [v]	The arrow keys on the keyboard are used to select items in lists, move the text cursor from field to field in dialog boxes, and to manipulate the cursors in the Data Analysis window.
ENTER	The word *enter* is often used in conjunction with data that you type using the keyboard. To enter data means to type the words or data and press the ENTER key.
NOTE:	A note box indicates that the information is vital to remember.
CAUTION:	A caution or warning box suggests that you might damage the instrument or injure yourself.

1.7.2 TERMINOLOGY

Before continuing, you need to familiarize yourself with several terms used throughout this publication. A more complete listing of words and terms is provided in the glossary at the back of the manual.

Arrow Keys

The four *arrow keys* found on the operator keyboard. Each arrow key points in a specific direction. The arrow keys are used in many places throughout the Tencor P-20 software. For example, when you want to move the selection bar in menus, you press [v] to move the bar downwards and [∧] to move the bar upwards. Use the [<] and [>] keys to move the measuring cursors in the Data Analysis window.

Boot

The term used to describe the operation of powering up a computer where the computer sets up its internal software configuration, loads operating system software, and perhaps executes an application program, depending on the instructions and data found in two DOS files named AUTOEXEC.BAT and CONFIG.SYS. Ordinarily, the Tencor P-20 initializes the Windows environment and starts up the P-20 application software.

Choose

The terms *choose* and *select* are used interchangeably to indicate selecting options from the screen with the keyboard or trackball.

Click

The term used to indicate quickly pressing and releasing one of the trackball buttons (usually the left button) when the trackball cursor is over a specific section of a window. Depending on what you click on, a window might close, a dialog box might open, an option might be selected, and so on.

Command

The action associated with selecting one of the options appearing on a menu, clicking on an icon in Windows, or pressing certain keys on the keyboard.

Cursor

In Windows, there are several kinds of *cursors*, which are moveable objects on the computer screen used to indicate position. The *trackball cursor* is a small graphic picture or icon, most often in the form of an arrow, that indicates the position of the trackball in relation to the objects on the screen. The trackball cursor can also change appearance and action depending on its location. When entering text in dialog boxes, a *text cursor* (usually in the form of a vertical bar) indicates where typed text will be echoed. The Tencor P-20 also provides *measurement cursors* and *leveling cursors* superimposed on scan data in the Data Analysis window.

Database

A set of computer files containing information and the software used to maintain and access the information. The Tencor P-20 database contains recipe and sequence files describing how to perform scans and sequences of scans as well as the associated measurement data files.

Directory

Computer files are stored on the computer's hard disk organized in *directories*. The directory name identifies the location where the files are stored. The directory name is prefaced with a backslash (\) character. For instance, the \TENCOR directory contains program and data files necessary to run theTencor P-20 main program.

Double-click

The term used to indicate quickly pressing and releasing one of the trackball buttons (usually the left button) *twice* in rapid succession when the trackball cursor is over a specific portion of a window. Depending on what you double-click on, a window might close, a dialog box might open, an option might be selected, and so on.

Drag

The mouse action performed when you hold down the mouse button and move the mouse. You can drag the mouse to choose a menu item and to move a graphics cursor.

Field

Reserved area provided on many windows for typing data, displaying data, or selecting options associated with the field. Three types of fields can appear on windows—*data entry fields*, *option fields*, and *display-only fields*. Data entry fields are reserved for typing numeric values or alphanumeric data for recipe parameters. Option fields have associated tables with predefined values. Display-only fields are used by the instrument to display the current status of inspections and values acquired after calculating inspection results.

Highlight

In the Windows environment, there are several ways of indicating the current condition of the program by visual means. For example, in a *drop-down list*, a series of items appear, one of which can be selected at a time. The item that is currently selected usually appears with a differently-colored background that makes it stand out clearly from the other items in the list. This kind of visual indication is called *highlighting*.

Keyboard

Instrument operation is performed using the instrument *keyboard*. It houses a set of typewriter-like keys with alphanumeric characters, a set of numeric keys arranged like a standard calculator, and miscellaneous special keys that perform designated functions.

Menu

A *menu* is a list of commands that can be selected. Menus take several different forms in Windows. A *drop-down menu* is a list of possible actions that appear when you click on a title in the *menu bar*. An *icon-based menu* is a group of graphic objects that might look like buttons that you click on with the trackball to select from a set of possible actions.

Option

One of several items you can select when programming recipe parameters. Many recipe parameter fields have an associated set of options that influence the behavior of the instrument when measurements are performed.

Profile

If you intersect a surface with a plane, the curve formed is a *profile*. The Tencor P-20 measures a profile by scanning a surface with a stylus. As the stylus moves up and down, the instrument records the variation along the length measured. The word *scan* or *trace* is sometimes used interchangeably with profile.

Prompt

An indication from the computer that it is waiting for information or instructions from the user.

Reboot

A term used to describe the operation of resetting a computer (without necessarily turning off the power) where the computer reloads operating system software and resets its internal software configuration. Usually used when some problem has caused the computer to lock up, and sometimes necessary after installing software to allow changes made to configuration files to take effect.

Recipe

The Tencor P-20 takes a scan based on the settings selected by the user in the *recipe*. A recipe is a list of scan parameters such as scan length, stylus force, and vertical range/resolution. A recipe also contains instructions for the analysis of the data collected in the scan.

Scan

Action performed when the Tencor P-20 measures a sample surface. Also used interchangeably with *profile* or *trace* to describe the plotted data that results from the scan.

Screen

The *screen* is the front of the video display where the computer displays information.

Select

The terms *select* and *choose* are used interchangeably to describe the actions you take when selecting options from windows with the built-in keyboard, remote keyboard, or the trackball.

Sequence

The Tencor P-20 allows you to write a *sequence*, which programs the instrument to take a series of scans rather than taking them all manually, one by one. A sequence is like a script that links specific locations on a sample (or on a number of samples) with specific scan recipes to be performed at each location.

Trace

The plotted data that results from a scan. The word *profile* or *scan* is sometimes used interchangeably with trace.

Trackball

The *trackball* is a pointing device used to provide input to the computer. By rolling the ball with the palm of your hand, you control the position of a *trackball cursor* on the computer screen. Two *trackball buttons* (left and right) are used to select available actions.

Window

Small to large rectangular boxes that open on the screen to display information and allow you to take actions and make selections. Specific main windows (such as the Recipe window) contain information and the control interface for a specific task or set of tasks and occupy most of the area of the screen. Smaller secondary windows are also often used to display information and allow operator actions. These secondary windows appear on top of the main window and disappear as needed.

2 BASIC SKILLS

Chapter 2 describes the Tencor P-20 Long Scan Profiler controls and general operations such as

- Starting, resetting, and shutting down the instrument
- Navigating through the instrument software
- Important cautions and safety information
- Getting help

2.1 INSTRUMENT COMPONENTS

Figure 1-1 through 1-3 show the major hardware components of the Tencor P-20, including the optional wafer handler.

Figure 1-1 shows the locations of controls and external components. Figure 1-2 shows the main features of the measurement area. Figure 1-3 shows the Tencor P-20h wafer handler and its major components.

2.2 INSTRUMENT CONTROLS

To operate the instrument use the keyboard and trackball. The system communicates with the user on the instrument video monitor. Data files can be imported and exported, and software options added or the system software upgraded, using the 3.5-in. diskette drive. The system can be powered on or off, or reset without powering down, from buttons on the auxiliary panel. In addition, there are several other controls located in and near the measurement area. These controls are described in the following sections.

2.2.1 KEYBOARD

You can operate the instrument primarily with a special keyboard that includes an integrated trackball pointing device, built in to the front of the instrument. Figure 2-1 illustrates the keyboard and shows the locations of the keys.

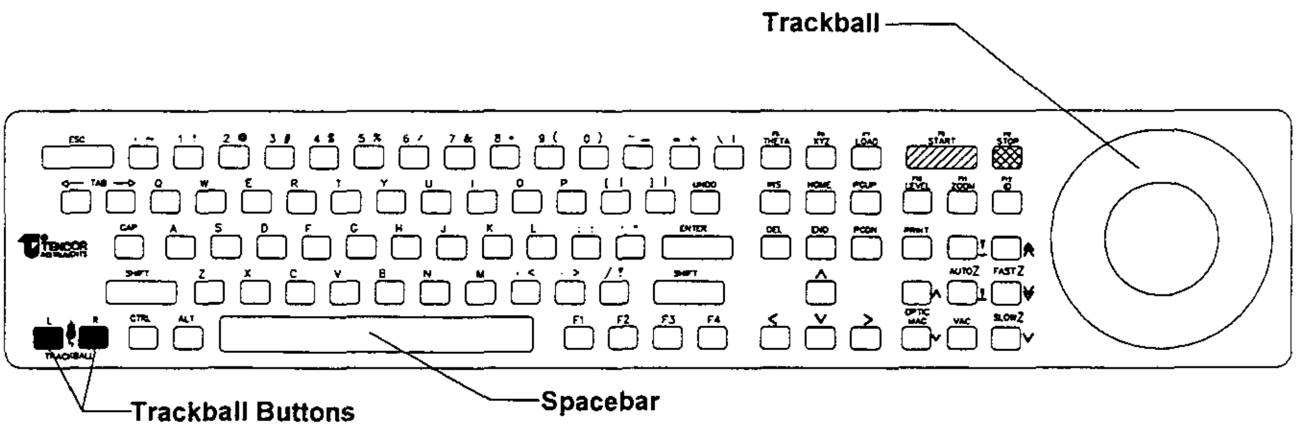


Figure 2-1 Tencor P-20 Operator Keyboard

The actions of the keys are described below.

Table 2-1 Keyboard Actions

Key	Function key/ Hot key	Action
ESC	CANCEL	If a dialog box is displayed, closes the dialog box. If a drop-down menu is displayed, collapses the menu.
TAB ←		In dialog boxes, puts text cursor in previous field.
TAB →		In dialog boxes, puts text cursor in next field.
HELP	F1	Provides help with the Profiler software.
F2, F3, F4		Function keys.
THETA	F5	Enters the View module in THETA mode.
XY	F6	Enters the View module in XY mode.
LOAD	F7	Loads or unloads the sample.
START	F8	Starts a scan.
STOP	F9	Stops a scan.
LEVEL	CTRL+L	Not implemented in this release.
ZOOM	F11	Not implemented in this release.
ID	F12	Not implemented in this release.
PRINT	CTRL+P	Prints data from the current page.
DELETE		Deletes any characters in a data field.

Table 2-1 Keyboard Actions (Continued)

Key	Function key/ Hot key	Action
[∧] [∨]		Activates Delta Average mode cursor operation. Selects previous or next menu in a menu bar. Moves cursor left or right in text-entry fields.
[<] [>]		Moves measurement and leveling cursors in Data Analysis window. Selects previous or next item in a drop-down menu. Moves cursor left or right in text-entry fields.
UNDO		Used in data entry to backspace from the end of a character string erasing one character at a time.
ENTER		Launches currently selected icon. Selects menu item from drop-down menu. Completes the entry of any dialog box. Same as OK.
Spacebar		In Data Analysis window, toggles between left and right cursors. If pressed twice in quick succession, spacebar activates both cursors that move in tandem.
AUTO Z ⊥	ALT+CTRL+Y	Not implemented in this release.
AUTO Z ⊥	CTRL+Y	Not implemented in this release.
FAST Z ︽	CTRL+U	Raises the head by 500 microns.
FAST Z ︾	CTRL+D	Lowers the head all the way down.
SLOW Z ∨	ALT+CTRL+D	Lowers the head by 500 microns.
VAC	CTRL+A	Turns the vacuum to on or off.
OPTIC MAG ∧	ALT+CTRL+M	Increases the magnification.
OPTIC MAG ∨	CTRL+M	Decreases the magnification.
Trackball L		See Section 3.5 (2), "Trackball."
Trackball R		See Section 3.5 (1), "Trackball."

2.2.2 TRACKBALL

The trackball is a pointing device that allows you to start software tasks, select commands from menus, enter data into the computer, and so on. It consists of a motion-sensing mechanism (the ball itself) and two buttons mounted in the keyboard.

To use the trackball, you place the palm of your hand over the ball and apply a gentle rolling motion. The ball responds by turning at the pressure from your hand and this motion causes a small pointer (called the *trackball cursor*) to move on the video monitor. When the cursor is located above certain regions on the screen, you can perform functions by manipulating the trackball in one of several general ways listed below.

Trackball Action	Using the trackball	The action is used to
Click	Press and release the left button.	Select an item or cancels a pending operation.
Double-click	Press and release the left button twice in rapid succession.	Select an item and begins the action associated with the item.
Drag and drop	Press and hold the left button; roll the ball with the button depressed; finally, release the button.	Select an item from a drop-down menu; select a section of text for editing; control scroll bars; move windows and dialog boxes around on the screen.

Actions performed by clicking, double-clicking, or dragging and dropping can be different when using the left or right button. Except where noted otherwise, you can use the keyboard, the trackball, or a combination of both to issue commands or enter data.

2.2.3 AUXILIARY PANEL

The appearance of the auxiliary panel differs slightly depending on whether you have a standard instrument or one equipped with the Emergency Off Option.

Standard Auxiliary Panel

The auxiliary panel is located on the front of the instrument to the left of the video monitor. Located on the panel are the Power button, the Reset button, the Keylock, and the opening to the floppy diskette drive.

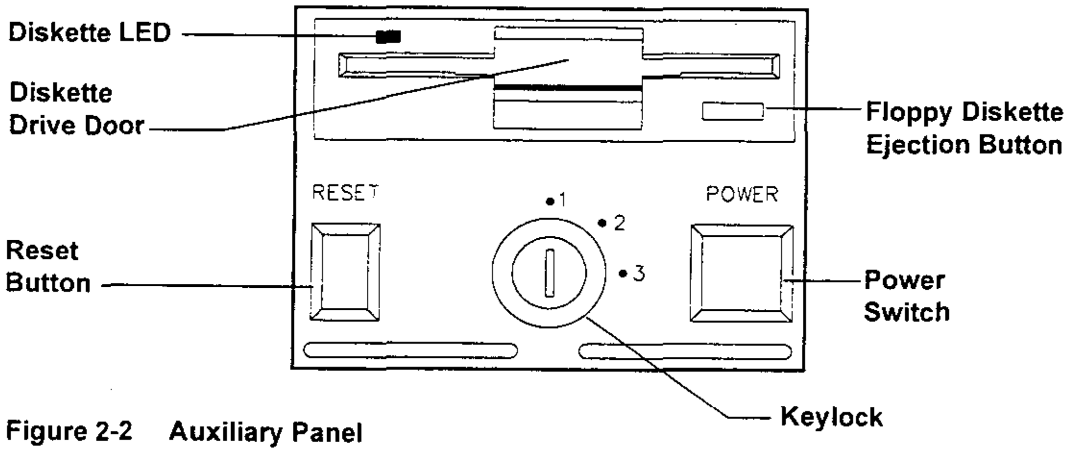


Figure 2-2 Auxiliary Panel

The functions of the controls on the auxiliary panel are described below.

Control	Action
Power Button	Turns system power on or off.
Reset Button	Restarts the instrument computer without turning the instrument power off.
Keylock	Not used in this release.
Diskette Eject Button	Ejects a floppy diskette from the drive if one is present.

Emergency Off Auxiliary Panel (Optional)

The auxiliary panel is located on the front of the instrument to the left of the video monitor. Located on the panel are the Emergency Off switch (with keylock), the Power On switch, the Power Off switch, the Reset button, the keylock, and the opening to the floppy diskette drive (see Fig. 2-3).

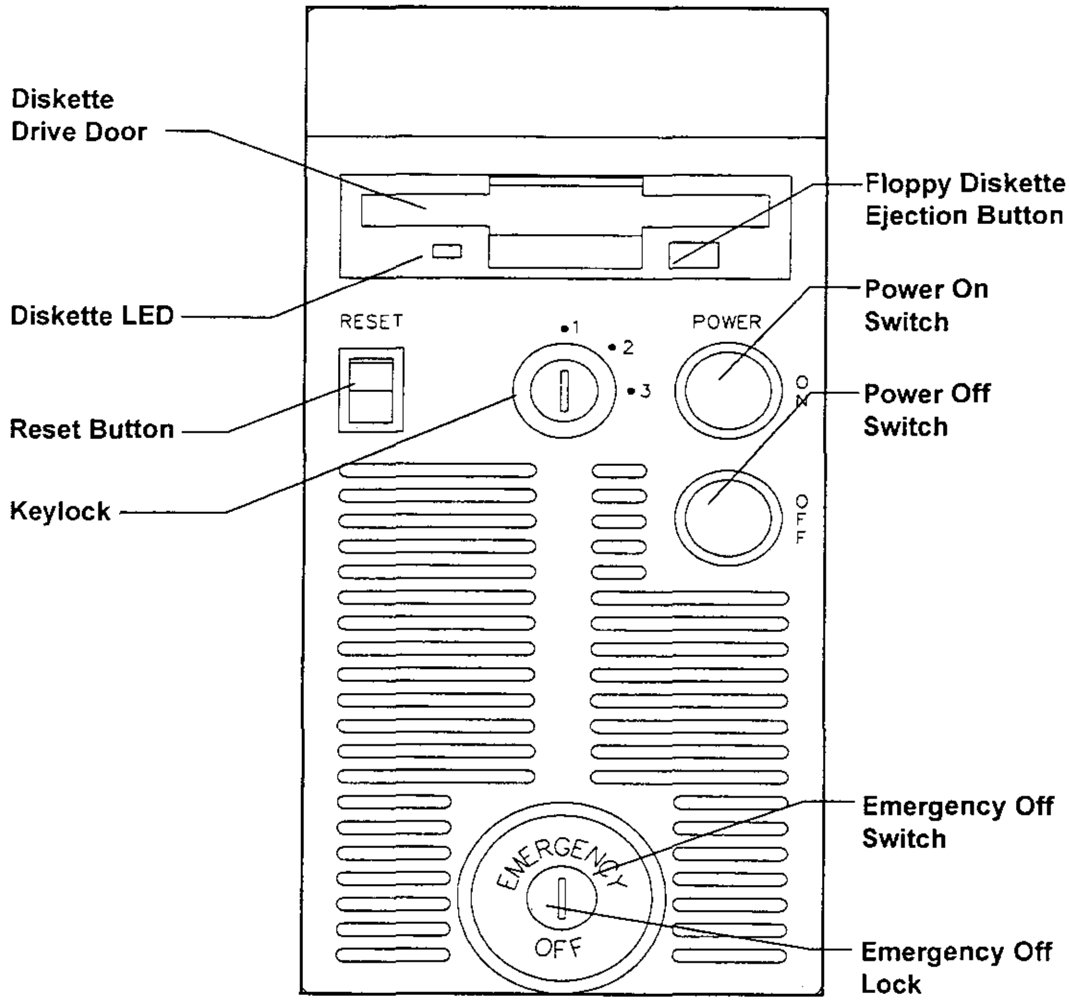


Figure 2-3 Auxiliary Panel–Emergency Off Option

The functions of the controls on the auxiliary panel are described below.

Control	Action
Emergency Off Lock	Enables and disables Emergency Off switch
Emergency Off Switch	If enabled, shuts system power off
Power On Switch	Turns system power on
Power Off Switch	Turns system power off
Reset Button	Restarts the instrument computer without turning the instrument power off
Keylock	Not used in this version

Control	Action
Diskette Eject Button	Ejects a floppy diskette from the drive if one is present

2.2.4 MISCELLANEOUS CONTROLS

Video Monitor Controls

The video monitor controls are located underneath the left side of the video monitor (see Fig. 1-1).

Control	Action
On/Off	Turns the video monitor on or off.
Brightness	Adjusts the level of screen brightness.
Intensity	Adjusts the level of screen intensity.

ESD Jacks

The ESD ground jack is located underneath the computer, to the left of the video monitor controls (see Fig. 1-1).

2.3 USING THE INSTRUMENT

The sections that follow describe the basic techniques needed to operate the Tencor P-20.

To power up the instrument:

Press the Power button on the auxiliary panel.

To reset the instrument without powering down:

1. From the Top Level menu, hold down the Shift key and double-click on the Log Off icon to close down the Profiler software.
2. Press ALT+F4. A message box appears with the prompt

   This will end your Windows session.

   Press ENTER, or click on OK to close down Windows.
3. Press the Reset button on the auxiliary panel, or type ALT+CTRL+DELETE.

> **NOTE:** **Do not press ALT+CTRL+DELETE until after exiting from Windows; otherwise, file and disk corruption can occur.**

When the instrument is powered up or reset, it displays a series of start-up messages, then displays the Microsoft Windows start-up screen and initializes the Windows environment. The Tencor P-20 software appears in the Tencor program group (Fig 2-4):

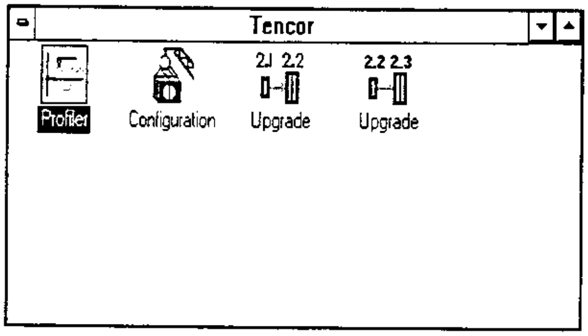


Figure 2-4 Tencor Program Group

To start the Tencor P-20 software:

Using the trackball, move the small arrow-shaped cursor until its tip is on the Profiler icon in the Tencor program group. Double-click the left button (or click once and press ENTER).

The arrow-shaped cursor changes into an hourglass. A series of messages appear as the various components of the software are loaded into memory. At the end of this process, the Top Level menu appears and the cursor becomes a Tencor logo.

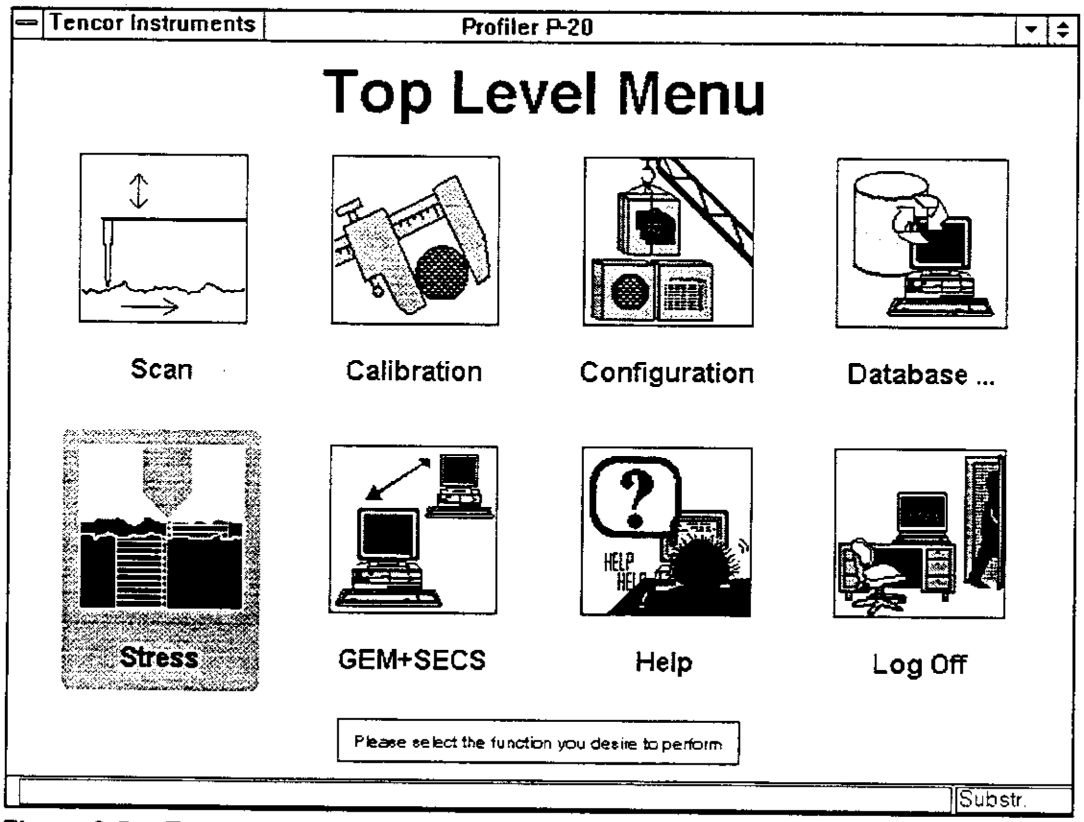


Figure 2-5 Top Level Menu

The Top Level menu is the starting point for operating the instrument. Each picture in the menu represents a group of related operations.

Before describing the operation of the instrument, it is necessary to understand a little about the Windows environment. The following sections describe the Windows environment as seen from within the Tencor P-20 software.

2.4 WORKING WITH WINDOWS

The Tencor P-20 software operates in the Microsoft Windows environment. In this environment, *windows* display information, *menus* provide lists of commands (in the form of text lists or as a set of graphic images called *icons*), and *forms* and *dialog boxes* request additional information or display error messages.

Most windows share some common features. Not all windows, however, have every element. As a typical example, refer to the Recipe Editor window in Figure 2-6:

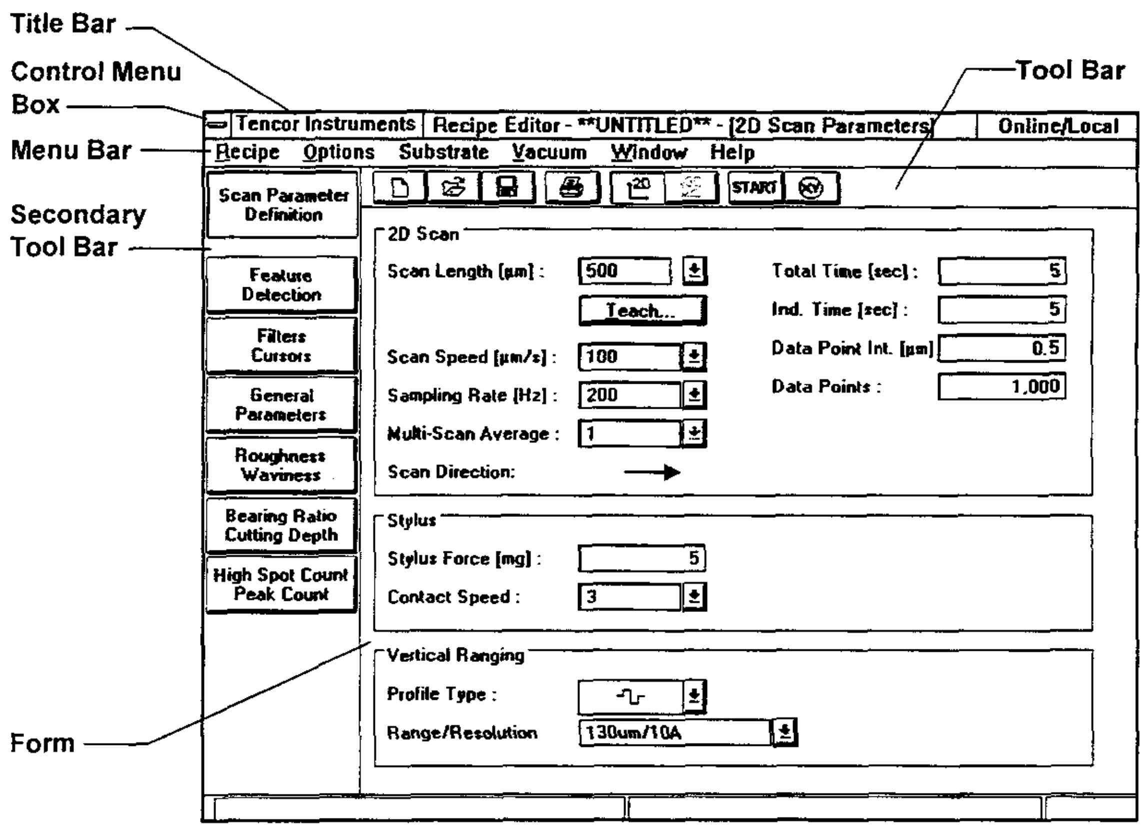


Figure 2-6 Recipe Editor Window

Title Bar

In the center, the window's title bar displays a title for the current window (in this example, the title contains the name of the recipe that is being edited).

Control Menu Box

The control menu box appears in the upper-left corner of a window. By clicking on the box, the control menu appears, which allows you to close, move and resize windows, and switch to other applications. In the Recipe Editor window, the Move, Resize, Minimize, and Maximize commands are all unavailable because this window is not moveable or resizeable. Unavailable commands appear as dimmed text. See Section 2.6.9, "Moveable and Resizeable Windows."

Menu Bar

The menu bar contains a list of menu titles. When you point at one of these titles with the trackball and click, a menu drops down below the title, listing a series of possible actions. See Section 2.5, "Working with Menus."

Tool Bar

The tool bar contains a series of icons that look like buttons. Clicking on one of these icons provides another way to select some of the items that can also be selected from the menu bar. Some windows have secondary tool bars, like the vertical set of buttons on the left side of the Recipe Editor window. See Section 2.5, "Working with Menus."

Forms

The main area of a window can contain many things depending on the purpose of that particular window a data display—a video image of a sample, or, as in the Recipe Editor window, a *form*, which displays information that usually can be edited and waits for you to make any desired changes or otherwise respond.

Dialog boxes are similar to forms. They are secondary windows that appear on top of another window when the software requires the operator to make some decisions or supply some additional information before proceeding with a command. See Section 2.6, "Working with Dialog Boxes and Forms."

2.5 WORKING WITH MENUS

A menu contains a list of actions from which you can choose. There are two types of menus:

- Icon-based menus
- Drop-down menus

The Top Level menu (Figure 2-5) is an icon-based menu. Each of the icons in the menu corresponds to a group of related operations that you can perform. For example, the Scan icon corresponds to all the activities related to using the instrument to scan samples—setting the parameters for the scan, performing the scan, analyzing the data taken, and so on.

To start an operation with the trackball:

Move the cursor over the desired icon and double-click.

To start an operation with the keyboard:

Press TAB← or TAB→ or the arrow keys until the desired icon is selected, then press ENTER.

The tool bars that appear in some windows are other examples of icon-based menus.

A *drop-down menu* is a box that appears in a window when it is opened by clicking on the menu title. The menu typically contains several items. Depending on the state of the program at the time, some menu items may not be available; these unavailable choices appear as dimmed text. In the following sample menu, the third, seventh, tenth, and eleventh items in the list are dimmed and cannot be selected while the system is in its current state.

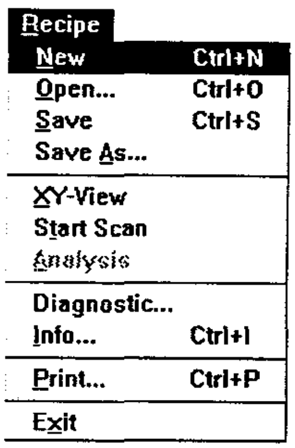


Figure 2-7 Drop-Down Menu

Some menu items have *hot keys* assigned to them. Hot keys are special key combinations that perform a specific menu function directly without having to first pull down the menu and then select the menu item. For example, pressing CTRL+O has the same effect as pulling down the Recipe menu in Figure 2-7 and clicking on Open. Hot keys offer some of the advantages of command-based user interfaces to the Windows graphical user interface.

2.6 WORKING WITH DIALOG BOXES AND FORMS

A dialog box is a secondary window that appears on top of the window that is currently on the screen. The instrument software uses dialog boxes to obtain additional information about an action you have selected.

A *message box* is a special type of dialog box that displays an error or warning message, and usually has only one or two responses, typically OK or Cancel.

Sometimes part of the main window has an appearance that is much like a typical dialog box. These are referred to as forms.

Dialog boxes and forms can differ widely in appearance depending on their function. A dialog box can contain any of the elements described in this section (see Fig. 2-8).

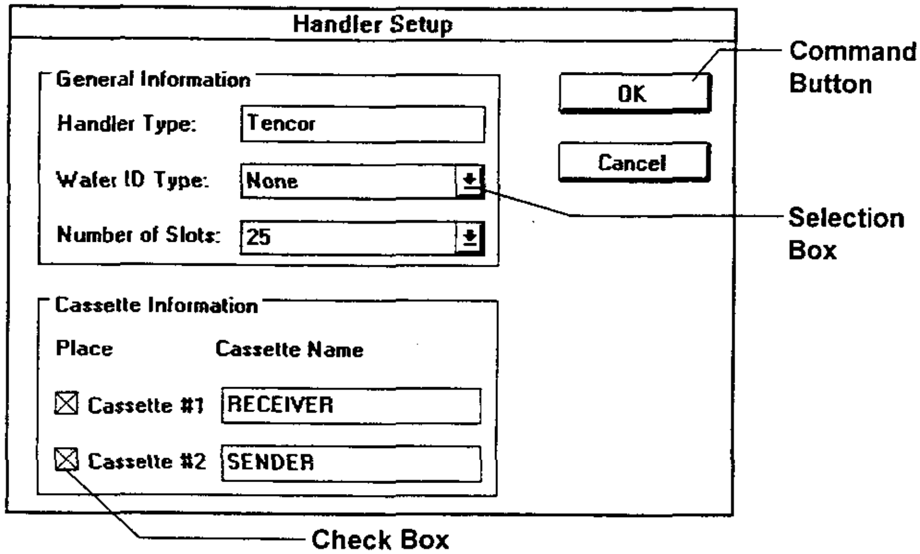


Figure 2-8 Typical Dialog Box

2.6.1 SELECTING ITEMS

In most dialog boxes, several items are available for selecting settings or entering desired values. Each item can be selected by clicking on it with the trackball.

Alternatively, you can press the TAB key on the keyboard to select an item in the dialog box. Items that are selected are made to stand out in the dialog box. If an item contains a field that has a menu of possible choices or accepts keyboard entry of information, the field appears highlighted. If the item is a check box, a radio button, or a control button, a small box appears, outlining the item's label.

To select an item with the trackball:

Click on the item.

To select an item with the keyboard:

Press TAB← or TAB→ repeatedly until the item is highlighted.

2.6.2 USING COMMAND BUTTONS

A command button performs the action described by the button's title. For example, clicking on the Cancel command button closes the dialog box without changing any settings.

Command buttons with an ellipsis (...) open another dialog box. Command buttons with two greater-than symbols (>>) after the title expand the current dialog box. Command buttons that are not available are dimmed.

In most dialog boxes, one button is the default button and can be chosen by pressing ENTER as well as by selecting it with the trackball or TAB keys. The default button is indicated by a dark border.

In most dialog boxes with a Cancel option, pressing the ESC key has the same effect as clicking on the Cancel command button.

To activate a command button with the trackball:

Click on the button.

To activate a command button with the keyboard:

Press TAB← or TAB→ until the button is selected, then press ENTER.

To activate the default command button at any time:

Press ENTER.

To cancel a dialog box at any time:

Press ESC.

2.6.3 USING CHECK BOXES

Check boxes are used to indicate options that can either be on or off. When an option is off, the check box is empty; when it is on, the check box has an x in it. A check box is dimmed if the option is unavailable.

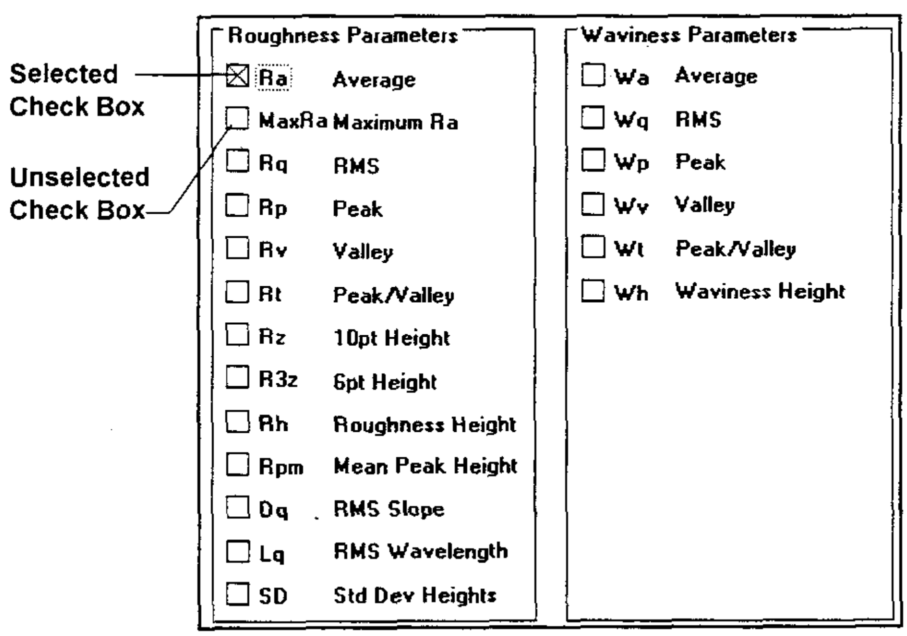


Figure 2-9 Check Boxes

To turn a check box on or off with the trackball:

Click on the box to toggle its state.

To turn a check box on or off with the trackball:

Press TAB← or TAB→ until the desired box is selected, then press the spacebar to toggle its state.

2.6.4 USING RADIO BUTTONS

Radio buttons are used to display a group of options where only one item in the group can be on at a time. The radio button that is on contains a black dot in the circle; all the others are empty circles. Choosing to activate another radio button automatically deactivates the current activated one. Radio buttons that are not available are dimmed.

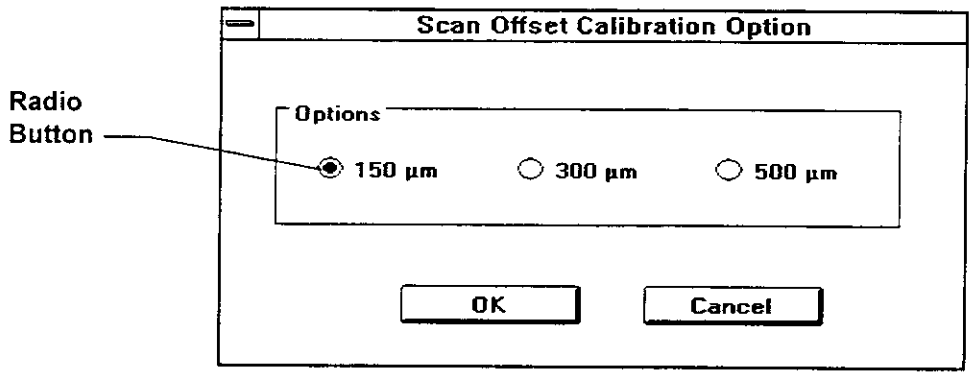


Figure 2-10 Radio Buttons

To turn a radio button on or off with the trackball:

Click on the radio button.

To turn a radio button on or off with the keyboard:

Press TAB← or TAB→ to select the radio buttons, then press [<], [>], [∧], or [∨].

2.6.5 USING LIST BOXES

List boxes display lists of options. When a list is longer than the list box can display, use scroll bars to see the remaining part of the list.

At the top of the list box is a selection box that displays the current selection from the list.

To choose a list item with the trackball:

1. Click on the desired item.
2. Click on the OK command button.

To choose a list item with the keyboard:

1. Press [∧] or [∨] to move the selection bar up or down.
2. Press ENTER to perform the action associated with the list.

Rather than selecting the list item from the list, you can also type the name of the list item desired directly in the selection box. The selection box is one example of a data entry field. See Section 2.6.6, "Using Data Entry Fields," for a discussion of the various ways that you can use to edit text.

If the data that you enter is invalid, the system does not accept the data.

To choose a list item by typing the list item name:

1. Click inside the selection box to place the text cursor in it, or double-click or drag the trackball cursor to select some or all of the current text.
2. Type the appropriate text.
3. Click on the OK command button or press ENTER to perform the action associated with the list.

2.6.6 USING DATA ENTRY FIELDS

A data entry field is a selection box into which you can type data—recipe names, a value for scan length, and so on.

To edit text in a data entry field box:

- Click on the trackball cursor once inside the box to place the text cursor (a blinking vertical bar) inside the box at the tip of the mouse cursor.
- Double-click the trackball cursor to select the entire word nearest the cursor, highlighting it.
- Drag the trackball cursor to select part or all of the text in the box. You do this by clicking the left button and holding it down while you move the cursor across some or all of the text in the selection box. As you drag, the text is highlighted. Release the button when the desired text is highlighted.

If you insert the text cursor by clicking in the box, characters typed from the keyboard are inserted to the right of the text cursor, moving existing characters to the right to accommodate the new ones. Press DELETE to erase the character to the right of the text cursor, or press UNDO to erase the character to the left of the text cursor.

If you select all or part of the text by double-clicking or dragging, you can press DELETE or UNDO to delete the selection, or start typing to overwrite the selection.

When finished, press ENTER or click on the OK command button. If the data that you enter is invalid, the system does not accept the data and beeps a warning.

To enter data in a selection box:

1. Click inside the selection box to place the text cursor in it, or double-click or drag the trackball cursor to select some or all of the current text.
2. Type the desired data from the keyboard and edit as necessary.

2.6.7 USING DROP-DOWN LISTS

Drop-down lists are similar to list boxes. Instead of the list appearing beneath the selection box, there is a small drop-down button to the right of the selection box. The drop-down list appears when you click on the drop-down button. If the list contains more choices than can be displayed in the drop-down list, scroll bars are provided.

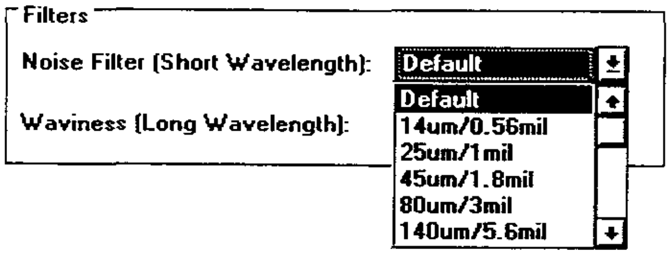


Figure 2-11 Drop-Down List

Note that if you use the TAB key to access a drop-down list, the list does not pull down, but you can see the list items appear one-by-one in the selection box by pressing the arrow keys or PAGE UP and PAGE DOWN.

To choose an item from a drop-down list:

1. Click on the drop-down button to display the list.
2. Click on the desired item or use the arrow keys to choose the desired item and press TAB to close the drop-down list. You can also click anywhere outside the drop-down list to close it.

2.6.8 USING SCROLL BARS

A window, dialog box, or list box uses scroll bars to allow display of more information than can fit in the existing screen space of the box. For example, if a file list box can only display the names for eight files, but there are twelve or more files present, the box appears with scroll bars along its right side. Scroll bars can also appear on the bottom of a box if the information displayed in the box does not have enough horizontal space.

There are different ways to control scrolling. Some methods are good for browsing slowly through the list; others can bring you rapidly to the beginning or end of a list or anywhere in between.

To scroll using the trackball

To scroll	Do this
One line	Click once on a scroll arrow.
One window	Click in the scroll bar, above or below the scroll box.
Continuously	Press and hold down the left trackball button while pointing to one of the scroll arrows. When the desired information appears, release the button.
To any position	Drag the scroll box along the scroll bar to the desired position. Since the length of the scroll bar is scaled to the amount of information that appears in the box, dragging to the middle of the scroll bar positions the center area of the information in the box, dragging to the end of the scroll bar positions the end of the information in the box, and so on.
Using indexing (only works for lists)	Click on the first item in the list. Then type the first letter of the desired item name. The list jumps to the first entry beginning with that letter.

You can also use keyboard commands to control scrolling.

To scroll using the keyboard

To scroll	Do this
One line	Press [∧] or [∨] once.
One window	Press PAGE UP or PAGE DN.
Continuously	Press and hold [∧] or [∨]. When the desired information appears, release the key.
To the top of the list	Press HOME.
To the bottom of the list	Press END.
Using indexing (only works for lists)	Then type the first letter of the desired item name. The list jumps to the first entry beginning with that letter.

2.6.9 MOVEABLE AND RESIZEABLE WINDOWS

Windows are sometimes *moveable* and *resizeable*. Moveable windows can be moved around the screen. Resizeable windows can be made larger or smaller. They can also be reduced to an icon, or *minimized*, or made to evenly fill the entire screen area available to them, or *maximized*.

In the Tencor P-20 software, these kind of windows are not used as often as in many other applications. The Data Analysis windows, however, use this approach to allow flexibility in viewing data plots and parameter calculations.

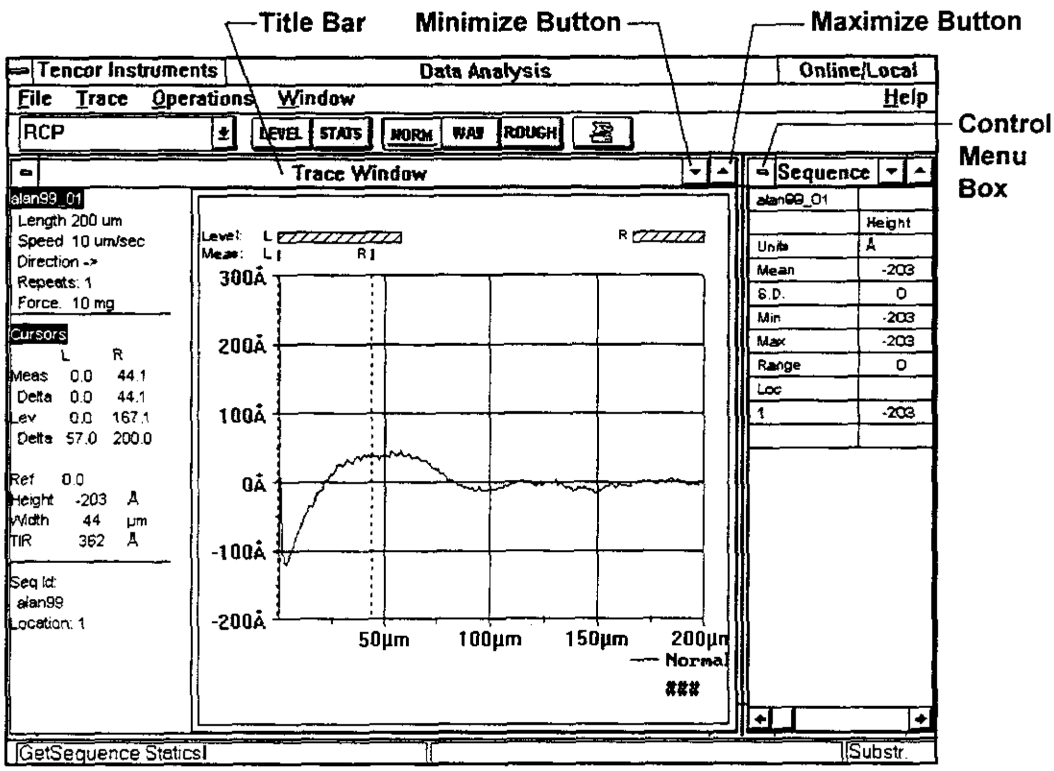


Figure 2-12 Moveable and Resizeable Windows

In the example shown in Figure 2-12, two subwindows (the Trace window and the Sequence Parameter Data window) appear inside the main Data Analysis window. These windows can be moved and resized as follows.

To move a window using the trackball:

Drag and drop the window using the title bar.

To move a window using the keyboard:

1. Press CTRL+F6 or CTRL+TAB to select the window or icon that you want to move.
2. Press ALT+- (hyphen) to display the Control menu for the selected window.
3. Use the arrow keys to select Move and press ENTER, or press the M key. The trackball cursor changes to a four-headed arrow.

4. Use the arrow keys to move the window to the new location. An outline of the window moves as you press the arrow keys.
5. Press ENTER to complete the move, or press ESC to cancel.

To change the size of a window using the trackball:

1. Select the window you want to resize.
2. Point to a border or corner of the window. The trackball cursor changes to a two-headed arrow.
3. Drag the border or corner until the window is the desired size. If you drag a border, the window size changes only in the direction perpendicular to the border. If you drag a corner, both adjoining sides change at the same time. An outline indicates the size and shape of the new size.
4. Release the trackball button. To cancel, press ESC before releasing the button.

To change the size of a window using the keyboard:

1. Press CTRL+F6 or CTRL+TAB to select the window or icon that you want to resize.
2. Press ALT+- (hyphen) to display the Control menu for the selected window.
3. Use the arrow keys to select Size and press ENTER, or press the S key. The trackball cursor changes to a four-headed arrow.
4. Use an arrow key to move the trackball cursor to the border you want. If you want to change the size both horizontally and vertically, press either [∧] or [∨] + either [<] or [>] simultaneously to move the cursor to the corresponding corner of the window.
5. Use an arrow key to move the border. If you are changing the size both horizontally and vertically, press [>] to stretch the window to the right, [<] to stretch it to the left, [∧] to stretch it upward, and [∨] to stretch it downward. Move the border or borders until the window is the size that you want. An outline indicates the size and shape of the new size.
6. Press ENTER to complete the resizing, or press ESC to cancel.

To minimize a window using the trackball:

1. Select the window you want to minimize.
2. Click on the Minimize button (the box with the downward-pointing arrowhead).

To minimize a window using the keyboard:

1. Press CTRL+F6 or CTRL+TAB to select the window or icon that you want to minimize.
2. Press ALT+- (hyphen) to display the Control menu for the selected window.
3. Use the arrow keys to select Minimize and press ENTER, or press the N key.

To maximize a window using the trackball:

1. Select the window you want to maximize.

2. Click on the Maximize button (the box with the upward-pointing arrowhead).

To maximize a window using the keyboard:

1. Press CTRL+F6 or CTRL+TAB to select the window or icon that you want to minimize.
2. Press ALT+- (hyphen) to display the Control menu for the selected window.
3. Use the arrow keys to select Maximize and press ENTER, or press the X key.

When a window is maximized, the Maximize and Minimize buttons are replaced by the Restore button. If you want to minimize a maximized window, you must first restore it to its original size.

To restore a window using the trackball:

Click on the Restore button (the box with both upward- and downward-pointing arrowheads).

To restore a window using the keyboard:

1. Press ALT+- (hyphen) to display the Control menu for the maximized window.
2. Use the arrow keys to select Restore and press ENTER, or press the R key.

2.7 USING THE WAFER HANDLER

The wafer handler automatically transports wafers in and out of the instrument. The handler consists of a robotic mechanism with a vacuum puck mounted on a turntable, one or two cassette locators (one is standard, the second is optional), and an aligner.

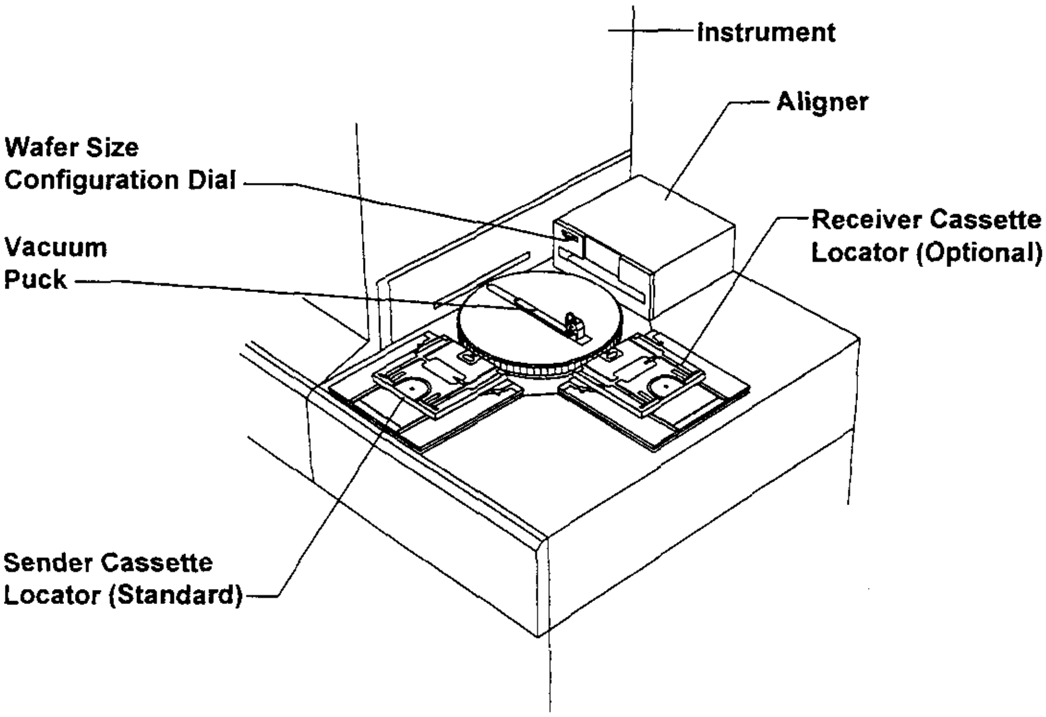


Figure 2-13 Wafer Handler

The vacuum puck picks up and transports the wafers, the cassette locators hold the cassettes of wafers in the proper position, and the aligner orients the wafers in X, Y, and θ as desired. See Section 5.2.2, "Loading a Sample with the Wafer Handler," and Section 7.11, "Sequencing with the Wafer Handler," for details on the operation of the wafer handler with the Tencor P-20h.

2.7.1 PROTECTING THE WAFER HANDLER

The following design features protect the wafer handler and its components from damage:

- If the handler does not initialize, the manual vacuum switch could be turned off. Check the switch to make sure that it is on (in the up position). The switch is located inside the instrument below the lower left of the measurement door.
- If the wafer loading or unloading process is interrupted while the handler puck is inside the instrument, the X and Y stages will not move. You need to home the puck by initializing the handler.
- If a wafer that has been loaded using the handler is unloaded manually, the handler will maintain that there is a wafer in the location until you run the unloading procedure from that location twice. This is a safety mechanism to prevent damage to wafers.

- If you attempt to use the wafer handler to unload a wafer to the cassette after removing the wafer's cassette and replacing it with the same or another cassette, the following prompt is displayed:

  Make sure the cassette slot to which you are unloading the wafer is empty; otherwise, the wafer might be damaged.

The following cases illustrate ways in which you could damage the wafer handler, the wafers, or the data:

- The handler is stopped at the exact moment of wafer handoff between the puck and a location.
- Changing a cassette during a scan could result in the loss of scan data.
- The handler is stopped while the handler puck is inside the profiler and the puck is not homed before manually operating the instrument. You must home the puck before using the instrument.

2.7.2 RESETTING THE WAFER HANDLER

You can reset the wafer handler by itself or you can reset both the Tencor P-20h and the wafer handler simultaneously. Resetting the handler alone is much faster than resetting both the instrument and the wafer handler.

NOTE:	**Before resetting or stopping the wafer handler, see Section 2.7.1, "Protecting the Wafer Handler," for information on protecting the wafer handler, wafers, and data from damage.**

To reset the instrument and the wafer handler:

Press the Reset button if the instrument is locked up. If the instrument is not locked up, exit to DOS before pressing RESET.

To reset the wafer handler only:

1. Press the button on the rear panel of the wafer handler.
2. Initialize the handler before using. To initialize, pull down the Handler menu from the Sequence Editor or Recipe Editor window and select Initialize.

2.7.3 HANDLER VACUUM CHUCK

The vacuum chuck (Figure 2-14) is specifically designed to accept the handler vacuum puck and to allow a quick vacuum release. The instrument is equipped with the vacuum chuck if your instrument comes with the wafer handler.

The lowest elevator position is set at the factory to allow the stylus to be nulled on the stage surface for both the standard stage and the wafer handler locator. If a wafer locator is installed, a new lowest position must be determined, and that position entered into the stage configuration file. The handler has a separate configuration table that is effective only when the handler is enabled.

CAUTION:	**It is very important to determine the correct lowest position for the elevator when a precision locator is installed. The stylus can be damaged if you leave the stage configuration with the factory settings and place a large substrate on the stage. See Section 5.8.4, "Lowest Elevator Position," for details.**

The vacuum chuck is equipped with a rotary valve so that 100-, 125-, 150-, or 200-mm wafers can be vacuum-clamped on the wafer locator.

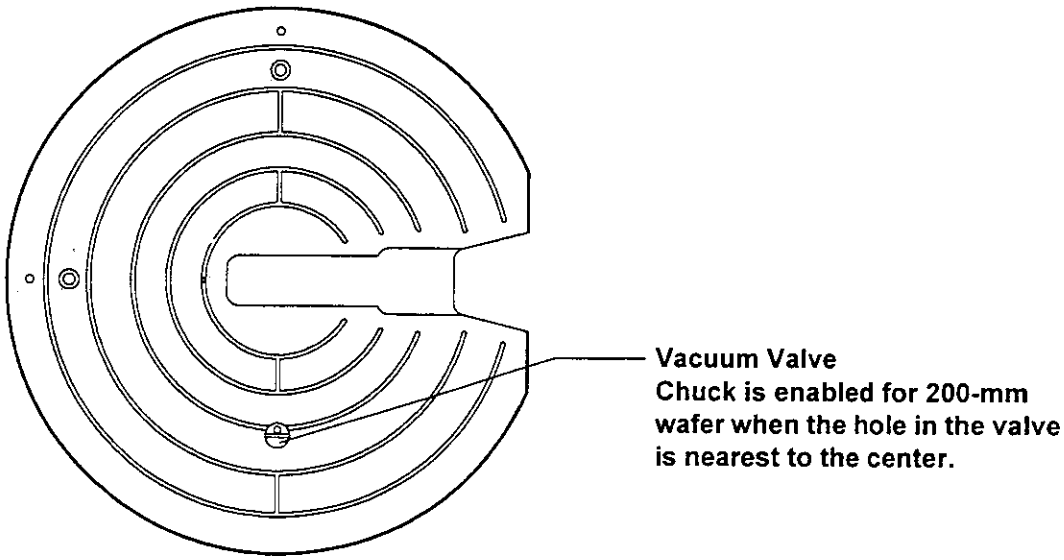


Figure 2-14 Vacuum Chuck

To set the vacuum valve for 100-, 125-, or 150-mm wafers:

- Rotate the valve so that the hole in the value is farthest away from the center of the chuck. The slot is perpendicular to a radial line.

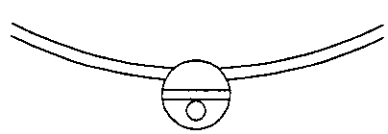


Figure 2-15 Valve Position for 100-, 125-, or 150-mm Wafers

To set the vacuum valve for 200-mm wafers:

- Rotate the valve 180° so that the hole in the value is closest to the center of the chuck. The slot is perpendicular to the radial line.

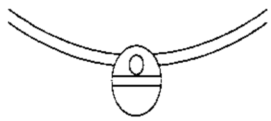


Figure 2-16 Valve Position for 200-mm Wafers

In some older chucks, the valve design is different. The valve has no hole in the top.

To set the vacuum valve on older chucks:

- To enable a 200-mm wafer, the slot should point toward the center.

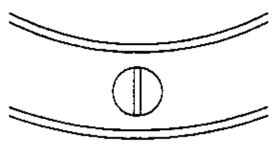


Figure 2-17 Valve Position for Older Chucks with 200-mm Wafers

- For 125- or 150-mm wafers, the slot is rotated 90° so that the slot is perpendicular to a radial line. The older chuck does not accommodate 100-mm wafers.

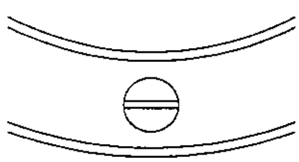


Figure 2-18 Valve Position for Older Chucks with 125- or 150-mm Wafers

2.8 PROTECTING THE STYLUS ARM ASSEMBLY

NOTE:	**The Tencor Instruments Warranty Policy does not cover damage to the stylus arm assembly or the pivot caused by operator error or carelessness.**

The Tencor P-20 incorporates several design features to protect the stylus from damage:

- Whenever the stylus is down (that is, near its lowest position) and you move the stage, the stylus automatically lifts to reduce the risk of hitting the edge of an artifact or a sample fixture. When the stylus is in the near null position (that is, resting on a substrate), it rises only when you select high speed XY movement.
- Whenever the stylus is down for longer than 60 s and a scan is not taking place, the stylus lifts automatically.

- When the stylus reaches its upper limit of travel, that is, the stylus cannot rise any higher while traveling up an incline, the stylus automatically retracts and the scan is terminated. (Note: When the stylus reaches its upper limit, the trace in the Scan window ascends and becomes level.)
- As a safety factor, you can program the elevator to lower only to a preset limit. Refer to Section 5.8.4, "Lowest Elevator Position."
- If the measurement head is lowered into contact with a surface, the stylus assembly retracts and thus is protected from damage.

Although we have taken these design precautions, there are still cases where damage can occur. Damage occurs whenever the stylus is down and a vertical wall fixed to the stage moves against the stylus shaft.

Specifically, the stylus can be damaged whenever it encounters an obstacle higher than the bevel height of the stylus tip, that is, higher than 440 μm (17 mils) for the MicroHead L-stylus (see Figure 2-19). In addition, the stylus can be damaged by a shorter object if it has sharp corners or burrs that bite into the stylus tip.

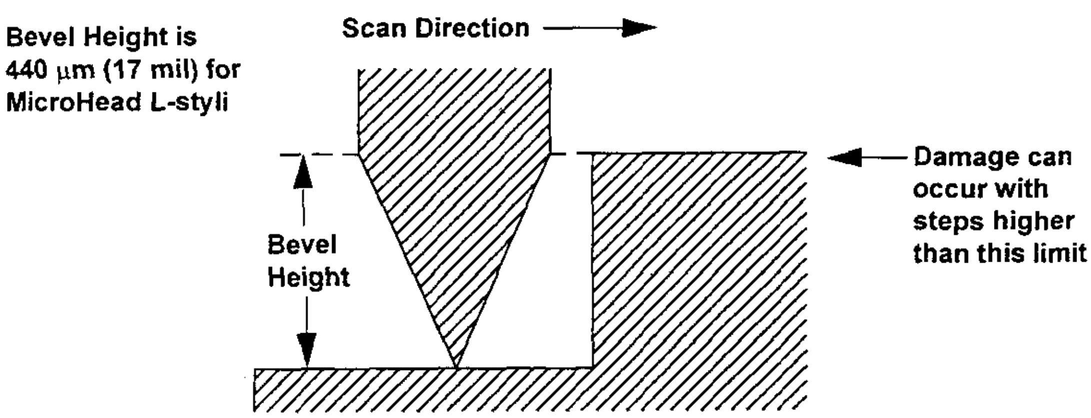


Figure 2-19 Protecting the Stylus

The following cases illustrate ways in which you could damage the stylus arm assembly:

- If you lower the stylus or start a scan when the sample is not directly under the stylus, you can damage the stylus. This is most likely to happen when you lower the measurement head such that the stylus drops into the center hole of a disk. Then if you move the stage, you will damage the stylus.

CAUTION:	**Do not start a scan or move the stage unless you know that the stylus is directly over the sample or you could damage the stylus.**

- If you change the substrate or precision locator without resetting the lowest elevator position, the head can lower onto the locator if the stylus misses the locator. Damage could occur if you click on Manual Load or Handler Load and cause the substrate or locator to hit the stylus. The measurement head must be at least 6.4 mm (0.25 in.) above the top of the precision locator. Note: The stylus drops about 4 mm (165 mils) below the measurement head.

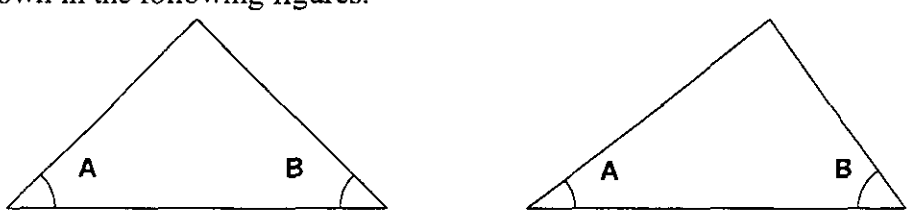
CAUTION:	**If you change the substrate or precision locator to a different height, reset the lowest elevator position (see Section 5.8.4, "Lowest Elevator Position"). Otherwise, you can damage the stylus and the measurement head.**

When designing custom jigs or fixtures, consider the precautions noted in this section. For instance, when designing a custom disk locator, its center section must be flushed with the top of the disk surface. Damage also can occur when there is a hole in a jig, a vacuum hole, or a groove in a surface.

2.9 STYLUS ARCAL ERROR CORRECTION

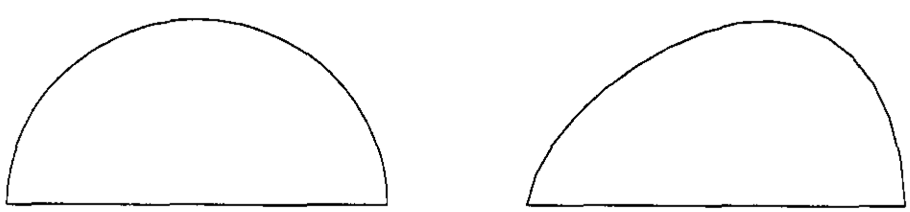
When the stylus scans over a feature, it travels in an arc instead of a straight line. As a result of the stylus pivoting around a central point, the radius measured values are distorted due to this stylus arcal error.

Arc contribution to geometric distortion can occur on either flat or curved surfaces, as shown in the following figures.



Actual Surface A=B **Scanned Shape A<>B**

Figure 2-20 Effect of Arcal Error on Flat Surfaces



Actual Surface **Scanned Shape**

Figure 2-21 Effect of Arcal Error on Curved Surfaces

This arcal error is automatically corrected by calculating the displacement of a distorted curved or flat feature from its actual shape.

2.10 TENCOR P-20 HELP SYSTEM

The Help system is currently not implemented.

2.11 TURNING OFF OR RESETTING THE INSTRUMENT

Before powering down the instrument, we recommend that you

- Exit the Tencor P-20 software into the Windows desktop.
- Exit Windows.

CAUTION: When the instrument is powered up or reset, the stage moves to the Z coordinate of the Manual Load Position. If the Z coordinate is not high enough above the stage, the measurement head might contact any sample or other hardware that might be present. See Section 5.8.2, "Manual Load Position." for procedures.

Whenever powering down the instrument, use the following procedure to ensure against loss of data and recipes. Note the following caution.

CAUTION: *Never* press the Reset button or the On/Off switch (Fig. 2-2) when the disk drive is in operation, otherwise, data, recipe, or program corruption can occur.

To exit to Windows:

While holding down the Shift key, click on the Log Off button in the Top Level menu (Fig. 2-5). The Tencor P-20 software closes and the screen reverts to the Windows desktop.To quit Windows:

1. Double-click on the Program Manager control button, or press ALT+F4.
2. The following message box appears:

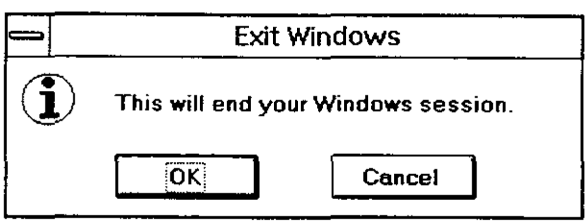


Figure 2-22 Exit Windows Message Box

Click on OK to exit, or Cancel to remain in Windows.

To reset the system without powering down:

Press the Reset button on the auxiliary panel (Fig. 2-2 or Fig. 2-3).

To power down the Tencor P-20:

Turn off the On/Off switch on the auxiliary panel (Fig. 2-2 or Fig. 2-3).

3 GETTING STARTED

This chapter is a brief tutorial to guide you through a simple sample measurement. It assumes that you have a basic knowledge of the instrument as described in Chapter 2, "Basic Skills." If you have not done so already, read Chapter 2 before proceeding.

The example used throughout this tutorial follows a continuous sequence of steps. By carefully following the instructions, the windows that appear on your monitor should be very similar to the example windows reproduced in this chapter.

This tutorial is intended to quickly familiarize you with the operation of the Tencor P-20, and, therefore, defers many important details to later chapters. Throughout, you will be referred to the appropriate chapters for more complete information.

This chapter covers

- Starting the system
- Selecting a scan recipe
- Loading a sample
- Viewing and positioning the sample
- Taking a scan
- Examining and saving the scan data
- Unloading the sample

To work through this chapter, you will need a sample to profile. We recommend a step-height standard for this purpose.

3.1 STARTING THE SYSTEM

To power up the instrument:

Press the Power button on the auxiliary panel.

To reset the instrument without powering down:

Press the Reset button on the auxiliary panel.

When the instrument is powered up or reset, it displays a series of start-up messages, then displays the Microsoft Windows start-up window and initializes the Windows environment. The Tencor P-20 software appears in the Tencor program group (Fig. 3-1).

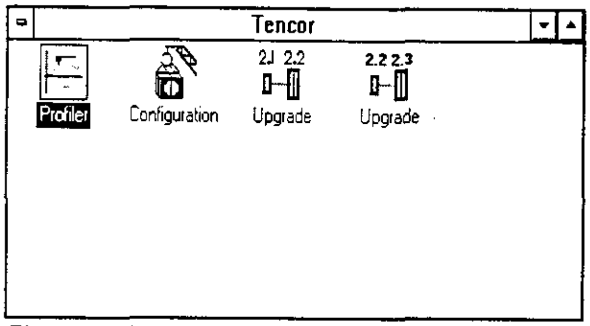


Figure 3-1 Tencor Program Group

To start the Tencor P-20 software:

Using the trackball, move the small arrow-shaped cursor until its tip is on the Profiler icon in the Tencor program group. Double-click the left button (or click once and press ENTER).

The arrow-shaped cursor changes into an hourglass. A series of messages appear as the various components of the software are loaded into memory. At the end of this process, the Top Level menu appears and the cursor becomes a Tencor logo.

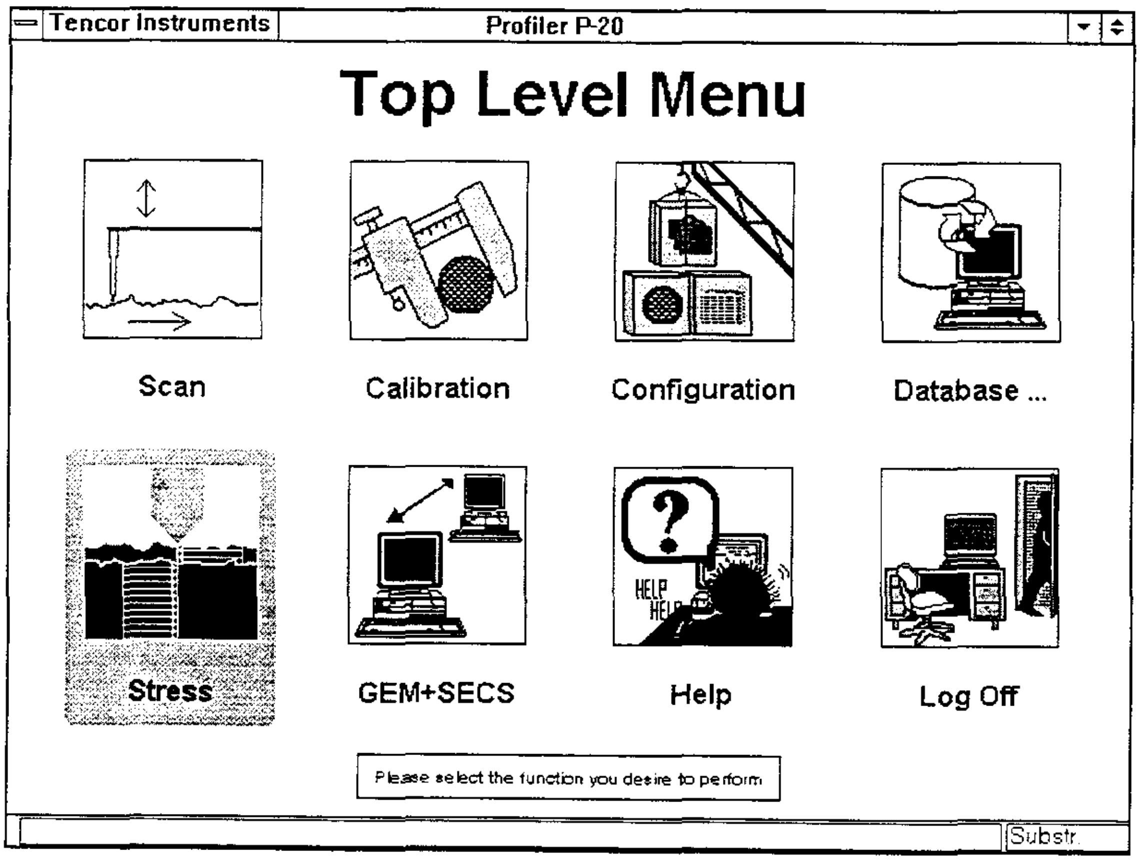


Figure 3-2 Top Level Menu

The Top Level menu is the starting point for operating the instrument. Each picture in the menu represents a group of related operations.

Move the trackball cursor over the Scan icon and double-click. The Database Catalog window appears with the Sequence Recipe catalog active. Click on the Scan Recipe button on the left side of the window to display the Scan Recipe catalog.

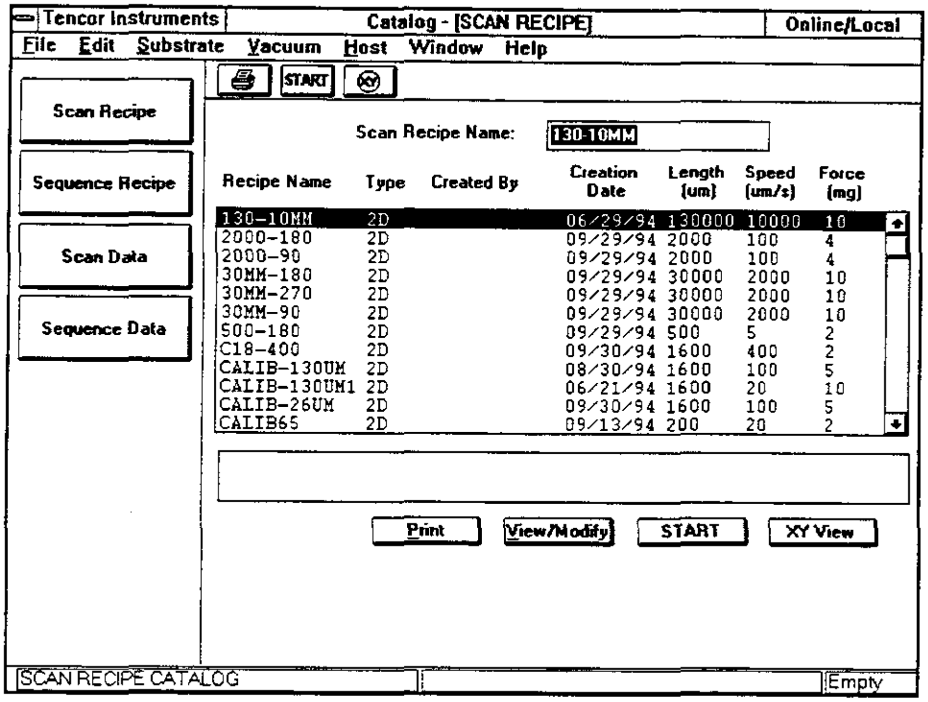


Figure 3-3 Scan Recipe Catalog Window

3.2 CHOOSING A SCAN RECIPE

Each scan that you take with the Tencor P-20 requires a Scan recipe. The Scan recipe specifies how the stage is to move during the scan. The Scan recipe contains the current settings of such parameters as scan length, scan speed, stylus force, and so on. It also contains instructions for post-processing of the scan data.

Chapter 4, "Recipes," describes how to edit these parameters. For this tutorial, we assume that they are already set to appropriate values. We will use the standard default recipe.

To choose the default recipe:

1. Click on the View/Modify button below the list of recipes, or double-click on any of the recipes in the list. The Recipe Editor appears (Fig. 3-4):

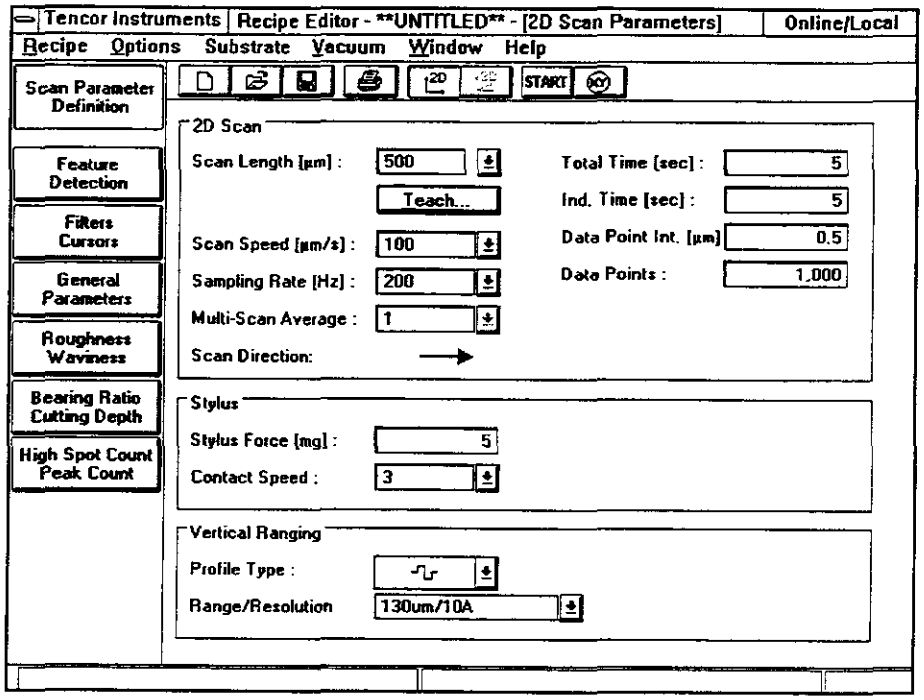


Figure 3-4 Recipe Editor Window

2. Select New from the Recipe menu. The Recipe Editor fields are reset with their default values. We will use the default values to take our first scan.

3.3 LOADING THE SAMPLE

You load samples into the Tencor P-20 either manually or by use of the optional wafer handler. For this tutorial we only consider manual loading.

You load and view samples in the XY View window.

To change to the XY View window:

Click on the XY View button or select XY View from the menu bar.

The XY View window appears (Fig. 3-5).

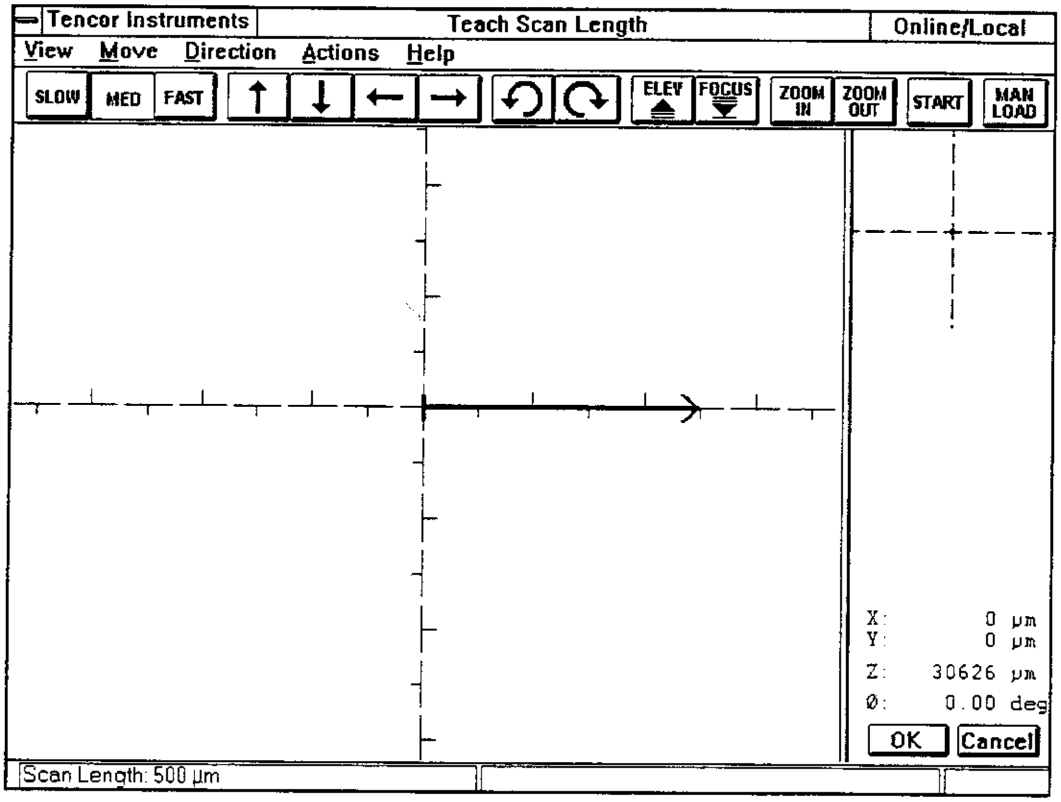


Figure 3-5 XY View Window

To load the sample:

1. Click on the Manual Load button in the XY Stage View tool bar.
2. Open the measurement area door and place the sample on the stage table, disk holder, or precision locator.
3. Turn on the vacuum valve (if desired to hold down the sample) by pressing the VAC key.
4. Click approximately in the center of the Stage Position control on the right side of the window. The stage moves until its center is beneath the measurement head.

3.3.1 VIEWING AND POSITIONING THE SAMPLE

Once you have loaded the sample and the stage has moved beneath the measurement head, you view the sample in the XY View window and position it to a desired location to start a scan.

You need to do two things to view the sample and prepare for a scan:

- Lower the measurement head until the sample comes into focus.
- Move the sample beneath the head until you have located a feature you want to scan.

3.3.2 LOWERING THE MEASUREMENT HEAD

To lower the measurement head using the trackball:

Click on the Focus button in the tool bar.
Note that the stylus lowers into position before the head actually begins to descend. As the head approaches the stage, the image of the sample surface should begin to come into focus.

To lower the measurement head using the keyboard:

This method is currently not implemented.

To stop lowering the measurement head using the trackball:

Click again on the Focus button in the tool bar.

Note that the stylus (*not* the measurement head) automatically lifts after 60 s unless a scan is in progress.

3.3.3 POSITIONING IN X AND Y

Now that the sample surface is clearly visible, you can position the stage and sample beneath the measurement head until you have located where the scan should begin.

The following figure shows the coordinate system used in the Tencor P-20. The coordinate system follows the SEMI Standard M20-92. The X and Y displayed in the Scan window represent the lateral position of the stage relative to the right rear corner of the measurement area. The possible travel area of the stage is limited to a 210-mm (8.2-in.) circle.

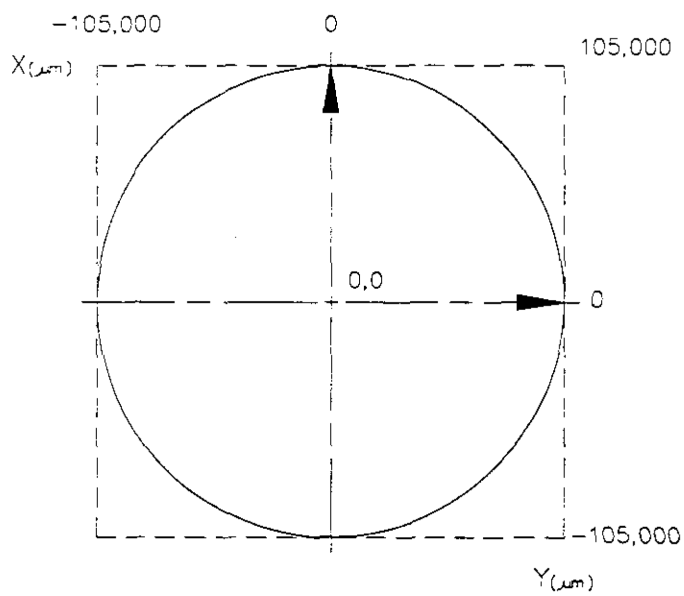


Figure 3-6 Coordinate System of the Tencor P-20

There are several ways to move in X and Y to allow quick gross positioning as well as very fine adjustment. Note that the directions indicated by the controls are consistent with the direction of motion of the *stage*; in the XY View window, the video image will appear to be moving in the opposite direction.

CAUTION:	**If there is any hardware fixed to the stage and it is above the sample surface, raise the stylus or the measurement head before moving the stage; otherwise, stylus or head damage can occur.**

To move quickly from one area to another using the trackball:

- To move quickly to a position currently visible in the video image, click on the desired location. The stage moves so that the cross hairs are centered on the chosen location.
- To move quickly to an area not currently visible in the video image, click on the approximate desired location on the Stage Position control on the upper right of the window (Fig. 3-5). The stage moves and the small blue dot moves to indicate the new position.

Finer control is available by clicking on the control buttons in the XY View tool bar or using the motion keys on the keyboard.

To move in X and Y using the trackball:

1. Click on the Fast, Medium, or Slow control buttons in the XY View tool bar (Fig. 3-5).
2. Click and hold the left button down over the desired direction control button; release the trackball button to stop.

NOTE:	**When Slow speed is active, notice that when motion ceases, the image appears to do a momentary wiggle. This is normal and desirable. It is this motion that eliminates the slight mechanical backlash in the stage movement that would otherwise make precise positioning to very small features difficult.**

3.4 TAKING A SCAN

Once you have selected a recipe, lowered the head, and at least approximately positioned the sample, you are almost ready to take your first scan. First, you need to set up by adjusting the sample position so that the stylus will lower and begin taking data at the right place.

To set up for a scan:

1. Choose a simple feature to scan. A step is ideal. The width of the step should be small enough that the scan length of 500 µm in the default recipe allows the surface on either side of the step to be sampled, as in the following figure:

Beginning and end of scan should clearly straddle the step

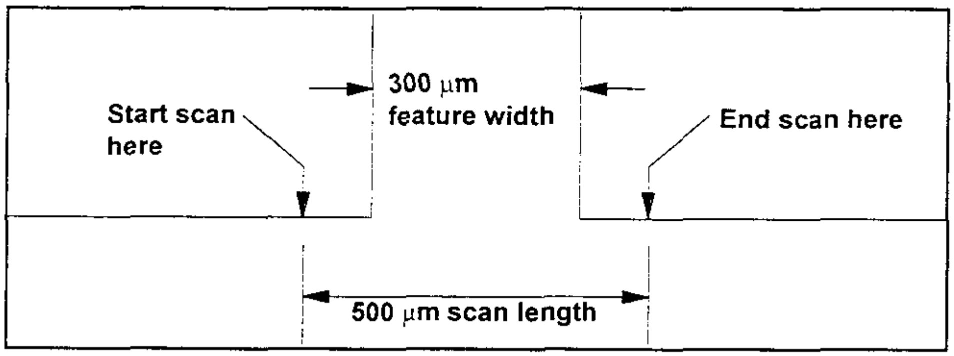


Figure 3-7 Setting Up to Scan a Step

2. Click on the Focus button in the tool bar to lower and null the stylus.
3. Move in X and Y until you are at a desired start-of-scan position.
4. Click on the Start Scan button in the tool bar.

The stylus lowers until the stylus makes contact with the sample at the start-of-scan position. Then the scan begins. Note that it first travels *opposite* to the scan direction for a short distance, then stops and moves in the scan direction. This allows the scanner to reach the programmed scan speed before the instrument begins to collect data. The Scan window is displayed during the scan, with an image of the trace overlaid on top of the video image.

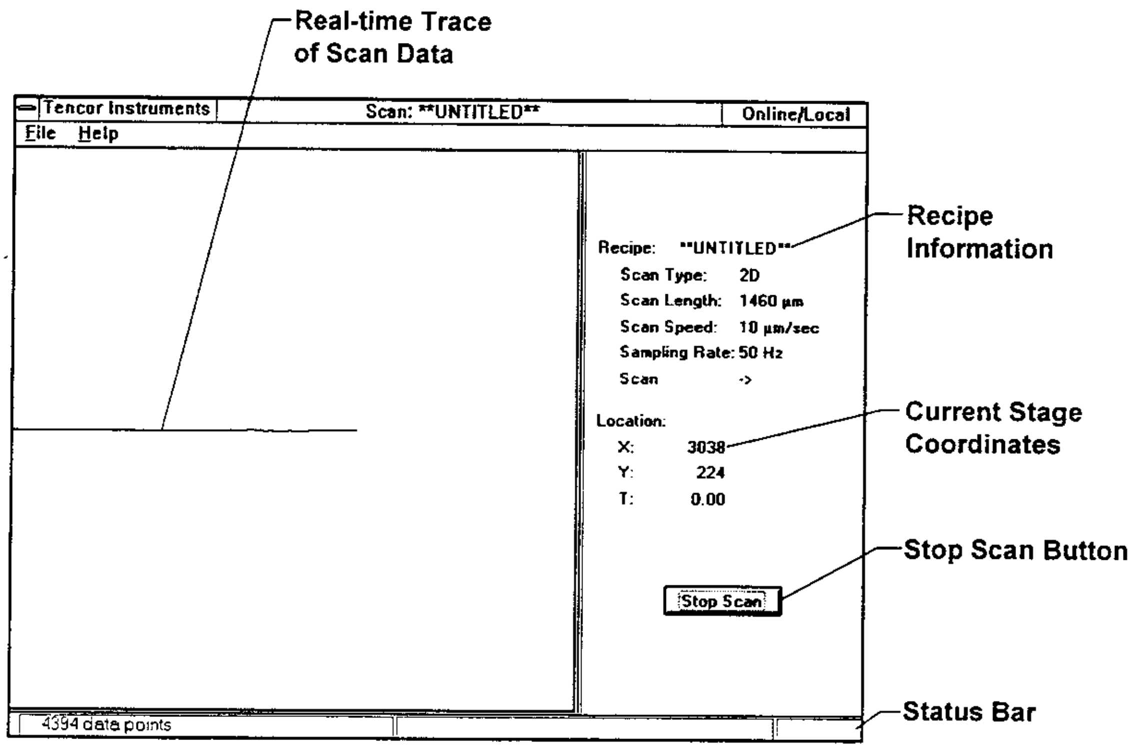


Figure 3-8 Scan Window

When the scan is completed, the stylus lifts, the scanner returns to its original position above the start-of-scan location, and the Data Analysis window displays with the profile plotted in dimensioned coordinates (see Fig. 3-9). Note: If the trace runs off scale or is not horizontal, refer to Section 5.7.2, "Leveling the Stage," and Section 6.2, "Data Leveling and Measurement."

To abort a scan:

Click on the Stop Scan button at any time.

3.5 READING, PRINTING, AND SAVING DATA

When the scan is completed, the raw data is processed and displayed in the Data Analysis window with a summary of the data displayed to the left of it in the Summary box (Fig. 3-9):

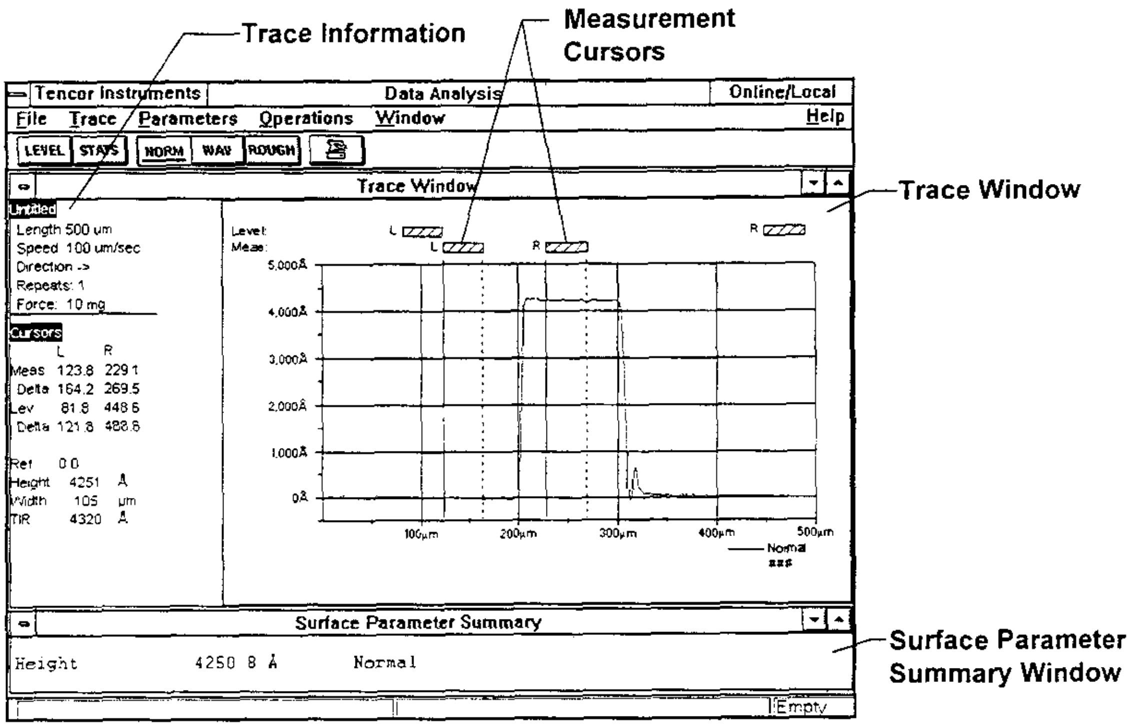


Figure 3-9 Data Analysis Window

On the left side of the plotted data is the Trace Information area. The Height field displays the vertical distance between the trace intersections of the left and right *measurement cursors*. The Width field displays the horizontal distance between the cursors. Each cursor position and the stage position is displayed.

The Surface Parameter Summary window shows the calculated values of whatever surface analysis parameters were selected in the recipe. (Refer to Chapter 4, "Recipes," for definitions of these parameters.)

When the scan data is plotted, the leveling and measurement cursors (L and R) appear at their preset positions with the right measurement cursor activated. By positioning the leveling cursors, you define the level reference points for the scan. By positioning the measurement cursors, you define the endpoints of the portion of the scan that is used for parameter calculations (called the *sampling length*).

Note: If the trace in Fig. 3-9 does not appear level, see Section 6.2, "Data Leveling and Measurement."

If you want to check the step height of the scan, for example, move the cursors so that one is on the top of the step, and the other on the bottom.

To read the data:

1. Move R to the desired position with [<] and [>], or drag and drop R using the trackball.
2. Press the spacebar to activate L and adjust its position, or drag and drop L using the trackball.

You can also press the spacebar twice quickly to simultaneously activate both L and R. The cursors will move in tandem.

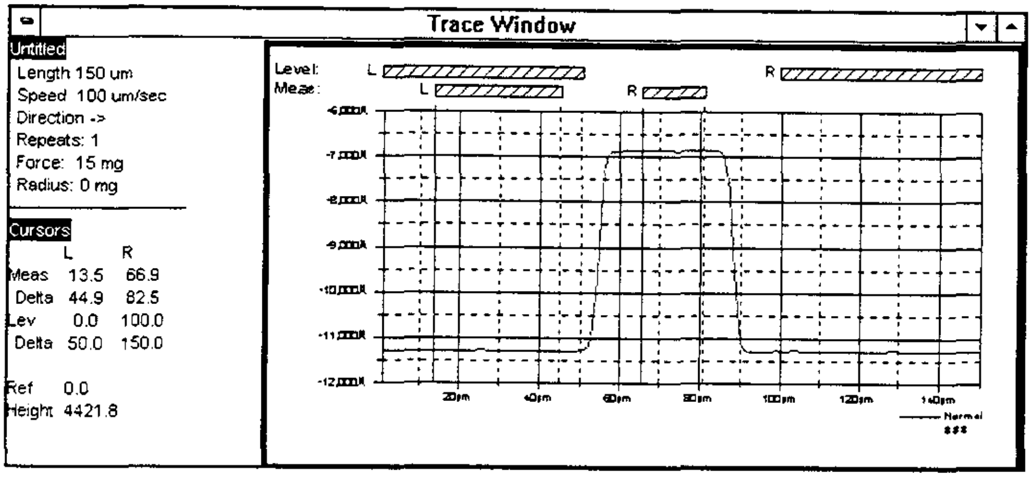


Figure 3-10 Trace Window after Positioning Cursors to Measure Step Height

Note: If you are using a calibration standard for this tutorial and there is an unacceptable discrepancy between your reading and the value for the standard, refer to Section 5.2, "Calibration," in the *P-20 Reference Manual.*

Note also that the vertical and horizontal scales are typically not scaled the same way. They are automatically scaled to fit the scan length to a fixed-length horizontal axis, and the largest vertical variation of the scan data to the fixed-length vertical axis. For example, a scan that has a vertical variation of 400Å and a 100-mm scan length will be displayed with a vertical scale that is magnified by about 10^7 times compared to the horizontal scale. The result is a sometimes very dramatic distortion in the shape of features as plotted when compared to the actual shape.

3.6 UNLOADING THE SAMPLE

When you are finished scanning the sample, remove it from the instrument.

To unload the sample manually:

1. In the XY-View window, click on ManuLoad in the tool bar to move the stage forward.
2. Open the measurement area door.
3. Turn off the stage vacuum (if it is on) to release the sample and lift it carefully from the measurement stage.

4 RECIPES

A recipe is a list of all the information that the instrument needs to perform a scan and to process and display the data. A recipe can be saved in the instrument computer's database to be recalled at any later time.

The Recipe Editor allows you to examine and modify any recipe that exists in the database. There is also a default generic recipe that you can use as a template for new recipes, but any existing recipe can serve as such a template.

This chapter discusses the three main windows of the Recipe Editor:

- The Recipe Information window, where you include information such as the recipe's title, author, and date of creation, and a brief text description, if desired.
- The Scan Parameters window, where you set the physical parameters of the scan, such as speed, scan length, sampling rate, and so on.
- The Surface Analysis window, where you enable calculation and/or display of surface analysis parameters, such as average roughness, total indicator readout, and so on.

This chapter also discusses saving and maintaining recipes.

4.1 SCAN RECIPE CATALOG

The Recipe Editor is started from the Scan Recipe Catalog window (Fig. 3-3).

To start the Scan Recipe Catalog window from the Top Level menu:

1. Double-click on the Scan icon (Fig. 3-2). The Database Catalog window appears with the Sequence Recipe catalog active.
2. Click on the Scan Recipe button on the left side of the window to display the Scan Recipe catalog (Fig. 4-1).

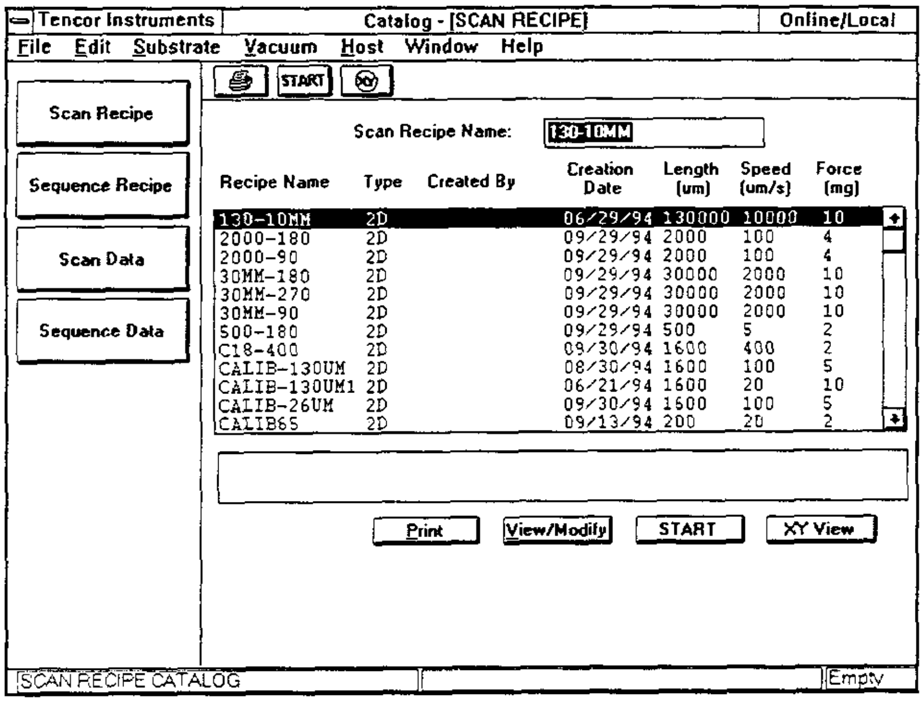


Figure 4-1 Scan Recipe Catalog Window

4.1.1 SCAN RECIPE CATALOG MENU BAR

The Scan Recipe Catalog menu bar provides the following menus. You can view menus by clicking on the titles in the menu bar, or by pressing ALT + *l*, where *l* is the letter that appears with an underscore in the desired title in the menu bar. You can choose menu items by clicking on a menu entry or by typing the letter that appears with an underscore in the desired menu item.

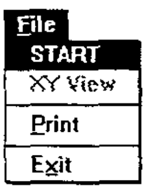


Figure 4-2 File Menu

Figure 4-3 Edit Menu

Figure 4-4 Substrate Menu

Figure 4-5 Vacuum Menu

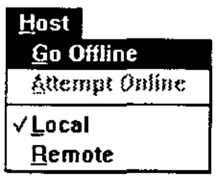


Figure 4-6 Host Menu

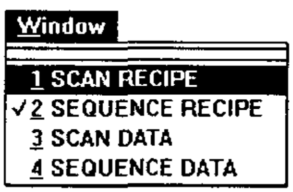


Figure 4-7 Window Menu

4.1.2 SCAN RECIPE CATALOG TOOL BAR

The Scan Recipe Catalog tool bar contains a row of icons that resemble buttons. Clicking on these icons provides an alternative way to access commonly used functions.

Each icon suggests the function of the button. For example, the Print button resembles a printer. Buttons that appear dimmed are unavailable.

The Scan Recipe Catalog tool bar contains the following buttons:

Button	Action
	Displays the Print dialog box
	Starts a scan using the current recipe
	Switches to the XY View window

4.2 RECIPE EDITOR WINDOW

You can start the Recipe Editor from the Scan Recipe Catalog window (Fig. 4-1). You can also open the Recipe Editor directly from the Data Analysis and Sequence Editor windows.

To start the Recipe Editor from the Scan Recipe Catalog window:

Select a recipe from the list and click on the View/Modify button at the bottom of the list, or double-click on the desired recipe. The Recipe Editor window appears with the selected recipe.

To start the Recipe Editor from the Data Analysis window (Fig. 6-1):

Select Edit Recipe from the File menu. The Recipe Editor window appears with whatever recipe had last been edited or run.

To start the Recipe Editor from the Sequence Editor window (Fig. 7-2):

Click on the Edit Recipe button in the main window. The Recipe Editor window appears with the selected recipe.

The Recipe Editor window (Fig. 4-8) consists of the following elements:

- A menu bar
- A tool bar
- A secondary tool bar with a set of command buttons to select which group of recipe parameters to display and edit
- The main area of the window, with the selected group of parameters currently displayed

The main part of the window consists of a large form where you can view and modify the available fields. You can use any recipe as the starting point for a new one, or you can start with a new recipe with default values.

To start with a new recipe with default values:

Select New from the Recipe menu. The recipe name in the title bar is replaced with the word Untitled, and all fields are reset with default values.

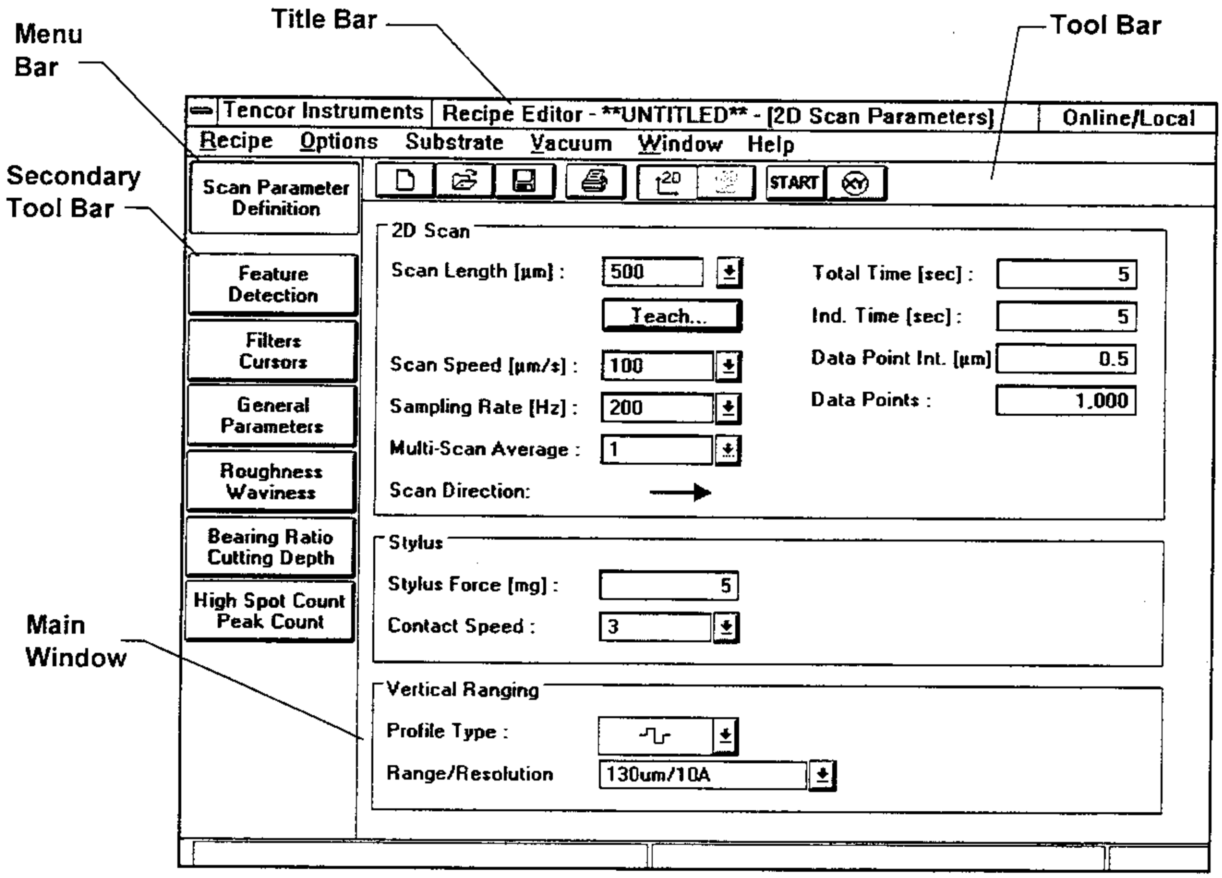


Figure 4-8 Recipe Editor Window

4.2.1 RECIPE EDITOR MENU BAR

The Recipe Editor menu bar provides access to commands and allows easy navigating through the three subwindows.

The Recipe Editor menu bar provides the following menus. You can view menus by clicking on the titles in the menu bar, or by pressing ALT + *l*, where *l* is the letter that appears with an underscore in the desired title in the menu bar. You can choose menu items by clicking on a menu entry or by typing the letter that appears with an underscore in the desired menu item. Some menu items have hot keys assigned to them.

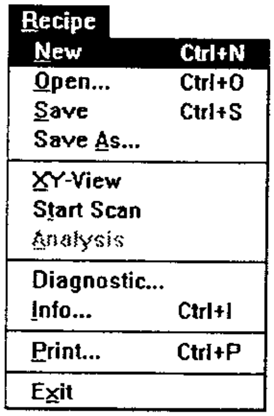


Figure 4-9 Recipe Menu

Figure 4-10 Options Menu

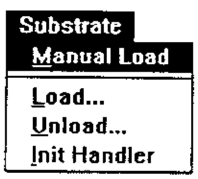


Figure 4-11 Substrate Menu

Figure 4-12 Vacuum Menu

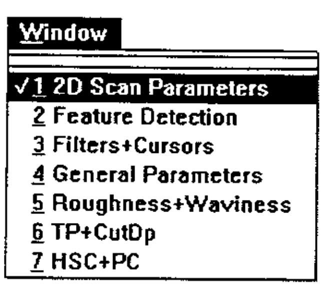


Figure 4-13 Window Menu

4.2.2 RECIPE EDITOR TOOL BAR

The Recipe Editor tool bar contains a row of icons that resemble buttons. Clicking on these icons provides an alternative way to access commonly used functions.

Each icon suggests the function of the button. For example, the Print button resembles a printer. Buttons that appear dimmed are unavailable.

The Recipe Editor tool bar contains the following buttons:

Button	Action
	Loads a new default recipe
	Displays the Open Recipe dialog box
	Saves the current recipe; if the current recipe has never been saved, displays the Save Recipe As dialog box first
	Displays the Print dialog box
	Switches the Scan Recipe type to 2-D
	Switches the Scan Recipe type to 3-D (not currently implemented)
	Starts a scan using the current recipe
	Switches to the XY View window

4.2.3 RECIPE INFORMATION DIALOG BOX

The Recipe Information dialog box displays the title, author, date and time of creation (or modification) of the recipe, and a section for annotating the recipe with comments.

To display the Recipe Information dialog box:

Choose Info from the Recipe menu or press CTRL + I. The Recipe Info dialog box also appears when you are saving a recipe.

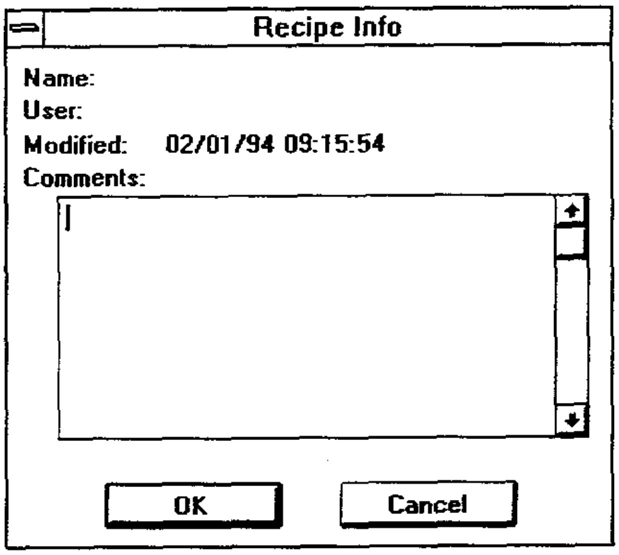


Figure 4-14 Recipe Information Window

The Name, User, and Modified fields are supplied automatically by the system. These fields cannot be edited.

To enter Comments:

1. Click in the Comments text box or press TAB← or TAB→ until the Comments text box is highlighted.
2. Type the desired text.

4.2.4 RECIPE EDITOR COMMAND BUTTONS

You choose which set of parameters to view and edit by selecting one of the seven command buttons on the left side of the window. These buttons are visible at all times in the Recipe Editor window and allow you to quickly change parameter groups.

The following command buttons appear:

Button	Action
Scan Parameter Definition	Switches the main window to the Scan Parameter Definition form
Feature Detection	Switches the main window to the Feature Detection form
Filters Cursors	Switches the main window to the Filters/Cursors form
General Parameters	Switches the main window to the General Parameters form
Roughness Waviness	Switches the main window to the Roughness/Waviness form
Bearing Ratio Cutting Depth	Switches the main window to the Bearing Ratio/Cutting Depth form
High Spot Count Peak Count	Switches the main window to the High Spot Count/Peak Count form

To select a group of parameters to view and edit:

Click on the appropriate command button, or select the appropriate view from the Window menu. The right side of the window displays the selected view with its parameter fields.

4.3 SCAN PARAMETER DEFINITIONS

You set the operational parameters of the scan with the set of fields in this form (see Fig. 4-8).

The Scan Parameter Definitions view is a large form divided into three labeled sections:

- 2-D Scan
- Stylus
- Vertical Ranging

The following sections discuss the possible settings for each of the fields.

4.3.1 2-D SCAN

The 2-D Scan section contains the following fields.

Scan Length

The Scan Length can be any value up to 210 mm (8.2 in.). Enter a value by clicking in the text box and typing the desired length, or click on the drop-down button to select a value from a drop-down list.

You can also teach the scan length. Clicking on the Teach command button activates the XY View window and allows you to interactively teach the scan length using the trackball. See Section 5.4.1, "Teaching the Scan Length," for details.

Scan Speed

Only preselected values can be entered for Scan Speed. Click on the drop-down button to select a value from the drop-down list. You can click in the text box and type a value, but only one of the preselected values will be accepted.

Note that the Scan Length and Scan Speed parameters are limited by the requirement that the total time of a scan not exceed 100 s. For example, if you attempt to set a scan length of 100 mm with a scan speed of 10 μm/s (which would require a scan time of 10000 s), the system displays a message that this would involve a scan time of greater than 100 s, and, therefore, is not allowed.

Scan speeds of less than 400 μm/s cannot have a scan length greater than 9.999 mm (0.39 in.). Available settings for scan speed in μm/s are as follows:

1	50	5000
2	100	10000
5	400	25000
10	1000	
20	2000	

Sampling Rate

Sampling Rate is the nominal rate at which data is collected (number of data points per second). Only preselected values can be entered for Sampling Rate. Click on the drop-down button to select a value from this list. You can click in the text box and type a value, but only one of the preselected values will be accepted.

Available settings for Sampling Rate are

- 50 or 100 Hz for scan speeds of 1 or 2 μm/s
- 50, 100, or 200 Hz for all other scan speeds

Multi-Scan Average

This field is not currently implemented.

Scan Direction

A scan can be made left-to-right or right-to-left. Choose the Scan Direction by clicking on the arrow to change its direction.

Total Time

Total Time is the time taken during the data collection phase of all scans in the recipe. The value for Total Time is calculated from the chosen values for Multi-scan Average and the time required for a single scan (Ind. Time).

Ind. Time

Ind. Time is the time taken during the data collection phase of an individual scan. The value for Ind Time is calculated from the chosen values for Scan Length and Scan Speed. Ind. Time cannot exceed 100 s.

Data Point Interval

The Data Point Interval is the distance between successive data points in a scan. The value for Data Point Interval is calculated from the chosen values for Scan Speed and Sampling Rate.

Data Points

Data Points is the number of points in the scan.

4.3.2 STYLUS

The Stylus section contains the following fields.

Stylus Force

The stylus force is the nominal value of the downward force applied to the stylus when in contact with a sample surface during a scan. Enter a value by clicking in the text box and typing the desired value in mg. Allowed values depend on which measurement head is installed in the instrument.

Higher speeds tend to require higher stylus forces to ensure constant contact between the stylus and the sample surface. A stylus with a small radius might require a low stylus force on soft materials. Generally, a higher force minimizes the effects of environmental noise.

The stylus force varies slightly as the stylus moves away from the center position. The force decreases approximately 1 mg for every 8 µm below the null position (14 µm for the optional Extended Range MicroHead). Therefore, use at least 10 mg when operating in the ±63-µm range with the MicroHead (25 mg for the optional Extended Range MicroHead).

Contact Speed

This parameter defines the relative stylus drop speed at contact with the substrate. Allowed values are integers between 1 and 10, with 1 being the slowest and 10 the fastest. Click on the drop-down button to select a value from the drop-down list. You can click in the text box and type a value, but only one of the preselected values will be accepted.

Very soft substrates such as pure aluminum or photoresist can require a setting of 1 or 2. We recommend slower contact speeds of 1 to 3 for styli with radii smaller than 5 µm.

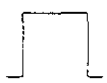
4.3.3 VERTICAL RANGING

The Vertical Ranging section contains the following fields.

Profile Type

Click on the drop-down button to select the appropriate Profile Type as described below:

Center: use this type when profiling most features unless you are measuring large peaks or valleys that are near or beyond the normal vertical range.



Peak bias: select this type when measuring a high peak (near or higher than 65 µm for the standard MicroHead, 325 µm for the Extended Range MicroHead).

Valley bias: select this type when measuring a deep valley (near or deeper than 65 µm for the standard MicroHead, 325 µm for the Extended Range MicroHead).

Range/Resolution

CAUTION:	**Use special care when profiling samples in the Valley bias mode. The stylus can only move freely upward from null by a small amount in this mode. If the stylus climbs too high from null, the stylus force begins to increase. The sample surface could be damaged.**

The vertical ranges of the MicroHead II are

- 6.5 µm (±3.25 µm) at 0.5Å resolution
- 26 µm (±13 µm) at 2Å resolution
- 130 µm (±65 µm) at 10Å resolution

The vertical ranges of the optional Extended Range MicroHead are

- 14 µm (±6.55 µm) at 1Å resolution
- 130 µm (±65.5 µm) at 10Å resolution
- 650 µm (±325 µm) at 50Å resolution

Click on the drop-down button to select the Range/Resolution that is most suitable for the size of sample artifacts to be profiled.

Table 4-1 shows the minimum stylus force required to cover the full downward range of the stylus at each of the vertical range settings.

Table 4-1 Minimum Stylus Forces to Cover Full Vertical Ranges Below Null

MicroHead II		Extended MicroHead	
Range (μm)	**Minimum Stylus Force (mg)**	**Range (μm)**	**Minimum Stylus Force (mg)**
±3.25	0.4	± 6.55	0.6
±13	1.6	± 65.5	6
±65	8.2	± 325	24

4.4 FEATURE DETECTION

Feature Detection is used to enable automatic detection of some common classes of profile features to facilitate measurement throughput and consistency. Feature Detection is described in Section 6.3, "Using Feature Detection."

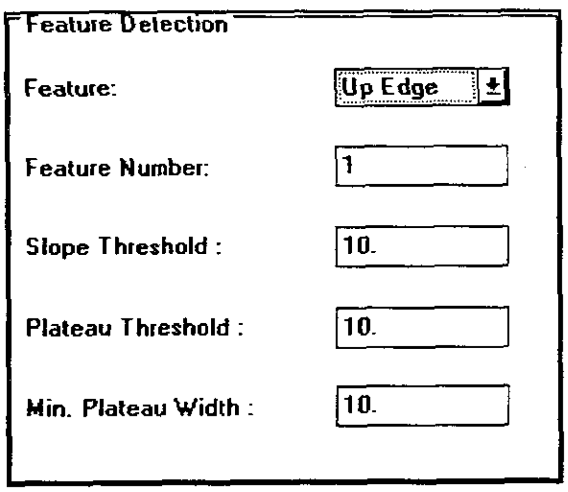


Figure 4-15 Feature Detection Form

The Feature detection form contains the following fields.

Feature

The Feature field identifies the type of feature to be detected, or turns Feature Detection off. The selection box has seven possible choices:

- None (no Feature Detection)
- UpEdge (rising edge)

- UpBase (rising base)
- DownEdge (falling edge)
- DownBase (falling base)
- Convex (hill-like arc)
- Concave (valley-like arc)

If None is selected, the remaining fields in the section are unavailable and appear dimmed.

Feature Number

If there are multiple edges detected in a scan, Feature Number provides a way to select a particular edge for detection. Detected edges are numbered sequentially from 1 to n.

Slope Threshold

This factor sets the value at which an upward slope in the trace is considered to be preceding the edge or arc; that is, when an upward slope appears that rises significantly above the general roughness of the surface. Valid values range between 0–50.000. The default values of 5.000 (for a step) and 1.000 (for an apex) are sufficient for most scans above 200Å. See Section 6.3, "Using Feature Detection," for a detailed description of Slope Threshold.

Plateau Threshold

This factor affects the precise horizontal location calculated for the edge or arc. Since the edge of a step is rarely a perfectly defined location, this factor allows you to adjust the value to the left or right, depending on whether you consider the edge to be the bottom of the step, the top of the step, or somewhere in between. Valid values range between 0–50.000. The default values of 5.000 (for a step) and 0.000 (for an arc) are sufficient for most scans above 200Å. See Section 6.3, "Using Feature Detection," for a detailed description of Plateau Threshold.

Minimum Plateau Width

This value specifies the minimum horizontal length between a rising and falling edge, used in the feature detection calculation to assist in determining the correct edge. Valid values are in the range 0.005–1000.00 µm (0.0002–39.3701 mil). See Section 6.3, "Using Feature Detection," for a detailed description of Minimum Plateau Width.

4.5 FILTERS/CURSORS

The Filters/Cursors form contains two sections: one for setting the software data filters and one for presetting the cursor positions.

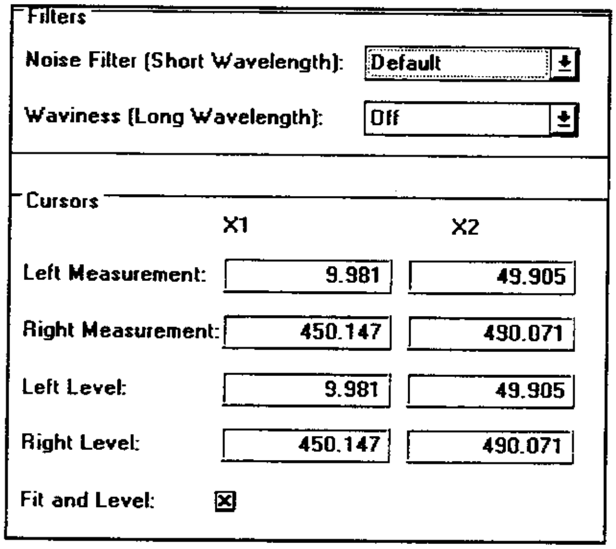


Figure 4-16 Filters/Cursors Form

4.5.1 FILTERS

The Filters section contains the following fields.

Noise Filter (Short Wavelength Cutoff)

The Short Wavelength Cutoff is an adjustable software short wave cutoff filter, allowing you the flexibility to reject short wave components of scan data. In conjunction with the Long Wave Cutoff, it also allows you to isolate band passes for wavelengths. See Section 6.4, "Using Cutoff Filters," for a detailed discussion of using the cutoff filters in surface analysis.

Click on the drop-down box to choose a value from the range of cutoff filters provided, or use the default setting (Table 4-2). Default cutoffs depend on the scan speed and sampling rate. The full range of default short wave cutoffs are listed in Table 4-3.

Table 4-2 Default Short Wave Cutoffs

Speed (μm/s)	Sampling Rate (Hz)	Short Wave Cutoff Frequency (Hz)	Short Wave Cutoff Wavelength (μm)
2	50	4	0.50
	100	7.5	0.27
	200	12	None available
5	50	4	1.25
	100	7.5	0.67
	200	12	0.42
10	50	4	2.50
	100	7.5	1.33
	200	12	0.83
20	50	4	5.00
	100	7.5	2.67
	200	12	1.67
50	50	4	12.50
	100	7.5	6.67
	200	12	4.17
100	50	4	25.00
	100	7.5	13.33
	200	12	8.33
400	50	4	100.00
	100	7.5	53.33
	200	12	33.33

Up to nineteen filter choices are provided. The full range of selectable values are listed in Table 4-3.

Table 4-3 Short Wave Cutoffs

μm	mil	μm	mil	mm	mil
Default[1]	–	14	.56	1.4	56
.25	.01	25	1.0	2.5	100
.45	.02	45	1.8	4.5	180
.80	.03	80	3.0	–	–
1.4	.06	140	5.6	–	–
2.5	.10	250	10.0	–	–
4.5	.18	450	18.0	–	–
8.0	.30	800	30.0	–	–

[1]Refer to Table 4-2 for default short wave cutoff values.

The cutoffs available depend on the scan speed. You are prevented from mistakenly entering a short wave cutoff that is longer than the currently selected long wave cutoff, or shorter than the value of the analog cutoff. For scan speeds greater than 5 µm/s, the shortest short wave cutoff selection turns the short wave filter off entirely.

If subsequent changes to the scan speed or scan length cause the short wave cutoff setting to become invalid, the cutoff is automatically changed to the nearest available valid value (possibly the default).

Waviness Filter (Long Wavelength Cutoff)

The Long Wavelength Cutoff is an adjustable software long wave cutoff filter, allowing you the flexibility in rejecting long wave components of scan data. In conjunction with the Short Wave Cutoff, it also allows you to isolate band passes for wavelengths. See Section 6.4, "Using Cutoff Filters," for a detailed discussion of using the cutoff filters in surface analysis.

Click on the drop-down box to choose a value from the range of cutoff filters provided, or turn off the filter. Sixteen filter choices are provided. Selectable values are listed in Table 4-4.

Table 4-4 Long Wave Cutoffs

µm	mil	µm	mil	mm	mil
4.5	.18	80[1]	3.0[1]	1.4	56
8.0	.30	140	5.6	2.5	100[1]
14	.56	250[1]	10.0[1]	4.5	180
25	1.0	450	18.0	–	–
45	1.8	800[1]	30.0[1]	–	–

[1]Cutoffs specified in ANSI B46.1-1985

The cutoffs available depend on the scan speed. You are prevented from mistakenly entering a long wave cutoff that is shorter than the currently selected short wave cutoff or the value of the analog cutoff.

If subsequent changes to the scan speed or scan length cause the long wave cutoff setting to become invalid, the cutoff is automatically changed to the nearest available valid value (possibly the default).

4.5.2 CURSORS

Two pairs of cursors are used in the Data Analysis window. The *leveling cursors* X1 and X2 define two points that establish a leveled baseline for the trace. The *measurement cursors* X1 and X2 define the endpoints of the sampling length, the region used for calculation of surface parameters.

The Cursors section allows initial locations to be set for the cursors. The location of the cursors can also be freely changed at any time while viewing the scan data. See Section 6.2, "Data Leveling and Measurement," for information about how to use the cursors when analyzing data.

The Cursors section contains the following fields.

Left Measurement (X1 and X2)

Enter the desired left measurement cursor position for each cursor by clicking in the X1and X2 fields and typing the value. You can also wait until viewing the data to position the cursors interactively, and store a selected setting directly into the recipe from the Data Analysis window.

Right Measurement (X1 and X2)

The right measurement field differs from the left measurement field if delta averaging is desired. Delta averaging is described in Section 6.2, "Data Leveling and Measurement." Enter the desired right measurement cursor position for each cursor by clicking in the X1and X2 fields and typing the value. You can also wait until viewing the data to position the cursors interactively, and store a selected setting directly into the recipe from the Data Analysis window.

Left Level (X1 and X2)

Enter the desired left leveling cursor position for each cursor by clicking in the X1and X2 fields and typing the value. You can also wait until viewing the data to position the cursors interactively, and store a selected setting directly into the recipe from the Data Analysis window.

Right Level (X1 and X2)

The right leveling field differs from the left leveling field if delta averaging is desired. Delta averaging is described in Section 6.2, "Data Leveling and Measurement." Enter the desired right leveling cursor position for each cursor by clicking in the X1and X2 fields and typing the value. You can also wait until viewing the data to position the cursors interactively, and store a selected setting directly into the recipe from the Data Analysis window.

Fit and Level

Fit and Level allows the software to "subtract out" the curvature of a curved surface to allow step height measurements as if the surface were flat. See Section 6.6, "Fit and Level," for more information.

Click on the check box to enable (an "X" in the check box) or disable (clear check box) Fit and Level.

4.6 GENERAL PARAMETERS

The General Parameters form contains the first of the surface analysis parameters. These represent a variety of calculations performed on the data collected in a scan. In the recipe, you can enable or disable these parameters. When a particular surface analysis parameter is enabled, the calculation is performed and the results displayed for that parameter.

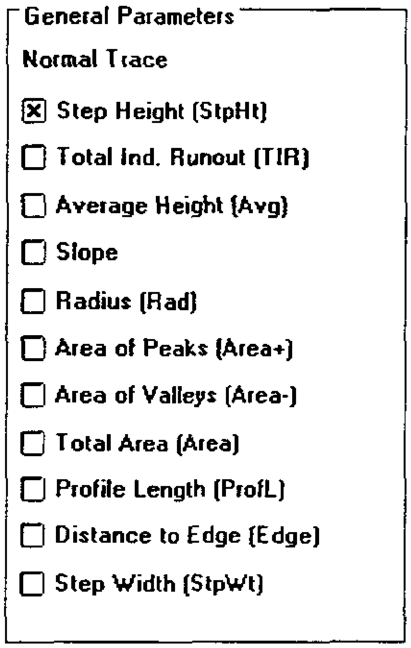


Figure 4-17 General Parameters Form

Click on the check box to enable (an "X" in the check box) or disable (clear check box) any of the parameters. You can enable or disable as few or as many of these parameters as you want, before or after the scan.

Parameter definitions are from ANSI B46.1-1985 or ISO 4287/1-1984 where indicated. The General Parameters view contains the following fields.

Step Height (StpHt)

The difference in height between the bottom and the top of a step.

Total Indicator Runout (TIR)

The difference in height between the highest and the lowest points within the sampling length. Note the similarity to the roughness parameters R_t, R_{max}, and R_y described later in this section. (ANSI)

Average Height (Avg)

Average height of all data points between the measurement cursors relative to the leveled baseline. (ANSI)

Slope

The ratio of the difference in vertical positions to the difference in horizontal positions of the measurement cursors. The slope is reported as an angle in degrees. In Delta Average mode, the position of each cursor is taken to be the horizontal midpoint of each delta cursor band, and the data value at this location is the average of the vertical values within these bands. (ANSI)

Radius (Rad)

The distance from the center of curvature of the profile arc (assuming a circular profile within the sampling length) to the profile. The measurement cursors define two points of a circular arc. A least-squares fit is performed on the points between the cursors. You should *not* level the normal trace unless definite level reference points exist. In Delta Average mode, the position of each cursor is taken to be the horizontal midpoint of each delta cursor band, and the data value at this location is the average of the vertical values within these bands.

Area of Peaks (Area+)

The total area bounded by the leveled baseline and the profile where it rises *above* the baseline within the sampling length. The Delta cursors are not used. (ANSI)

Area of Valleys (Area-)

The total area bounded by the leveled baseline and the profile where it descends *below* the baseline within the sampling length. The Delta cursors are not used. (ANSI)

Total Area (Area)

The sum of Area of Peaks and Area of Valleys within the sampling length. The Delta cursors are not used. (ANSI)

Profile Length (ProfL)

The length that would be obtained from drawing out the profile in a straight line, within the sampling length. The Delta cursors are not used. (ANSI)

The following two parameters are associated with Feature Detection. To use them correctly, Feature Detection must be enabled and set up appropriately for the type of artifact to be measured. See Section 6.3, "Using Feature Detection," for details.

Distance to Edge (Edge)

Depending on the setting of two threshold parameters, this distance is either

- The distance between the beginning of the scan and the first rising or falling edge of a profile artifact; or
- The distance between the beginning of the scan and the first concave or convex arc of a profile artifact.

Step Width (StpWt)

The distance between the first rising edge of an upward step and the falling edge that follows, or the first falling edge of an downward step and the rising edge that follows. This value is meaningless for a convex or concave arc.

4.7 ROUGHNESS/WAVINESS

The Roughness/Waviness form contains two sections, one containing roughness parameters, the other waviness parameters.

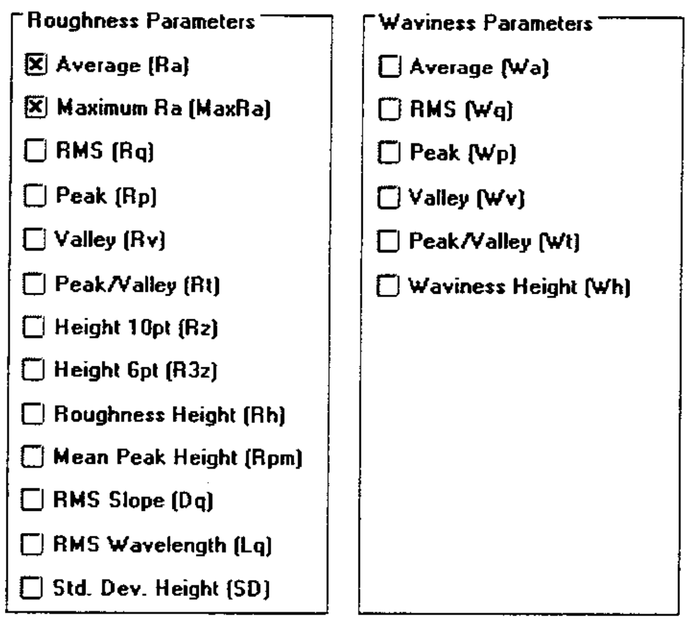


Figure 4-18 Roughness/Waviness Form

Click on the check box to enable (an "X" in the check box) or disable (clear check box) any of the parameters. You can enable or disable as few or as many of these parameters as you want, either before the scan or after.

4.7.1 ROUGHNESS

The Roughness Parameters section contains the following fields.

Average (R_a)

The arithmetic average deviation of the absolute values of the roughness profile from the mean line or centerline. (Also known as centerline average roughness.) The centerline divides profiles such that all areas above it are equal to all areas below it. (ANSI)

Maximum R_a (Max R_a)

The trace within the cursors is divided into 19 overlapping sections. Each section is one-tenth of the sampling length. The R_a of each section is calculated, and the maximum is displayed. (ANSI)

RMS (R_q)

The Root-Mean-Square (RMS) or geometric average deviation of the roughness profile from the mean line measured in the sampling length. (ANSI)

Peak (R_p)

The distance between the mean line and the highest peak within the sampling length. (ANSI)

Valley (R_v)

The distance between the mean line and the lowest valley within the sampling length. (ANSI)

Peak/Valley (R_t)

The vertical distance between the highest peak and the lowest valley in the sampling length leveled on the mean line. (Also known as R_{max}, R_y, Maximum Peak-To-Valley Roughness.) (ANSI)

Height 10pt (R_z)

The average height difference between the five highest peaks and the five deepest valleys within the cursors measured from a line parallel to the mean line. (ANSI)

Height 6pt (R_{3z})

The average height difference between the three highest peaks and the three deepest valleys in the sampling length measured from a line parallel to the mean line and not crossing the profile. (ANSI)

Roughness Height (R_h)

The difference in height in the roughness profile between the left and right cursor positions (analogous to the Height data that always appears in the Summary box of the Data Analysis window). (ANSI)

Mean Peak Height (Rpm)

The mean value of the local peak heights of the roughness trace within the sampling length. The Delta cursors are not used.

RMS Slope (D_q)

The root mean square (RMS) value of the roughness trace slope. The Delta cursors are not used.

RMS Wavelength (L_q)

2π times the ratio of the root mean square (RMS) deviation of the profile (R_q) to the root mean square slope of the profile (D_q). L_q is a measure of the spacing of local peaks and local valleys, taking into account their relative amplitudes and individual spatial frequencies. (ISO)

Std. Dev. Height (SD)

The standard deviation of the local peak heights about the mean peak height within the sampling length.

4.7.2 WAVINESS

The following waviness parameters correspond to the roughness parameters listed previously after introducing a low pass filter of selectable cutoff length. See Section 4.5.1, "Filters," and Section 6.4, "Using Cutoff Filters," for more information.

Average (W_a)

The arithmetic average deviation of the absolute values of the waviness profile from the mean line or centerline. (Also known as centerline average waviness.) The centerline divides profiles such that all areas above it are equal to all areas below it. (ANSI)

RMS (W_q)

The Root-Mean-Square (RMS) or geometric average deviation of the waviness profile from the mean line measured in the sampling length. (ANSI)

Peak (W_p)

The distance between the mean line and the highest peak within the sampling length. (ANSI)

Valley (W_v)

The distance between the mean line and the lowest valley within the sampling length. (ANSI)

Peak/Valley (W_t)

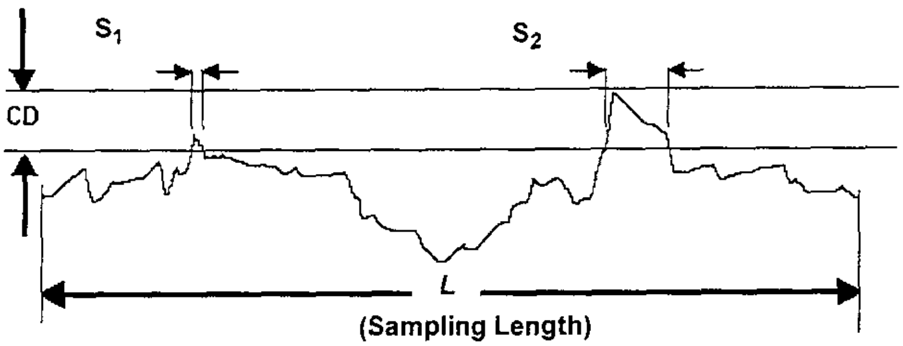
The vertical distance between the highest peak and the lowest valley in the sampling length leveled on the mean line. (Also known as W_{max}, W_y, Maximum Peak-To-Valley Waviness.) (ANSI)

Waviness Height (W_h)

The difference in height in the waviness profile between the left and right cursor positions. (Analogous to the Height data that always appears in the Summary box of the Data Analysis window.) (ANSI)

4.8 BEARING RATIO/CUTTING DEPTH

As shown in Figure 4-19, a reference line is drawn parallel to the mean line and at a preselected or predetermined distance below the highest peak in the sampling length (called the *cutting depth*) to intersect the profile in one or more subtended lengths. The *bearing length* is the sum of these subtended lengths. The *bearing ratio* is the ratio of the bearing length to the sampling length; it is also called the bearing length ratio. (ANSI)



$$t_p = \frac{S_1 + S_2}{L}$$

Figure 4-19 Determination of Bearing Length and Bearing Length Ratio

The Bearing Ratio/Cutting Depth form contains two sections, one for setting up Bearing Ratio calculations, the other for setting up Cutting Depth calculations.

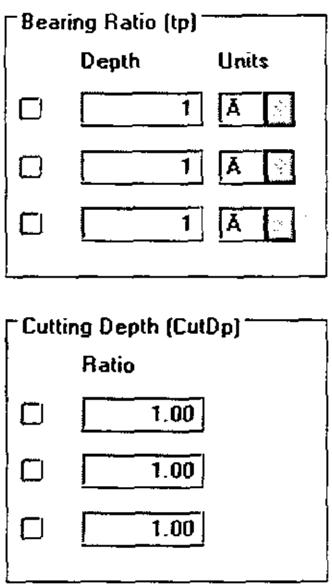


Figure 4-20 Bearing Ratio/Cutting Depth

4.8.1 BEARING RATIO

The Bearing Ratio section allows calculating up to three values of bearing ratio corresponding to three different values of the Cutting Depth parameter. There are three columns:

- Column 1 consists of a check box. Click on a box to enable or disable calculation of the bearing ratio for the value of cutting depth in the next column to the right.
- Column 2 contains a field that holds the magnitude of the desired value for cutting depth. Click in the field and type the desired value. Valid values are any integers from 1–999.
- Column 3 contains a field that holds the units corresponding to the value for cutting depth in Column 2 of the same row. Click on the drop-down button to select the desired units. Available settings are 1Å or 1 μm.

4.8.2 CUTTING DEPTH

The Cutting Depth section allows calculating up to three values of cutting depth corresponding to three different values of the bearing ratio parameter. There are two columns:

- Column 1 consists of a check box. Click on a box to enable or disable calculation of the cutting depth for the value of cutting depth in the next column to the right.
- Column 2 contains a field that holds the desired value for bearing ratio in percent. Click in the field and type the desired value. Valid values are any numbers in the range 0–99.9.

4.9 HIGH SPOT COUNT/PEAK COUNT

High spot count is defined as the number of profile peaks per unit of length projecting through a reference line parallel to and at a given height above a line drawn through the lowest point of the roughness trace, parallel to the mean line (see Fig. 4-21). *Projecting through* means that the profile curve climbs above and then falls below the band. Thus, if the profile rises above the band more than once without falling below the band, multiple peaks are not identified. Delta cursors are not used.

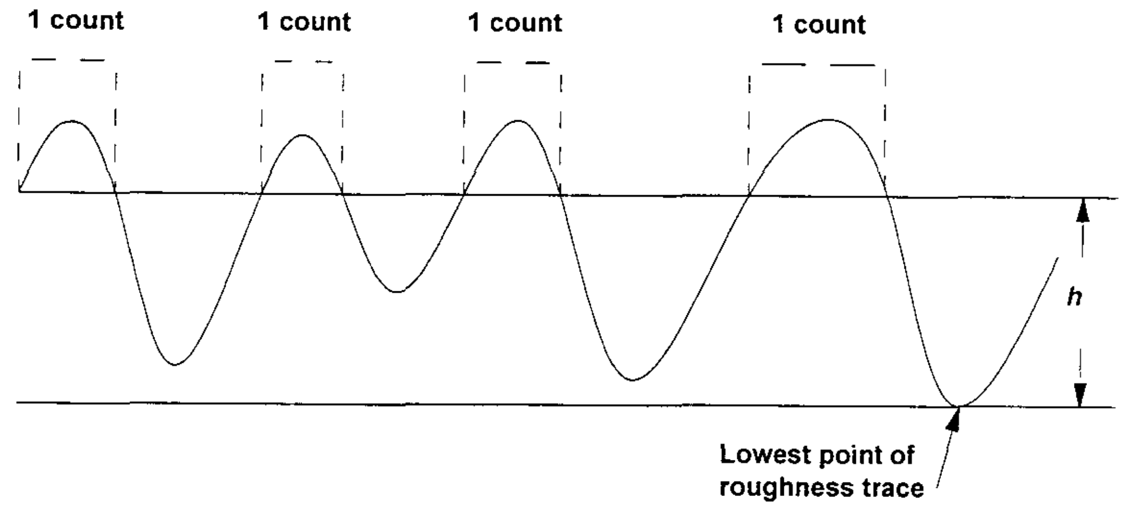


Figure 4-21 Determination of High Spot Count

Peak count is defined as the number of peak/valley pairs per unit length projecting through a band of width *b* centered about the mean line (see Fig. 4-22). Note the similarities (and the differences) to Peak Count. Compare Fig. 4-21 and Fig. 4-22.(ANSI).

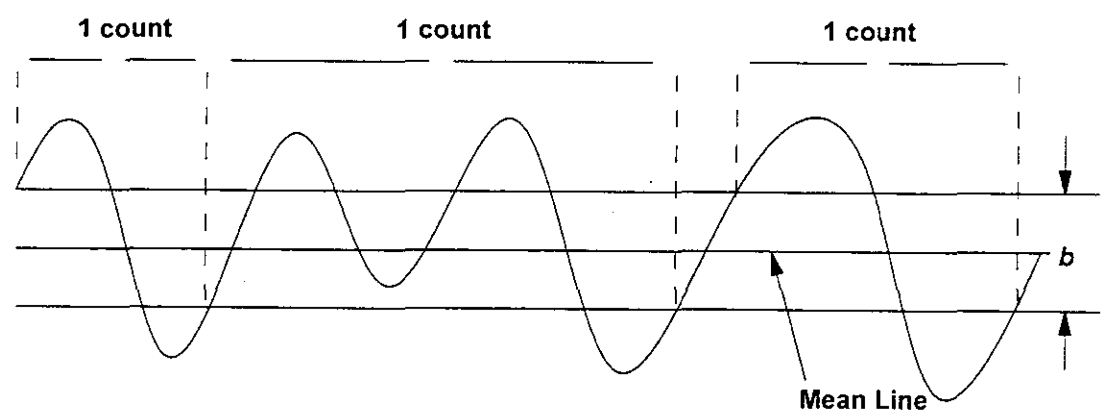


Figure 4-22 Determination of Peak Count

Mean peak spacing is defined as the mean value of the local peak spacing of the profile within the sampling length. The peaks are defined either by the criteria of the High Spot Count parameter or the Peak Count parameter.

The High Spot Count/Peak Count view contains two sections, one for setting up High Spot Count calculations and the associated Mean Peak Spacing, the other for setting up Peak

Count calculations and the associated Mean Peak Spacing.

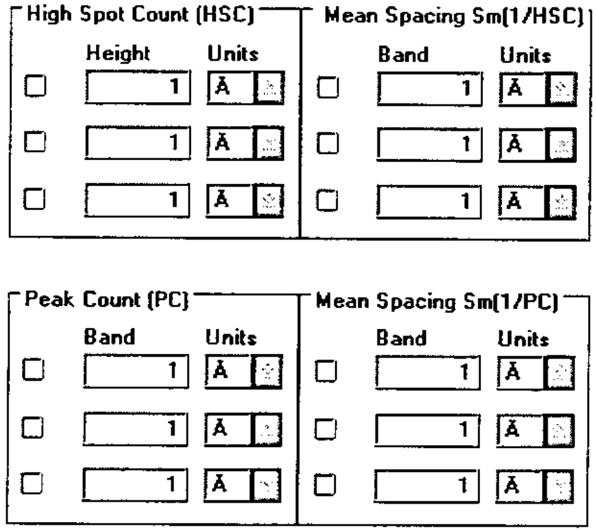


Figure 4-23 High Spot Count/Peak Count Form

4.9.1 HIGH SPOT COUNT AND MEAN PEAK SPACING

The High Spot Count section allows calculating up to three values of high spot count corresponding to three different values of the height of a reference line drawn parallel to the leveled baseline at a height *h* above a similar line drawn through the lowest point of the roughness trace, also parallel to the leveled baseline (Fig. 4-21). There are three columns:

- Column 1 consists of a check box. Click on a box to enable or disable calculation of the peak count for the value of Height in the next column to the right.
- Column 2 contains a field that holds the magnitude of the desired value for Height. Click in the field and type the desired value. Valid values are any integers from 1–999.
- Column 3 contains a field that holds the units corresponding to the value for Height in Column 2 of the same row. Click on the drop-down button to select the desired units. Available settings are 1Å or 1 μm.

The corresponding Mean Peak Spacing section contains the same fields.

4.9.2 PEAK COUNT AND MEAN PEAK SPACING

The Peak Count section allows calculating up to three values of peak count corresponding to three different values of the width *b* of a band centered about the mean line of the roughness trace (Fig. 4-22). There are three columns:

- Column 1 consists of a check box. Click on a box to enable or disable calculation of the peak count for the value of Band in the next column to the right.
- Column 2 contains a field that holds the magnitude of the desired width for the Band. Click in the field and type the desired value. Valid values are any integers from 1–999.

- Column 3 contains a field that holds the units corresponding to the value for the width of the Band in Column 2 of the same row. Click on the drop-down button to select the desired units. Available settings are 1Å or 1 µm.

The corresponding Mean Peak Spacing section contains the same fields.

4.10 SAVING AND MAINTAINING RECIPES

Once you have written a recipe that you want to keep for future use, you need to save it on the hard disk.

NOTE:	**For SEMI compliance, both scan recipes and sequences share the same directory. This means that a sequence cannot have the same name as an existing recipe.**

To save a new recipe:

1. Choose Save As from the Recipe menu. The following dialog box appears:

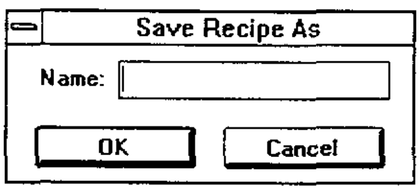


Figure 4-24 Save Recipe As Dialog Box

2. Type a name for the recipe, then click on OK, or click on Cancel to abort the Save operation. The recipe name must be a valid DOS filename. The valid DOS filenames
   - Can contain a maximum of eight characters. A three-character extension is supplied by the system.
   - Are not case-sensitive. It does not matter whether you use uppercase or lowercase letters when you type them.
   - Can contain only the letters A–Z, the numbers 0–9, and the following special characters: tilde (~), exclamation point (!), at sign (@), number sign (#), dollar sign ($), percent sign (%), caret (^), ampersand (&), left parenthesis, right parenthesis, underscore (_), hyphen (-), left brace ({), right brace (}), single quotation mark (‘), and apostrophe ('). No other special characters are acceptable.
   - Cannot be identical to the name of another existing recipe.

To save a previously saved recipe:

Choose Save from the Recipe menu.
Or click on the Save button in the tool bar.

To save a previously saved recipe under a new name:

1. Choose Save As from the Recipe menu. The Save Recipe As dialog box (Fig. 4-24) appears.
2. Type a name for the recipe, then click on OK, or click on Cancel to abort the Save operation.

To load a recipe into the Recipe Editor:

1. In the Recipe Editor window, select Open from the Recipe menu. The following dialog box appears:

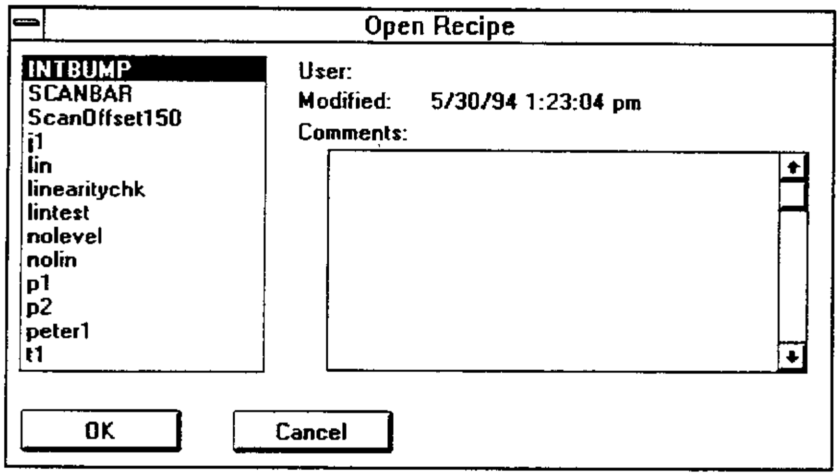


Figure 4-25 Open Recipe Dialog Box

2. Select the desired recipe from the list of recipes on the left side.
3. Click on the OK button.

To delete, import, and export recipes, see Chapter 8, "Using the Database."

5 PROFILING

This chapter discusses profiling a sample in detail. Once the Scan recipe has been chosen or created (Chapter 4), you take scans using the procedures described in this chapter. Chapter 6, "Analyzing Scan Data," explains how to interpret the results after a scan is taken.

This chapter describes

- The parts of the XY View window
- Loading samples (with and without the optional wafer handler)
- Viewing and positioning the sample for scanning
- Scanning the sample
- Special considerations when scanning with the MicroHead at low stylus forces
- Unloading samples (with and without the optional wafer handler)
- Stage adjustments

5.1 XY VIEW WINDOW

The XY View window contains a magnified video image of the sample surface and provides operator control of the stage motion and the optical system. The XY View window also appears when using automated configuration and calibration routines. The title in the window's title bar indicates the current state of operation. The default title is Teach Scan Length.

To view the XY View window:

Click on the XY View button from any tool bar that displays it, or select XY View from any menu that displays it. You can get to the XY View from the following windows and menus:

- Scan Recipe Catalog window
- Sequence Recipe Catalog window
- Recipe menu in the Recipe Editor window
- File menu in the Data Analysis window

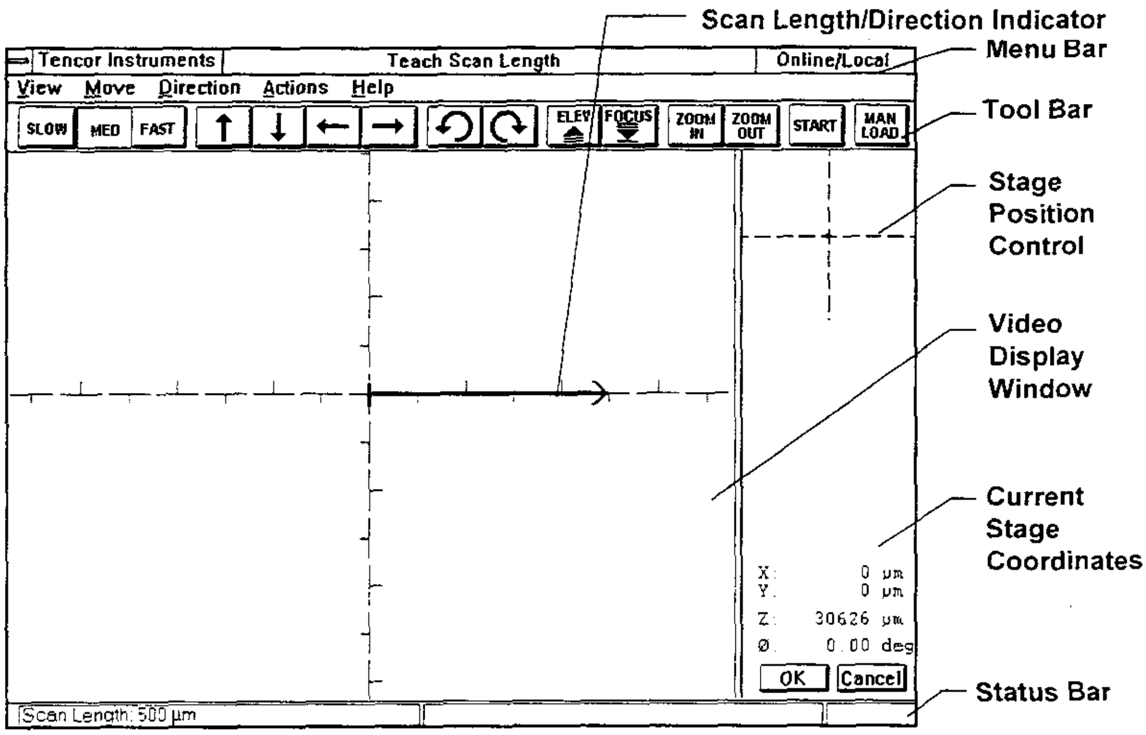


Figure 5-1 XY View Window

The appearance of the video image depends on the position of the stage beneath the measurement head (it needs to be close enough for the sample to be in focus), and the magnification ranges available. All measurement heads offer an optic magnification (zoom) control that allows a range of magnifications without changing lenses.

The XY View window consists of the following elements:

- Menu bar
- Tool bar
- Video display window
- Stage position control
- Current coordinate positions of the stage

5.1.1 XY VIEW MENU BAR

The XY View menu bar provides the following menus. You can view menus by clicking on the titles in the menu bar, or by pressing ALT+*l*, where *l* is the letter that appears with an underscore in the desired title in the menu bar. You can choose menu items by clicking on a menu entry or by typing the letter that appears with an underscore in the desired menu item.

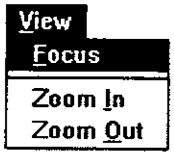


Figure 5-2 View Menu

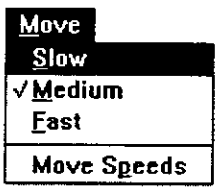


Figure 5-3 Move Menu

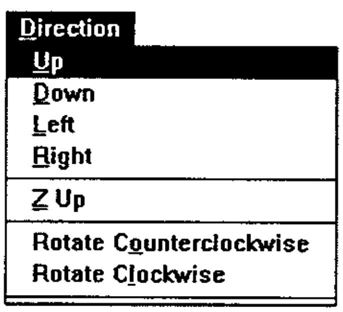


Figure 5-4 Direction Menu

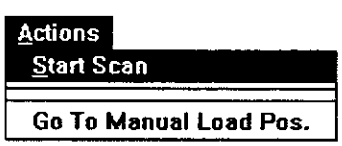


Figure 5-5 Actions Menu

5.1.2 XY VIEW TOOL BAR

The XY View tool bar contains a row of icons that resemble buttons. Clicking on these buttons provides an alternative way to access commonly used functions. Each icon suggests the function of the button. For example, the Print button resembles a printer. Buttons that appear dimmed are unavailable.

The XY View tool bar contains the following buttons:

Button	Action
SLOW	Sets current stage speed to Slow
MED	Sets current stage speed to Medium
↑	Sets current stage speed to Fast
FAST	Moves the stage in the +Y direction (away from the measurement area door)
↓	Moves the stage in the -Y direction (toward the measurement area door)
←	Moves the stage in the -X direction (to the left)
→	Moves the stage in the +X direction (to the right)
ELEV ▲	Raises the measurement head away from the stage
	Rotates the stage in the counterclockwise direction
	Rotates the stage in the clockwise direction
FOCUS ▼	Focuses the video image
ZOOM IN	Increases the optic magnification
ZOOM OUT	Decreases the optic magnification
START	Starts the scan
MAN LOAD	Moves the stage to the Manual Load position

5.2 LOADING A SAMPLE

The following sections describe how to load samples. Load the sample manually if your instrument does not have the wafer handler installed, or if you are loading odd-sized wafers or other sample types such as compact disks or magnetic storage media.

5.2.1 LOADING A SAMPLE WITHOUT THE WAFER HANDLER

The Manual Load and Soft Home positions are preprogrammed. You can change these positions, if desired. For details, see Section 5.8.2, "Manual Load Position," and Section 5.8.3, "Soft Home Position."

NOTE:	**This version of the Tencor P-20 software does not reposition the stage to the XY Soft Home Position after moving to the Manual Load Position. You might want to note the original X, Y, Z, and θ positions before clicking on the ManuLoad button in the tool bar.**

To load the sample:

1. Display the XY View window.
2. If the stage is not already in the load position, click on the ManuLoad button in the tool bar to move the stage forward.
3. Open the door to the measurement area and place the substrate on the stage table, disk holder, or precision locator.

   If you are using a precision locator on a manual stage, note the four detents at 90° and the two intermediate detents at 45°. (See Appendix D, "Precision Locators", in the *Tencor P-20 Long Scan Profiler Reference Manual* for graphic representations of the available locators.) When the precision locator is aligned as in Fig. 5-6, it is in the 0 theta position (theta = 0°).

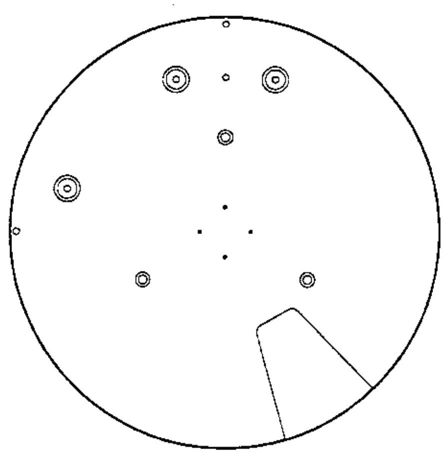


Figure 5-6 Precision Locator

4. Engage the stage vacuum with the switch found just inside the left side of the measurement door opening (see Fig. 1-1). Press the switch down to engage the vacuum.

5. Close the door. Click approximately in the center of the Stage Position Control (Fig. 5-1) on the right side of the window. The stage moves until its center is beneath the measurement head.

5.2.2 LOADING A SAMPLE WITH THE WAFER HANDLER

The wafer handler can be configured to load wafers of four different sizes:

- 100 mm (4 in.)
- 125 mm (5 in.)
- 150 mm (6 in.)
- 200 mm (8 in.)

The standard system configuration includes one cassette locator for 200-mm wafers. A second locator is available as an option. For 100-, 125-, or 150-mm wafers, an additional locator plate for each size attaches by thumbscrew on top of the 200-mm locator.

You cannot use this method of loading and unloading for samples other than wafers; use the procedures described in Section 5.2.1, "Loading a Sample without the Wafer Handler." For satisfactory operation the handler chuck must be installed (see Section 2.5, "Installing a Precision Locator," in the *Tencor P-20 Long Scan Profiler Reference Manual*) and the elevator limit properly set (see Section 5.8.4, "Lowest Elevator Position.").

Before operating the wafer handler for the first time, read Section 2.7.1, "Protecting the Wafer Handler," for important information on protecting the wafer handler and wafers from damage.

NOTE:	**Cassettes should be the same size and type that Tencor Instruments Field Service taught the wafer handler. Cassettes that have been used in chemical processing, which causes distortion, can make it difficult for the handler to center the wafers on the vacuum puck and stage. Dedicated machine cassettes are best.**

Before using the handler, check the following:

- Make sure the vacuum chuck is installed on the stage table.
- Make sure the handler parameters are set up properly.
- Make sure the wafer size is properly set for the aligner.

The instrument is shipped with the vacuum chuck installed if your instrument comes with the wafer handler. If a vacuum chuck has to be installed, a new lowest elevator position must be set (see Section 5.8.4, "Lowest Elevator Position.").

CAUTION:	**Do not use a precision locator when using the handler to load wafers; you could damage the instrument.**

To set handler parameters:

1. From the Top Level menu, double-click on Configuration. From the main Configuration window, click on System Configuration. The following dialog box appears:

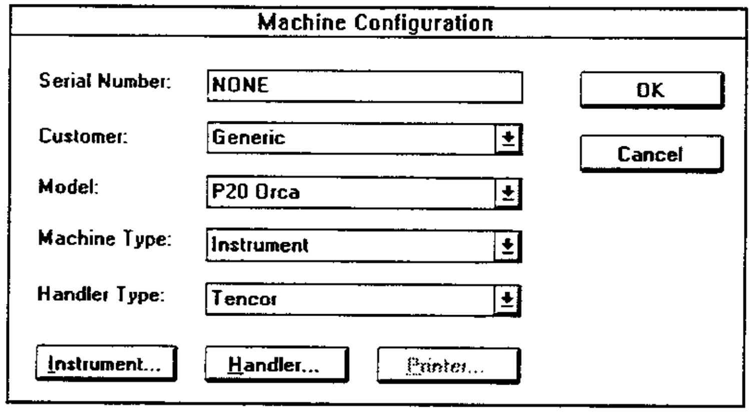


Figure 5-7 Machine Configuration Dialog Box

2. Click on the Handler button. The Handler Setup dialog box appears:

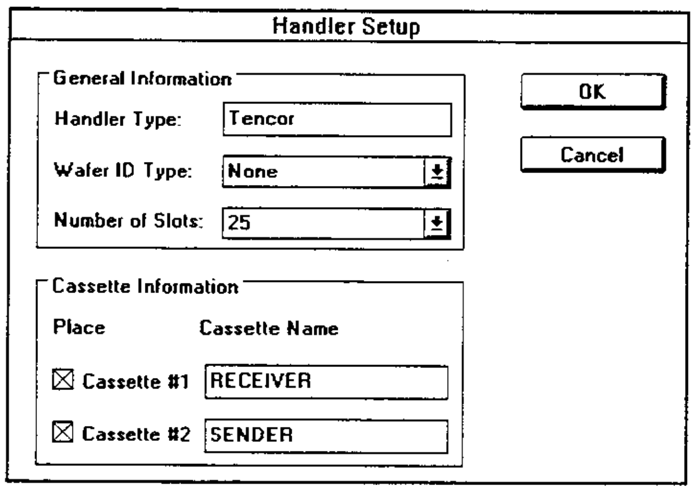


Figure 5-8 Handler Setup Dialog Box

3. Edit values as needed. When finished, click on OK to keep the changes, or Cancel to close the dialog box and leave the setup in its original state.

4. The following message box appears:

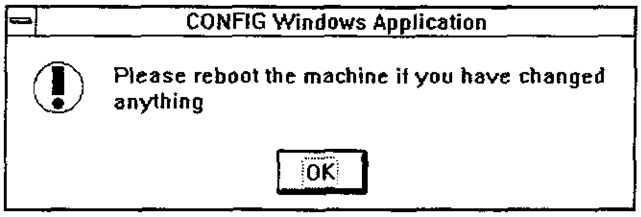


Figure 5-9 Configuration Reboot Message Box

5. Press ENTER or click on OK.

> **CAUTION: Be sure to reset the machine if you have made any changes. See Section 2.11, "Turning Off or Resetting the Instrument."**

Handler parameters are set up in the Configuration window. Values for the handler parameters are set as follows.

Handler Type

Handler Type can be either Tencor or None.

Wafer ID Type

Wafer ID Type can either be None or OCR.

Number of Slots

This field identifies the capacity of the wafer cassettes used. The possible choices are 25 or 26.

Cassette Information

These fields specify the number of cassettes used by the handler and how they are used. An X in the check box for a cassette indicates that the particular cassette is present on the instrument. The Cassette Name fields identify the particular cassette is either the Sender, Receiver, or Both. (If only one cassette is available, it must serve as both the receiver and the handler.)

To set the wafer size on the aligner:

Turn the wafer size selector dial on the aligner (Fig. 5-10) until it displays the appropriate wafer diameter.

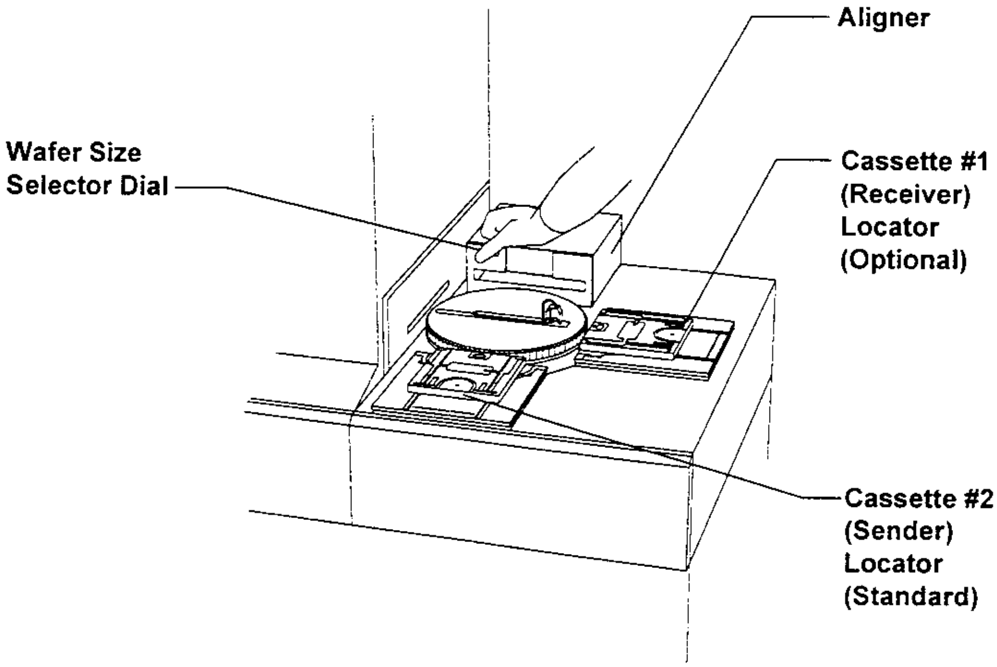


Figure 5-10 Setting the Wafer Size Selector

To load a single wafer using the handler:

1. Place the wafer in a slot of a cassette of the appropriate size. Note the number of the cassette slot. Load the wafer right side up. The bottom slot of the cassette is number 1.
2. Place the cassette on the sender cassette locator (Fig. 5-11) as follows:
   - Tilt the cassette back slightly and place the bottom rear corners of the cassette in the grooves on the locator. The grooves are marked with wafer sizes (100 mm, 125 mm, 150 mm, and 200 mm).
   - Tilt the cassette forward until it fits securely in the grooves of the cassette locator. The H-bar across the bottom of the cassette must trip the limit switch in the slot on the locator.

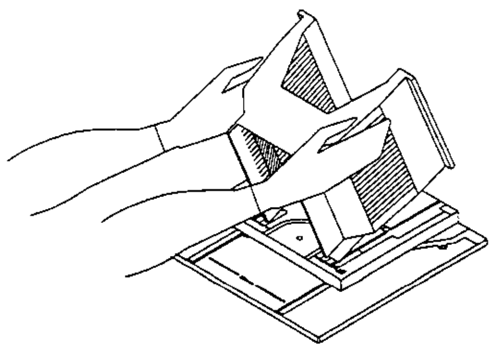


Figure 5-11 Placing a Cassette on a Locator

NOTE:	Cassettes placed on both locators must be the same size, otherwise wafers could be damaged and handler performance could be affected. Reinitialize the handler each time the cassette size is changed.

3. In the Recipe Editor window, select Handler Load from the Substrate menu. The Load Substrate dialog box appears:

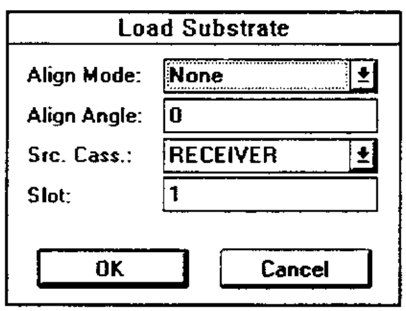


Figure 5-12 Load Substrate Dialog Box

4. The following options are available in the Align Mode field:

   Flat Orients the wafer by its major flat.

   Notch Orients the wafer by its alignment notch.

   None Turns wafer orientation off. The handler bypasses the aligner when it loads wafers. Bypassing the aligner reduces the accuracy of centering the wafer on the stage by the location error of the wafer in the cassette, typically about 3000 μm.

5. If you choose Flat or Notch in Step 4, select the Angle field. Type the degrees of arc to orient the wafer. You can type any number from 0 to 360.

   Figure 5-13 shows the angular orientation scheme. The top of the drawing represents the back of the instrument and the top of the computer screen. Entering 0 or 360 orients the flat or the notch to the front of the Tencor P-20 console and the bottom of the computer screen. When a wafer is unloaded into a cassette, the flat or notch is rotated 90 ° and in this example, the flat will be at the 9 o'clock position.

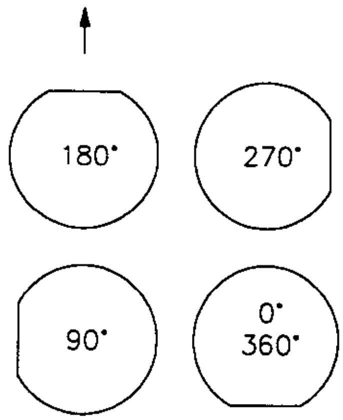


Figure 5-13 Wafer Orientation

6. Select a cassette to load the wafer from. The choices are Sender or Receiver.
7. Select a slot to load the wafer from. Enter any whole number in the range 1–25 (for 25-slot cassettes) or 1–26 (for 26-slot cassettes).
8. Click on OK to load the wafer.

   Note: If the wafer loading or unloading process is interrupted while the handler puck is inside the instrument, the X, Y stages will not move. You can home the puck by reinitializing the handler. Select Init Handler from the Substrate menu in the Recipe Editor window.

NOTE:	**If the handler does not initialize, the manual vacuum switch could be turned off. Check the switch to make sure that it is On (in the up position). The switch is located inside the instrument below the lower left of the measurement door.**

5.3 VIEWING AND POSITIONING THE SAMPLE

This section discusses controlling the head motion, controlling the stage motion, viewing the sample, zooming the image, and teaching the scan length.

Once you have loaded the sample and the stage has moved beneath the measurement head, you view the sample in the XY View window (Fig. 5-1) and position it to a desired location to start a scan.

You need to do two things to view the sample and prepare for a scan:

- Lower the measurement head until the sample comes into focus.
- Move the sample beneath the head until you have located a feature you want to scan.

5.3.1 LOWERING THE MEASUREMENT HEAD

To take a scan, the measurement head must be lowered so that the stylus is in contact with the sample surface. You can lower the head and null the stylus using the trackball in the XY View window.

CAUTION: **Before lowering the head, be sure that the sample is under the stylus, the stage is not significantly out of level, and be sure that there are no physical obstacles in the way, such as hardware affixed to the stage. See Section 2.8, "Protecting the Stylus Arm Assembly," for a complete discussion of potential damage to the stylus, measurement head, or sample.**

To lower the measurement head using the trackball:

Click on the Focus button in the XY View window tool bar. Notice that the stylus lowers into position before the head begins to descend. As the head approaches the stage, the image of the sample surface begins to come into focus. When the stylus touches down, the head stops descending, and the stylus retracts. The image should now be fully in focus.

5.3.2 POSITIONING IN X AND Y

Once the sample surface is clearly visible, you can position the stage and sample beneath the measurement head until you have located the area where you want the scan to begin.

The following figure (Fig. 5-14) shows the coordinate system used in the Tencor P-20. The coordinate system follows the SEMI Standard M20-92. The X and Y displayed in the Scan window represent the lateral position of the stage relative to the center of the measurement area. The possible travel area of the stage is limited to a 210-mm (8.2-in.) circle.

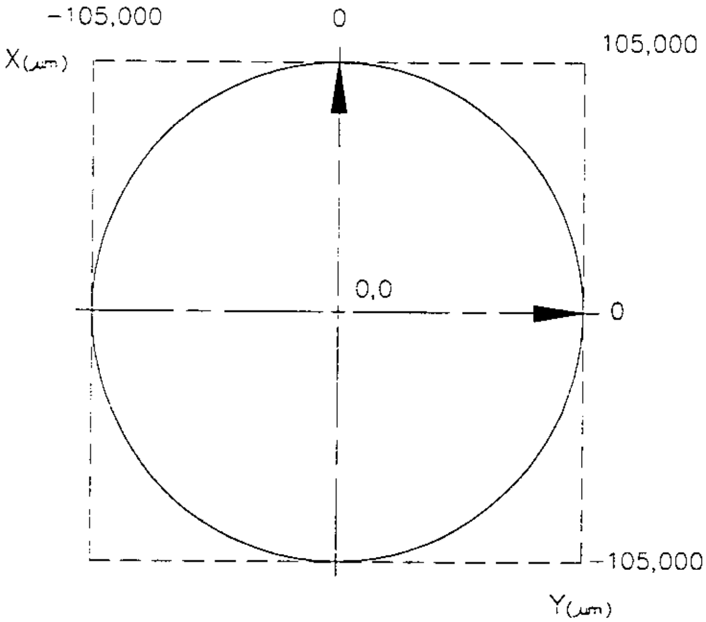


Figure 5-14 Coordinate System of the Tencor P-20

There are several ways to move in X and Y to allow quick gross positioning as well as very fine adjustment. Note that the directions indicated by the controls are consistent with the direction of motion of the *stage*; in the XY View window, the video image appears to be moving in the opposite direction.

CAUTION:	**If there is any hardware fixed to the stage and it is above the sample surface, raise the stylus or raise the measurement head before moving the stage; otherwise, stylus or head damage can occur.**

To move quickly from one area to another using the trackball:

- To move quickly to a position currently visible in the video image, click on the desired location. The stage moves so that the cross hairs are centered on the chosen location.
- To move quickly to an area not currently visible in the video image, click on the approximate desired location on the Stage Position control on the upper right of the window (Fig. 5-1). The stage moves and the small blue dot moves to indicate the new position.

Finer control is available by clicking on the control buttons in the tool bar or using the motion keys on the keyboard.

To move in X and Y using the trackball:

1. Click on the Fast, Medium, or Slow control buttons in the XY View tool bar (Fig. 5-1).

2. Click and hold the left button down over the desired direction control button; release the trackball button to stop.

NOTE:	**When Slow speed is active, notice that when motion ceases, the image appears to do a momentary wiggle. This is normal and desirable. It is this motion that eliminates the slight mechanical backlash in the stage movement that would otherwise make precise positioning to very small features difficult.**

5.3.3 ADJUSTING THE OPTICAL MAGNIFICATION

You might need to adjust the optical magnification of the sample image.

NOTE:	**For instruments equipped with the Pattern Recognition Option, we recommend that the lowest optical magnification be used exclusively.**

To magnify (zoom) the image:

- Click on the Zoom Out control button, or choose Zoom Out from the View menu.
- Click on the Zoom In control button, or choose Zoom In from the View menu.

NOTE:	**Whenever you change the optical magnification, you need to reteach the video calibration so that the screen pixel to stage coordinate ratio is determined correctly. See Section 5.4.1, "Teaching the Scan Length."**

5.4 TAKING A SCAN

Once you have lowered the head and at least approximately positioned the sample, you are almost ready to take a scan. First, you need to set up by adjusting the sample position so that the stylus will lower and begin taking data at the right place. The right place to start depends on the feature or features that you want to scan.

As an example, consider a simple step feature (Fig. 5-15). You might wish to determine the step's height and width. In this case, you want to make sure that you begin your scan far enough before the step to clearly see it rise from the surrounding surface, and you want to have set a long enough scan length in the recipe so that you get a complete view of the step. That is, you want to keep taking data until the stylus has clearly come down the other side of the step.

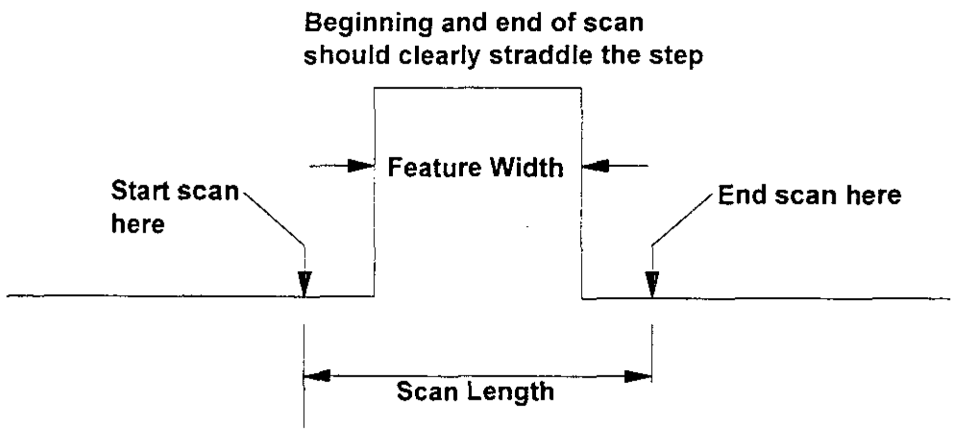


Figure 5-15 Setting Up to Scan a Step

Typically you want the beginning and end of such a scan to be long enough to be able to use them to establish a level baseline.

The general rule of thumb is to take a scan long enough to clearly discern the geometry of interest and (except in the case of a radius measurement) to clearly establish a level reference.

To set up for a scan:

1. Identify the feature(s) of interest.
2. Null the stylus and move in X and Y until satisfied with the start-of-scan position.
3. Click on the Start icon in the tool bar or choose Start Scan from the Actions menu.

If you wait more than 60 s between nulling the stylus and starting the scan, the stylus will retract into the measurement head. This is a safety feature. In this case, the stylus will descend and re-null on the surface automatically.

At the moment you begin a scan, the position of the cross hairs superimposed on the video image represents where the stylus tip will contact the sample surface and begin collecting data.

When the scan begins, note that the stage first travels *opposite* to the scan direction for a short distance, then stops and moves in the scan direction. This allows the scanner to reach the programmed scan speed before the instrument begins to collect data.

While the scan progresses, the Scan window displays an image of the trace overlaid on top of the video image, while the status bar displays a running count of data points taken as the scan progresses.

When the scan is completed, the stylus lifts, the scanner returns to its original position above the start-of-scan location, and the Data Analysis window is displayed with the profile plotted in dimensioned coordinates.

To abort a scan:

Click on the Stop Scan button at any time.

5.4.1 TEACHING THE SCAN LENGTH

Sometimes the best scan length for a particular scan is not known in advance. Although you can determine from the XY View window's scale and then return to the Recipe Editor to input an appropriate value, there is an easier way: teaching the scan length.

NOTE:	**For the Teach Scan Length feature to function properly, the correct ratio between the line drawn on the video image and the actual distance that the stage needs to move must be established. This is done by performing the Video Calibration. The Video Calibration needs to be done again if you change the zoom settings.**

To perform the Video Calibration:

1. From the Scan Calibrations window, click on the Video Calibration button. The Video Calibration window appears:

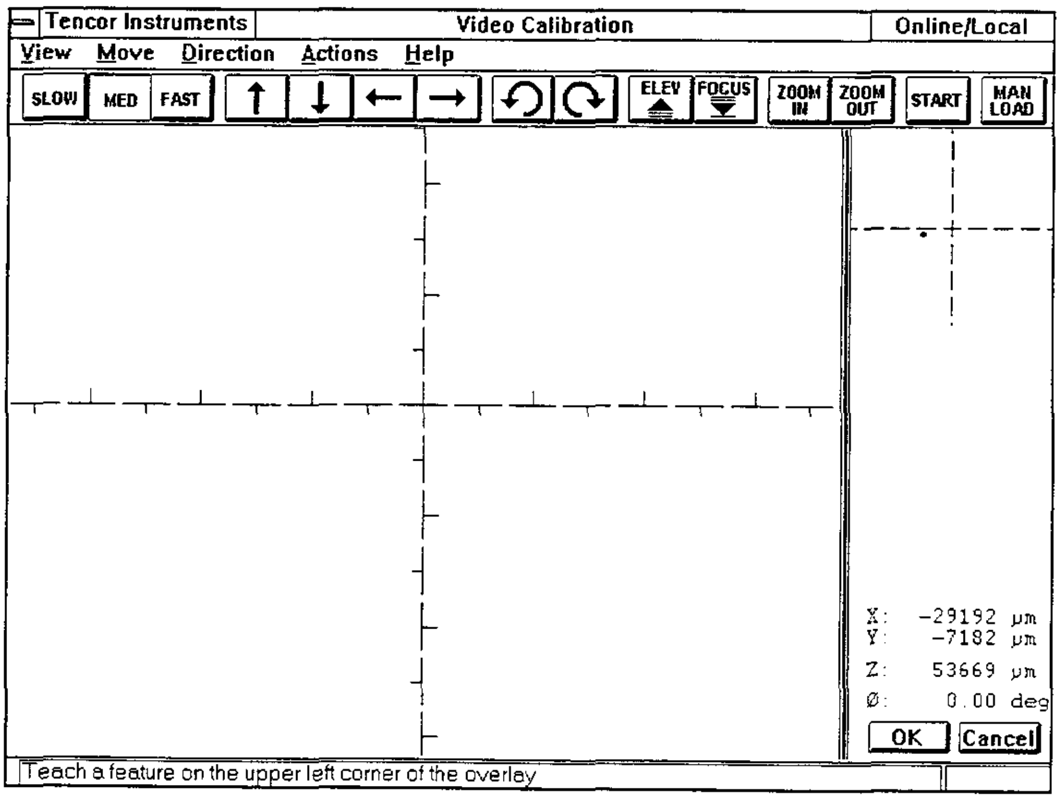


Figure 5-16 Video Calibration Window

The prompt area displays

Focusing-please wait

2. The stylus nulls on the sample surface and the image comes into focus. The prompt changes to

   Teach a feature in the upper left corner of the overlay

   Choose something on the sample to use to teach the calibration. The corner of a rectangle is ideal. Note: Avoid choosing something that is identical or very similar in appearance to other features nearby.

3. Move the trackball cursor over the chosen corner and click.

4. The stage moves slightly in X and Y, and the prompt changes to

   Teach the same feature again

   Move the cursor over the chosen corner in its new position and click.

5. The following message box appears:

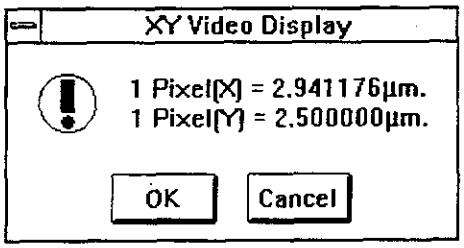


Figure 5-17 XY Video Display Message Box

   The values in the message box are the calculated ratios of vertical and horizontal screen units (called pixels) to X and Y stage coordinates in μm.

6. Click on OK. The message box disappears, and the prompt area displays

   Teach a feature in the upper left corner of the overlay

   Redo the calibration, or click on OK to accept the new values or Cancel to keep the original values and return to the Scan Calibrations window.

To teach the scan length:

1. Click once on the video image at the place that you want your scan to start.
2. Click again at the place that you want your scan to end.

The length of the line between the two points is then determined using the information in the video calibration file, then inserted automatically into the current recipe. In addition, the stage moves so that the origin of the line coincides with the cross hairs and the line extends along the X-axis.

5.5 SCANNING AT LOW STYLUS FORCES

There are some special considerations when using very low forces with the MicroHead II or Extended Range MicroHead. These issues are discussed below.

5.5.1 LIMITATIONS ON DOWNWARD TRAVEL

Because the stylus force varies as the stylus moves away from the center position, the depth of valleys that can be effectively profiled with low stylus force settings is limited (the full range is available for upward travel). The downward travel available at various stylus force settings is shown in Table 5-1.

Table 5-1 Maximum Downward Travel for Particular Values of Stylus Force

Stylus Force (mg)	Approximate Maximum Downward Travel (μm)	
	MicroHead II	Extended Range MicroHead
0.05	0.4	N/A
0.1	0.8	N/A
0.2	1.6	N/A
0.5	4.0	6.0
1.0	8.0	12
2.0	16	25
5.0	40	65
10	full range	130
15	full range	195
20	N/A	260
25	N/A	full range
30	N/A	full range
35	N/A	full range
40	N/A	full range
45	N/A	full range

If you exceed these values during the scan of a step or ramp, the stylus becomes suspended in air (see Fig. 5-18). The resulting trace displays a random wander (see Fig. 5-19).

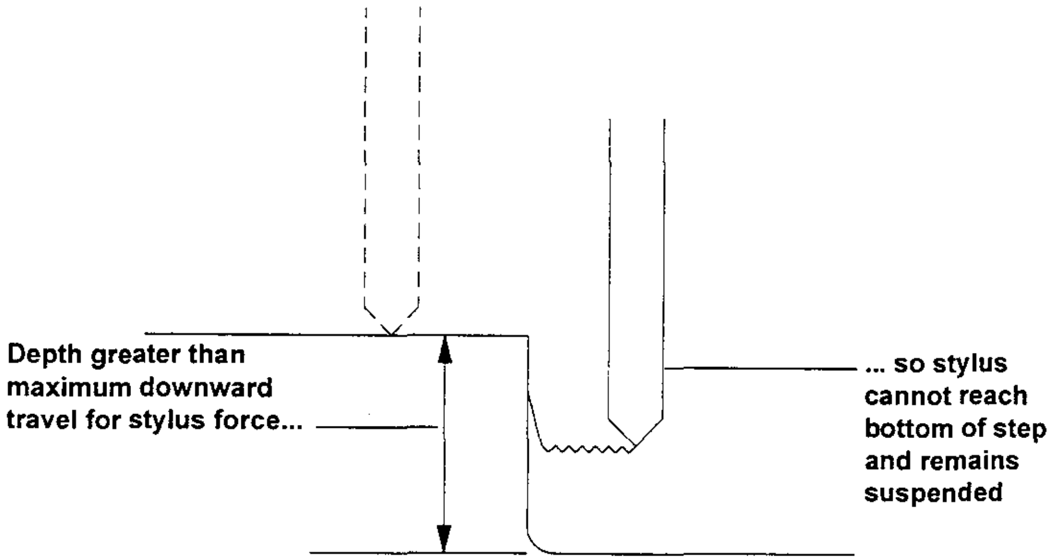


Figure 5-18 Maximum Downward Travel Not Large Enough to Scan Valley

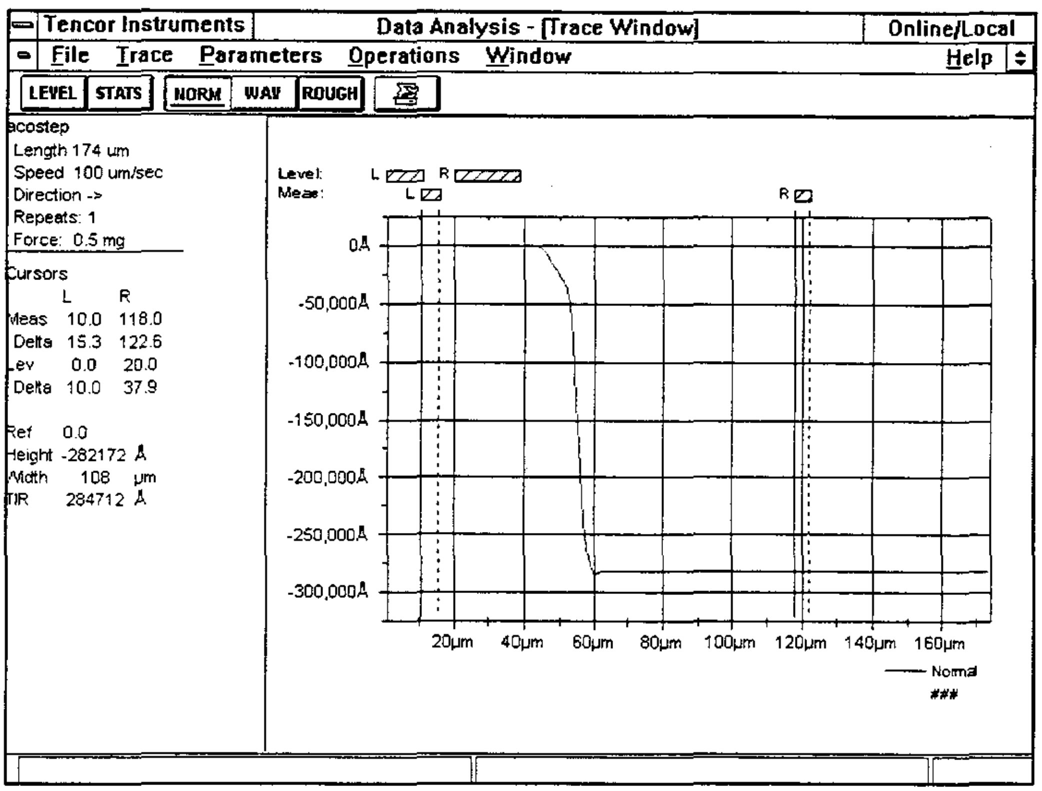


Figure 5-19 Example Trace—Stylus Force Too Low for Valley Depth

To reach the bottom of the step, increase the stylus force in the recipe (see Section 4.3.2, "Stylus.").

5.5.2 MECHANICAL LEVELING AND LOW STYLUS FORCES

The limit on downward travel discussed above also means that mechanical leveling becomes particularly important at low stylus forces. A small amount of tilt in the orientation of the sample surface can result in a situation where the maximum travel limit of the stylus is exceeded. Figure 5-20 shows what can happen if you set the stylus force as low as possible for a given artifact size, but the sample surface is not level.

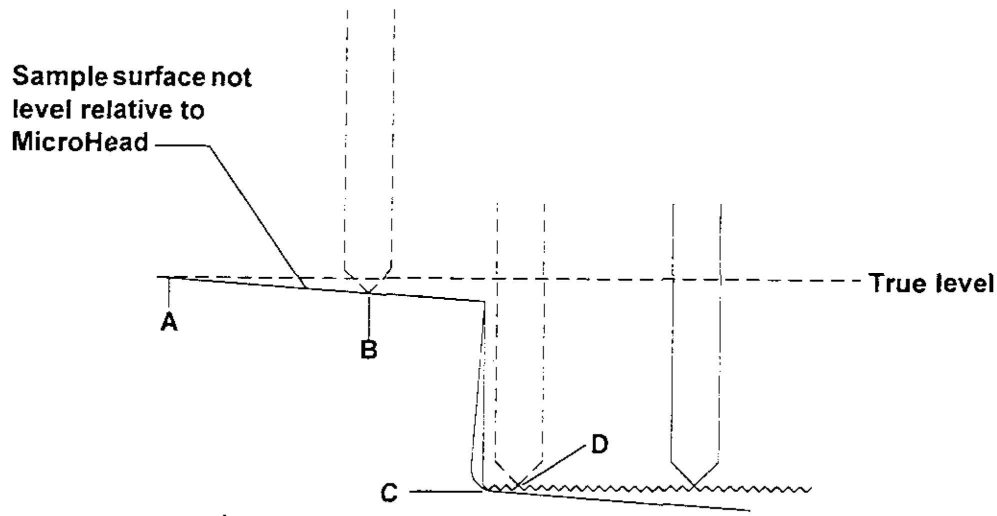


Figure 5-20 Scanning an Unleveled Surface at Low Stylus Force

The stylus is nulled at position A. As the stylus comes near the edge of the step (position B), it has already used up some of its range of vertical motion because of the tilt of the surface relative to the scan motion. At the bottom of the step (position C), the stylus begins to trace the surface, but it has come close to its limit of downward travel. As the stylus continues to move to the right while the sample surface slants away beneath it, it leaves the sample surface and hangs suspended in the air (position D).

Figure 5-21 shows a sample trace taken with low stylus force with a sample that is not level. The stage was purposefully tilted by about half a degree of arc.

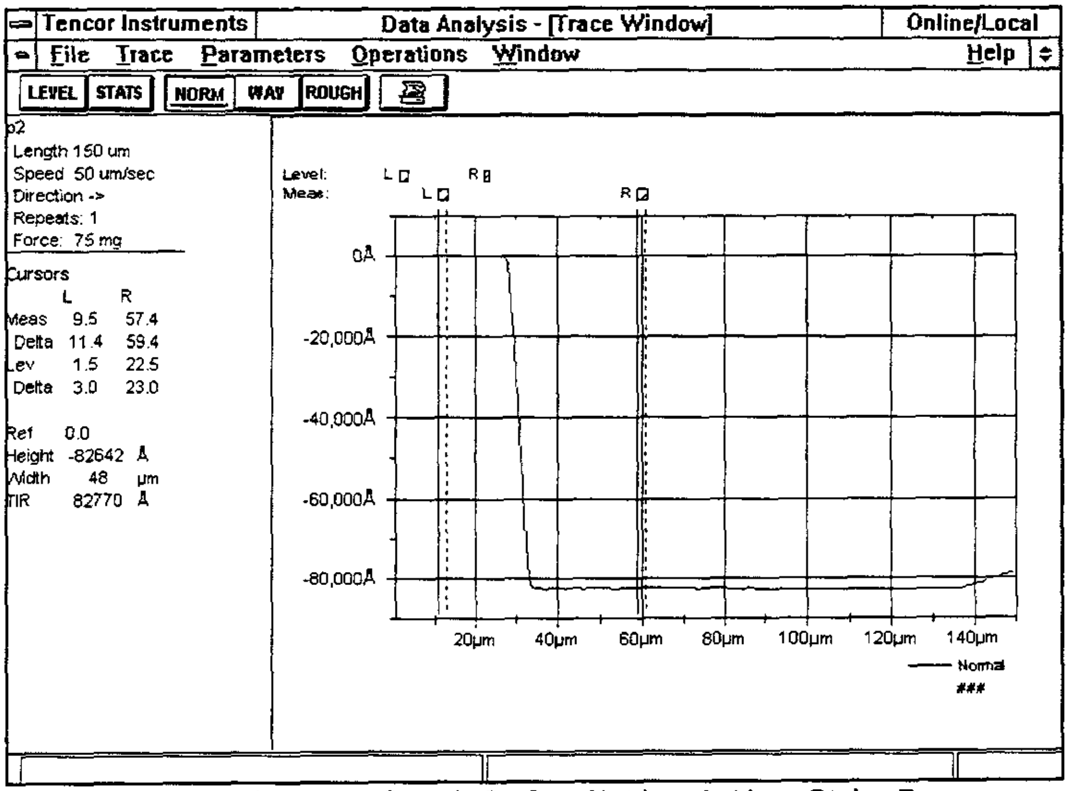


Figure 5-21 Example Trace—Sample Surface Not Level at Low Stylus Force (Data Leveled Correctly)

Good results are possible in such a situation if the stylus traces enough of a flat section of the sample surface so that the data can be leveled. In Figure 5-21, the height recorded in the Summary window is accurate because the data was leveled on the top of the step on the left side of the window.

It is not advisable, however, to take scans when the sample is not mechanically leveled. Figure 5-22 shows the same data as in Figure 5-21 but leveled on the portion of the trace where the stylus was not in contact with the surface. It might not be obvious on examining the Data Analysis window that the stylus was suspended above the sample surface. Ordinarily, there would be no reason to avoid setting the leveling cursors on the bottom of the valley. In fact, you might think it was preferable because you can more widely separate the L and R leveling cursors.

Note that while it is not immediately obvious that the leveling cursors were set on the wrong section of the trace, the measured valley depth is inaccurate.

Note difference between this value and the height in Figure 5-21

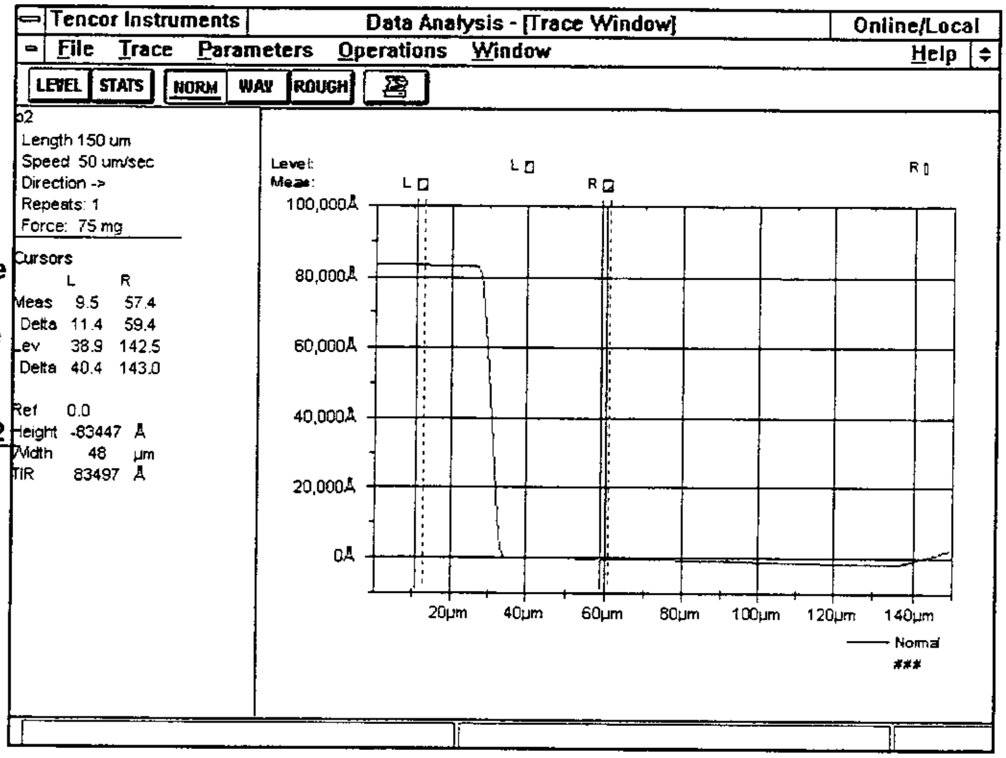


Figure 5-22 Example Trace—Sample Surface Not Level at Low Stylus Force (Data Leveled Incorrectly)

To avoid such effects, there are two things you can do:

- Make certain that the sample surface is mechanically level.
- Use a larger stylus force.

5.5.3 ELECTROSTATIC EFFECTS AND LOW STYLUS FORCES

It is possible for a large electrostatic force to develop between a highly charged sample surface and the MicroHead stylus. This can make calibration and operation at low stylus forces impossible. If you need to profile a non-conductive substrate such as a glass flat, remove any electrostatic charge prior to taking a measurement.

5.6 UNLOADING A SAMPLE

5.6.1 UNLOADING A SAMPLE WITHOUT THE WAFER HANDLER

Unload the sample manually if your instrument does not have a wafer handler, or if you are unloading a sample that is not a wafer.

To unload a sample manually:

1. Click on the Manual Load button in the XY View tool bar to move the stage forward.
2. Open the measurement area door.
3. Turn off the stage vacuum (if it is on) to release the sample and lift it carefully from the measurement stage.

5.6.2 UNLOADING A WAFER WITH THE WAFER HANDLER

This procedure applies to unloading wafers only from instruments that have the wafer handler installed. See Section 5.6.1, "Unloading a Sample without the Wafer Handler," if your instrument does not have a wafer handler, or if you are measuring samples other than wafers.

To unload wafers with the wafer handler:

1. Choose an empty slot in the receiving cassette and note the slot number.
2. Chose Handler Unload from the Substrate menu in the Recipe Editor. The Unload Substrate dialog box appears:

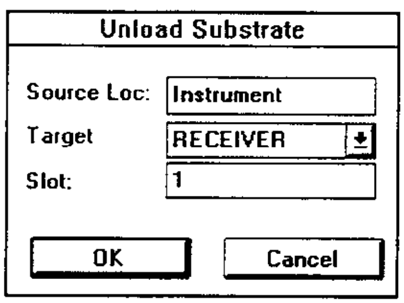


Figure 5-23 Unload Substrate Dialog Box

3. Enter an empty slot number and set the target to the appropriate cassette. Click on OK to continue, or Cancel to close this dialog box and abort unloading.
4. The stage moves to the handler load position, the shutter opens, and the puck removes the wafer from the stage and returns it to the target cassette.

5.7 STAGE ADJUSTMENTS

The stage has two leveling adjustments that might need to be made from time to time depending on whether you have a precision locator installed, or samples with surfaces that are not parallel to the stage table top.

Adjusting the stage alignment relative to the Y-axis of the instrument is called *tilting* the stage. Tilting the stage raises the front edge of the table while the back edge lowers, and vice-versa.

Adjusting the stage alignment relative to the X-axis of the instrument is called *leveling* the stage. Leveling the stage raises the left edge of the table while the right edge lowers, and vice-versa.

The stage can also be rotated about its central spindle to facilitate alignment of the scanning mechanism to the geometry of a given sample.

5.7.1 TILTING THE STAGE

The tilt knob is located at the lower left side of the stage. Note: make sure that there is sufficient clearance between the level motor and the X home switch if you turn the tilt knob more than one full revolution.

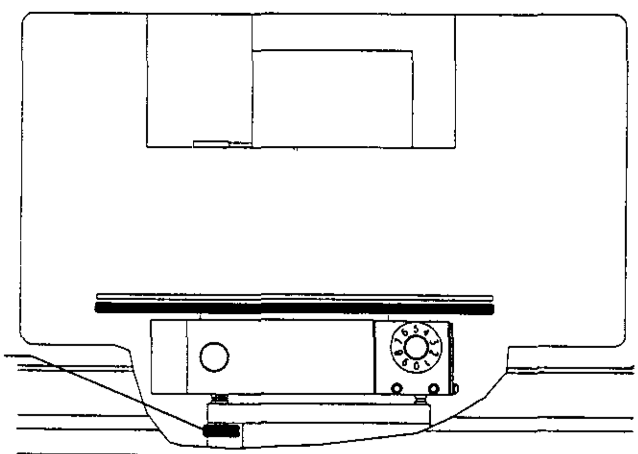


Figure 5-24 Tilting the Stage

5.7.2 LEVELING THE STAGE

If the measured surface is not parallel to the axis of scanning motion, the resulting trace in the Data Analysis window will not be level, causing inaccuracies in the data analysis. This is a particular problem for long scans, where the stylus nulls at the beginning of the scan but soon reaches the limit of its range as the sample surface angles away relative to the scan motion. Similar problems can arise in sequence measurements if the surface is not physically parallel to the scan motion.

If the relative angle between the sample surface and the scanning motion is small, and the scan length is short, it is not necessary to adjust the stage leveling. Software leveling of the data will give good results. Software leveling is discussed in Section 6.2, "Data Leveling and Measurement."

To level the stage:

1. Take a scan. For leveling purposes, it is best to take a long scan at least several millimeters in length.
2. In the Data Analysis window, activate the leveling cursors and set them appropriately.
3. Select Mechanical Leveling from the Operations menu. The following message box appears:

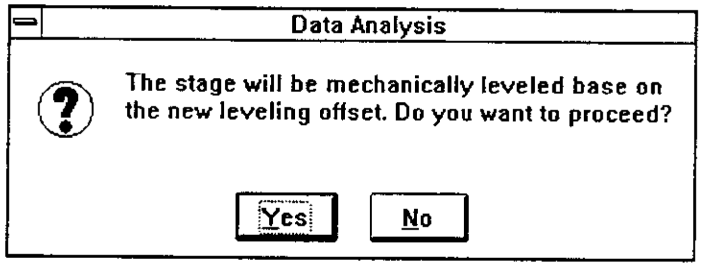


Figure 5-25 Mechanical Leveling Message Box

4. Click OK. The measurement head rises, and the stage level is adjusted. The leveling offset can be viewed in the main Configuration window (Fig. 5-26).

5.7.3 ROTATING THE STAGE

You can rotate the sample stage to adjust the alignment of a sample relative to the scan motion.

To rotate the stage with the trackball:

Click on the button for counterclockwise rotation.

Click on the button for clockwise rotation.

5.8 STAGE CONFIGURATION

The stage configuration settings are modified from the Configuration window.

To view or edit stage settings and configurations:

Double-click on the Configuration icon in the Top Level menu. The following window appears:

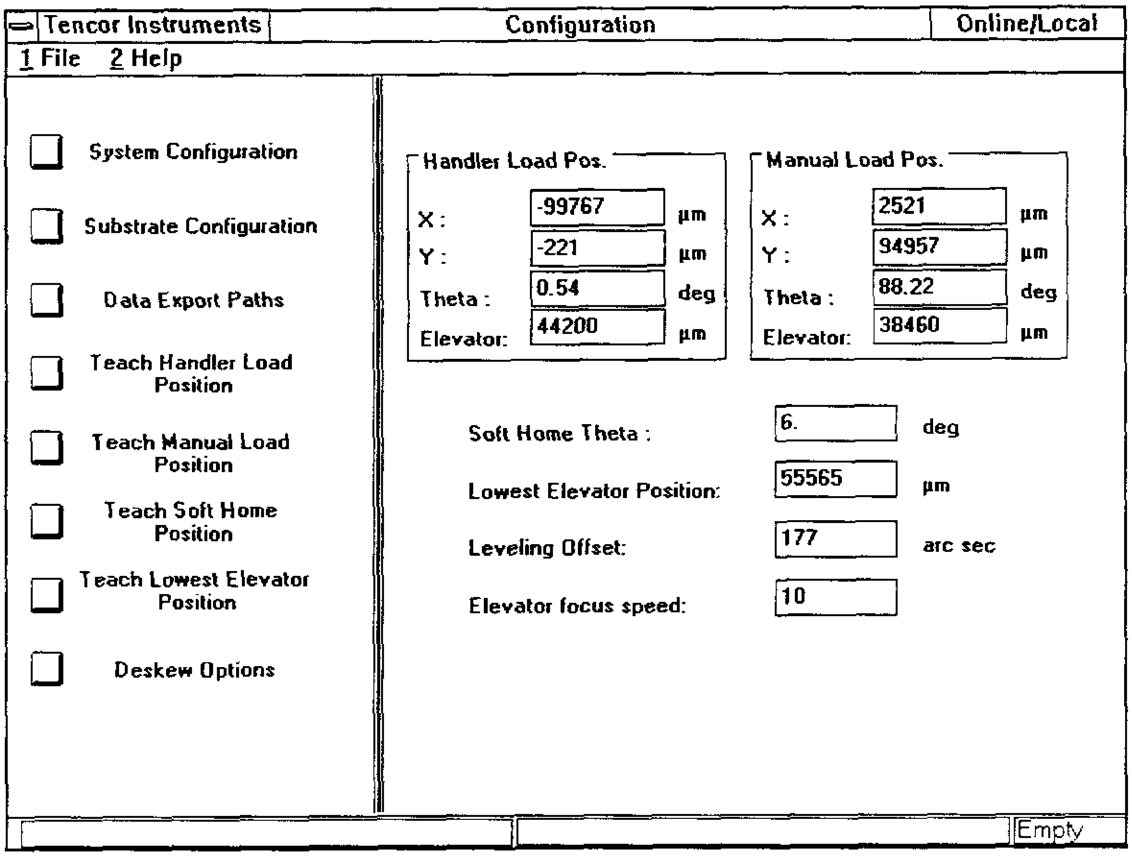


Figure 5-26 Configuration Main Window

The left side of the window contains a series of control buttons; the right side of the window shows the current settings.

The stage configuration routines are discussed in the following sections. For System and Substrate configurations, and Data Export Paths, see Section 2.4, "Configuration," in the *Tencor P-20 Reference Manual.*

5.8.1 HANDLER LOAD POSITION

The Handler Load Position is set by teaching the position. Once it is set it should not be changed.

> **CAUTION: The Handler Load Position should be changed by Tencor-authorized personnel *only*. Incorrect teaching can damage the instrument.**

To teach the Handler Load Position:

1. Click on the Teach Handler Load Position button. The Teach Handler Load Position window appears:

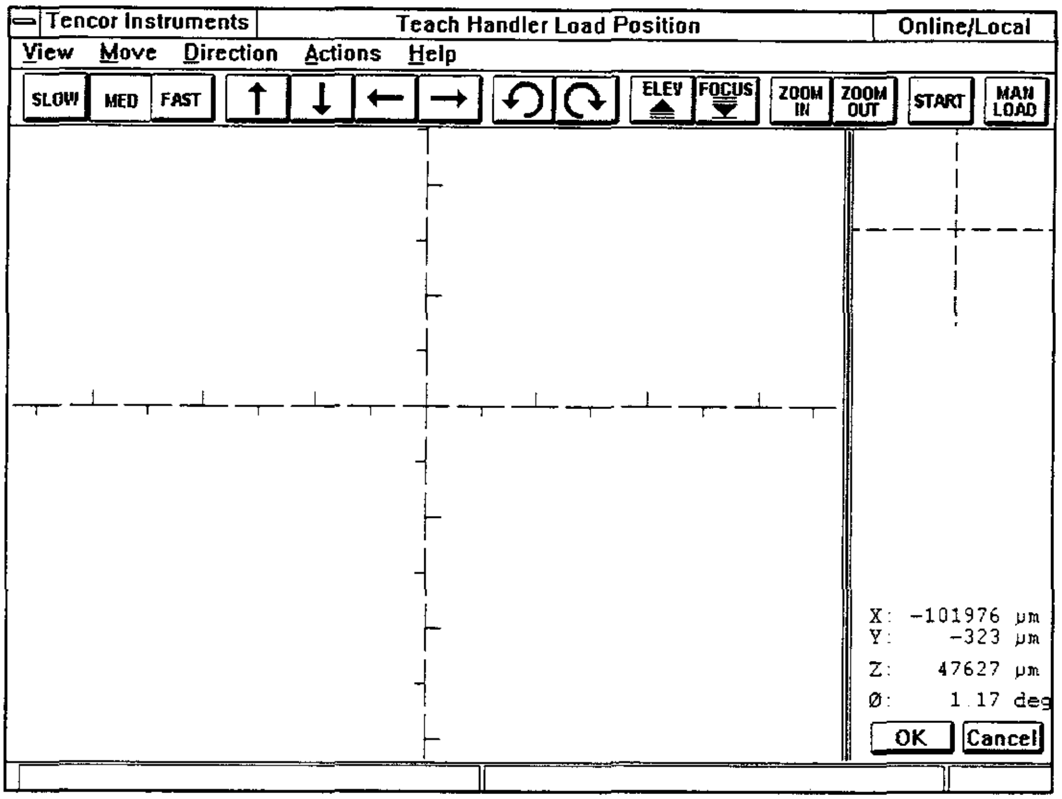


Figure 5-27 Teach Handler Load Position Window

   The stage moves to the current Handler Load Position. You can then move to the desired new position and click on the video image to record its coordinates.

2. Click on OK to save the new position, or click on Cancel to keep the original value and return to the Stage Configurations window.

5.8.2 MANUAL LOAD POSITION

The Manual Load Position can be changed by teaching the new position.

CAUTION:	**When the instrument is powered up or reset, the stage moves to the Z coordinate of the Manual Load Position. Be sure to set the Z coordinate high enough above the stage so that the measurement head will not contact any sample or other hardware that might be present. Incorrect teaching can damage the instrument.**

To teach the Manual Load Position:

1. Click on the Teach Manual Load Position button. The Teach Manual Load Position window appears:

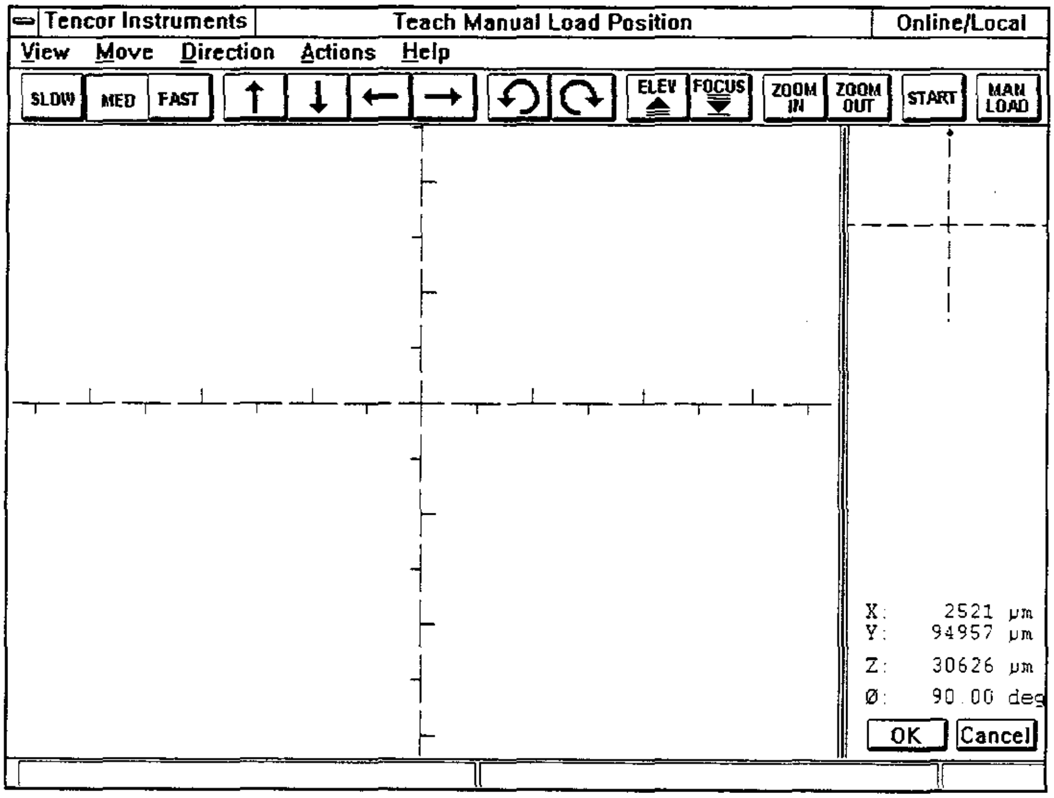


Figure 5-28 Teach Manual Load Position Window

   The stage moves to the current Manual Load Position. You can then move to the desired new position and click on the video image to record its coordinates.

2. If desired, adjust the Z coordinate by raising the head with the Z↑ button in the tool bar.
3. Click on OK to save the new position, or click on Cancel to keep the original value and return to the Stage Configurations window.

5.8.3 SOFT HOME POSITION

The Soft Home Position can be changed by teaching the new position.

To teach the Soft Home Position:

1. Click on the Teach Soft Home Position button. The following message box appears:

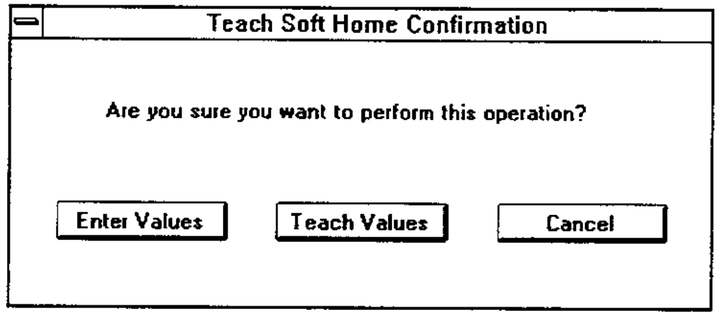


Figure 5-29 Machine Configuration Dialog Box

You can select to Enter Values, Teach Values, or Cancel.

2. If you select Teach Values, The Teach Soft Home Position window appears:

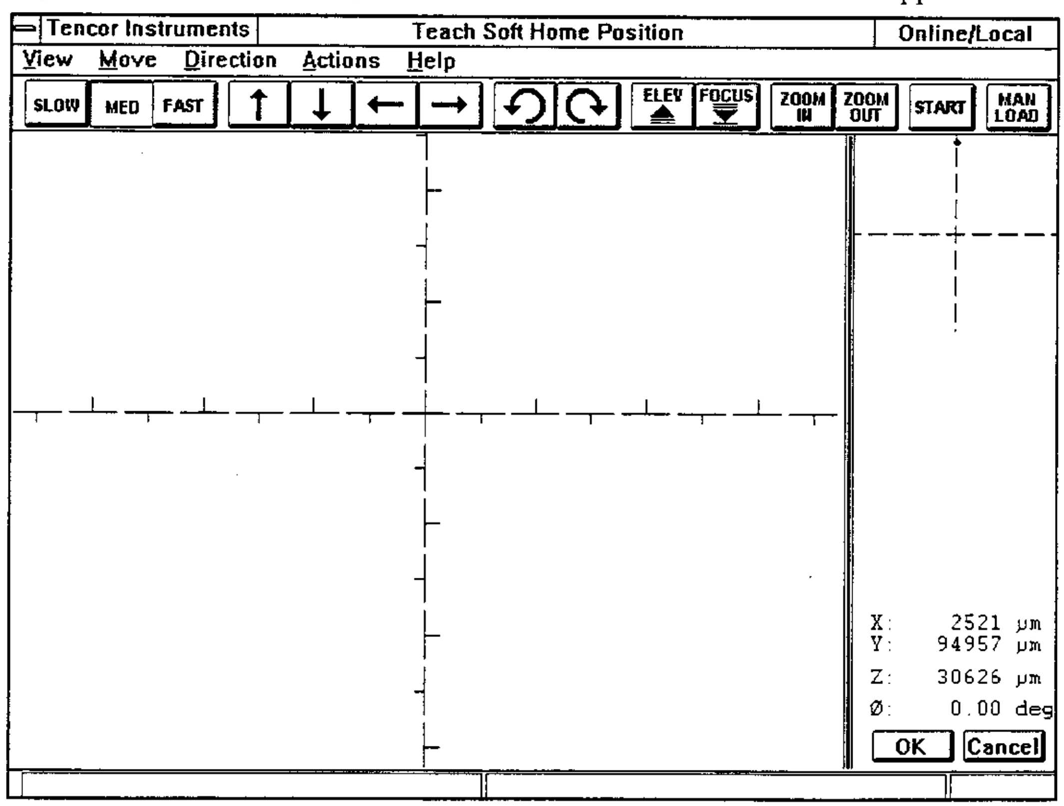


Figure 5-30 Teach Soft Home Position Window

The stage rotates to the current Soft Home theta position. You can then move to the desired new position and click on the video image to record its coordinates.

3. If necessary, rotate the stage to the desired theta position.

4. Click on OK to save the new position, or click on Cancel to keep the original value and return to the Stage Configurations window.

5.8.4 LOWEST ELEVATOR POSITION

The Lowest Elevator Position allow you to restrict the range of vertical motion of the stage. You might wish to set a limit for the elevator so that the measurement head cannot descend past the level of the sample surface, to avoid driving the head onto the sample surface in a case where the stylus drops into a hole or groove, or beyond the edge of a sample.

CAUTION:	**It is very important to determine the correct lowest elevator position when a precision locator is installed. The stylus can be damaged if you leave the stage configured with the original setting.**

To teach the Lowest Elevator Position:

1. Click on the Teach Lowest Elevator Position button. The following window appears:

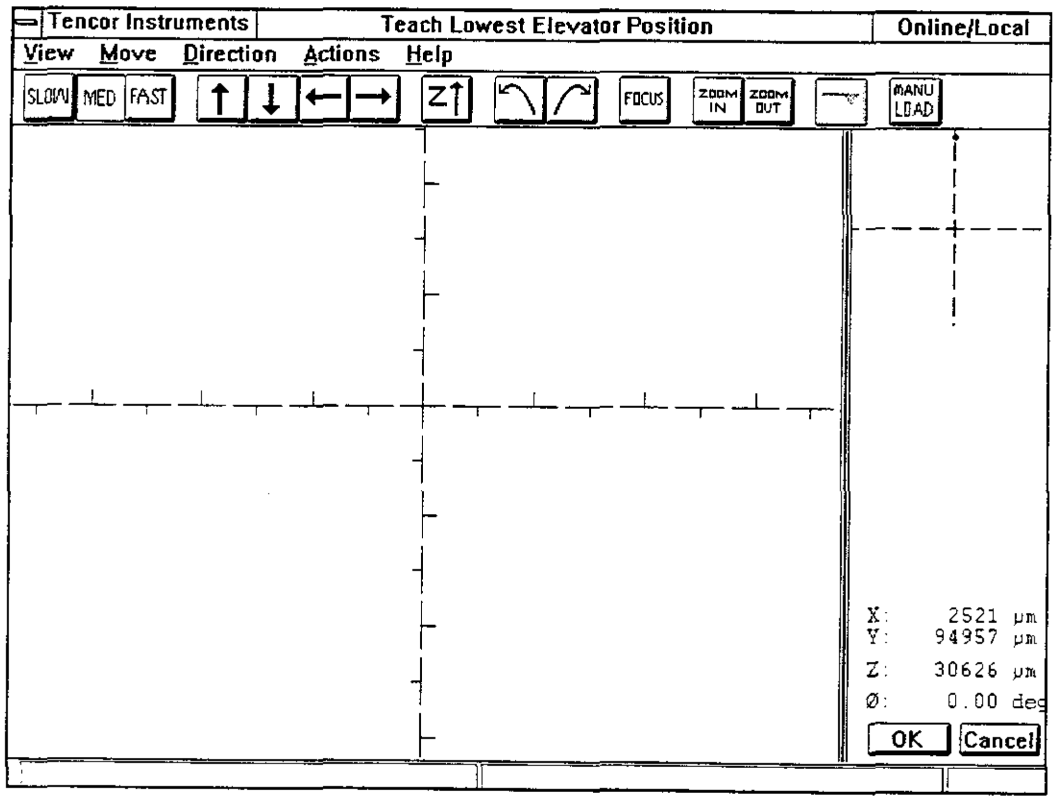


Figure 5-31 Teach Lowest Elevator Position Window

The stage moves to the current lowest elevator position. You can then move to a new position and click on the video image to set the new limit value.

2. Click on OK to accept the new value, or Cancel to retain the original value and return to the Stage Configurations window.

6 ANALYZING SCAN DATA

Once a scan has been completed, the computer processes the measurement data and displays it in the Data Analysis window. This chapter discusses how information is presented in the Data Analysis window and how to analyze and manipulate the data.

This chapter describes

- Parts of the Data Analysis window
- Leveling the data
- Using the measurement cursors
- Using Feature Detection
- Using cutoff filters on the data
- Radius measurements on curved surfaces
- Saving and maintaining data

6.1 DATA ANALYSIS WINDOW

When a scan is completed, the Data Analysis window appears:

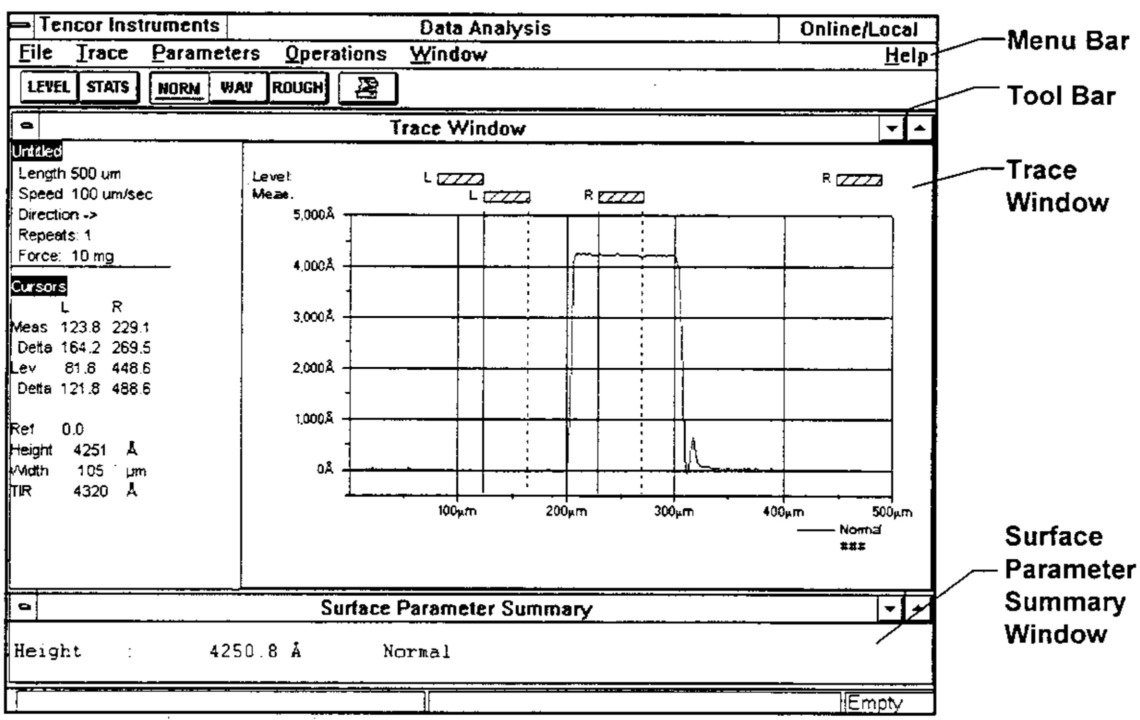


Figure 6-1 Data Analysis Window

The Data Analysis window has two moveable and resizeable subwindows. A plot of the normal data, along with a summary of parameter calculations, is displayed in the Trace window. The complete set of parameter calculations appear in the Surface Parameter Summary window.

You can also review previously saved data in the Data Analysis window.

To review previously saved data:

1. From the Database Catalog window, select Scan Data. The Scan Data Catalog is displayed:

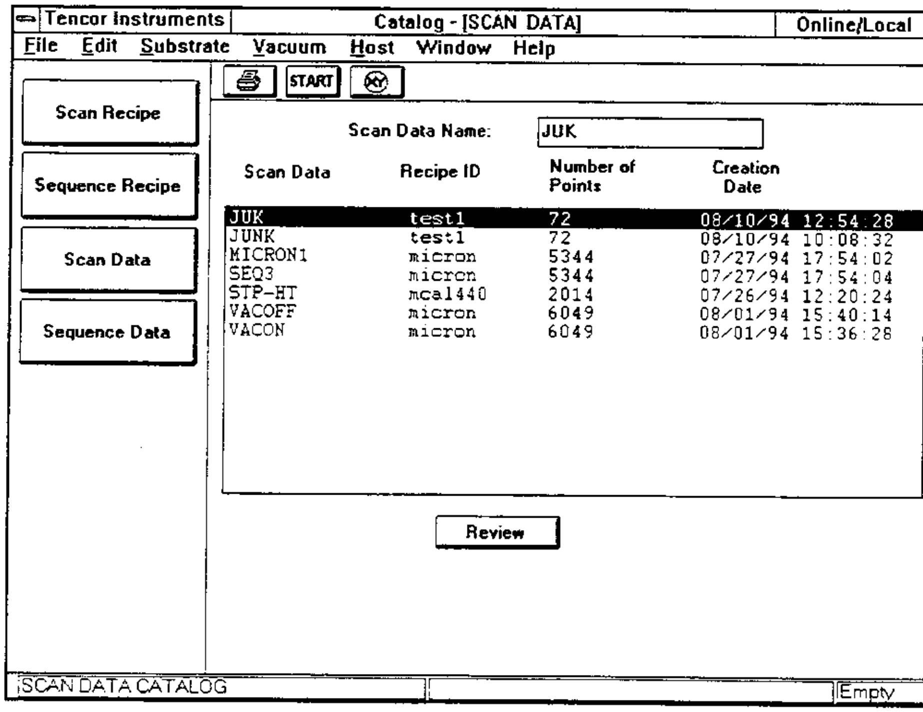


Figure 6-2 Scan Data Catalog Window

2. Click on the name of the desired data set in the list, and then click on the Review button below the list, or double-click on the name of the desired data set. The Data Analysis window appears with the selected data set displayed.

6.1.1 DATA ANALYSIS MENU BAR

The Data Analysis menu bar provides the following menus. You can view menus by clicking on the titles in the menu bar, or by pressing ALT + *l*, where *l* is the letter that appears with an underscore in the desired title in the menu bar. You can choose menu items by clicking on a menu entry or by typing the letter that appears with an underscore in the desired menu item.

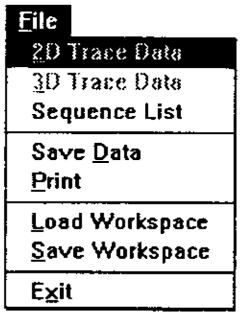


Figure 6-3 File Menu

Figure 6-4 Trace Menu

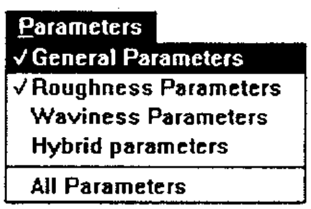


Figure 6-5 Parameters Menu

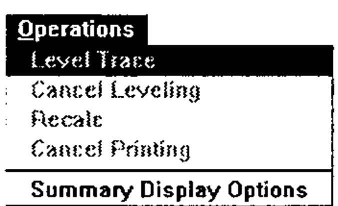


Figure 6-6 Operations Menu

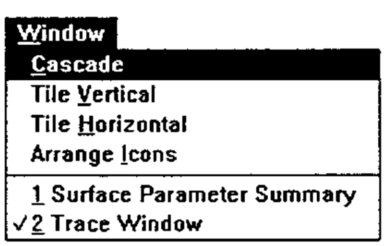


Figure 6-7 Window Menu

6.1.2 DATA ANALYSIS TOOL BAR

The Data Analysis tool bar contains a row of icons that resemble buttons. Clicking on these buttons provides an alternative way to access commonly used functions. Each icon suggests the function of the button. Buttons that appear dimmed are unavailable.

The Data Analysis tool bar contains the following buttons.

Button	Action
	Toggles between the leveling and measurement cursors.
	Switches focus to the Surface Parameter Summary window. If the Surface Parameter Summary window is currently minimized, it appears maximized upon clicking this button.
	Toggles display of normal trace.
	Toggles display of waviness trace.
	Toggles display of roughness trace.
	Displays the Print dialog box.

6.2 DATA LEVELING AND MEASUREMENT

This section discusses leveling of the scan data, not the mechanical leveling of the stage relative to the measurement head. See Section 5.7.2, "Leveling the Stage," for a discussion of mechanical leveling.

To accurately measure anything, you need to have a sensible frame of reference. For 2-D scan data, this amounts to indicating two points along the scan that are at equal heights. These two points define a reference axis for plotting the data and calculating surface parameters.

In the Tencor P-20 Data Analysis window, the two points are indicated by using a pair of vertical lines called the leveling cursors. The initial position of the leveling cursors is set in the recipe, but you are free to reset their positions at any time after the scan is taken.

Often you can determine acceptable leveling cursor positions in advance by viewing a sample in the XY View window prior to finalizing the recipe and scanning. However, it is not always obvious, or you might accidentally set them at inappropriate locations. In an extreme case, the left leveling cursor might be at the bottom of a large step, and the right leveling cursor on the top. Using these two points to define a reference axis, the plotted data looks something like the following figure.

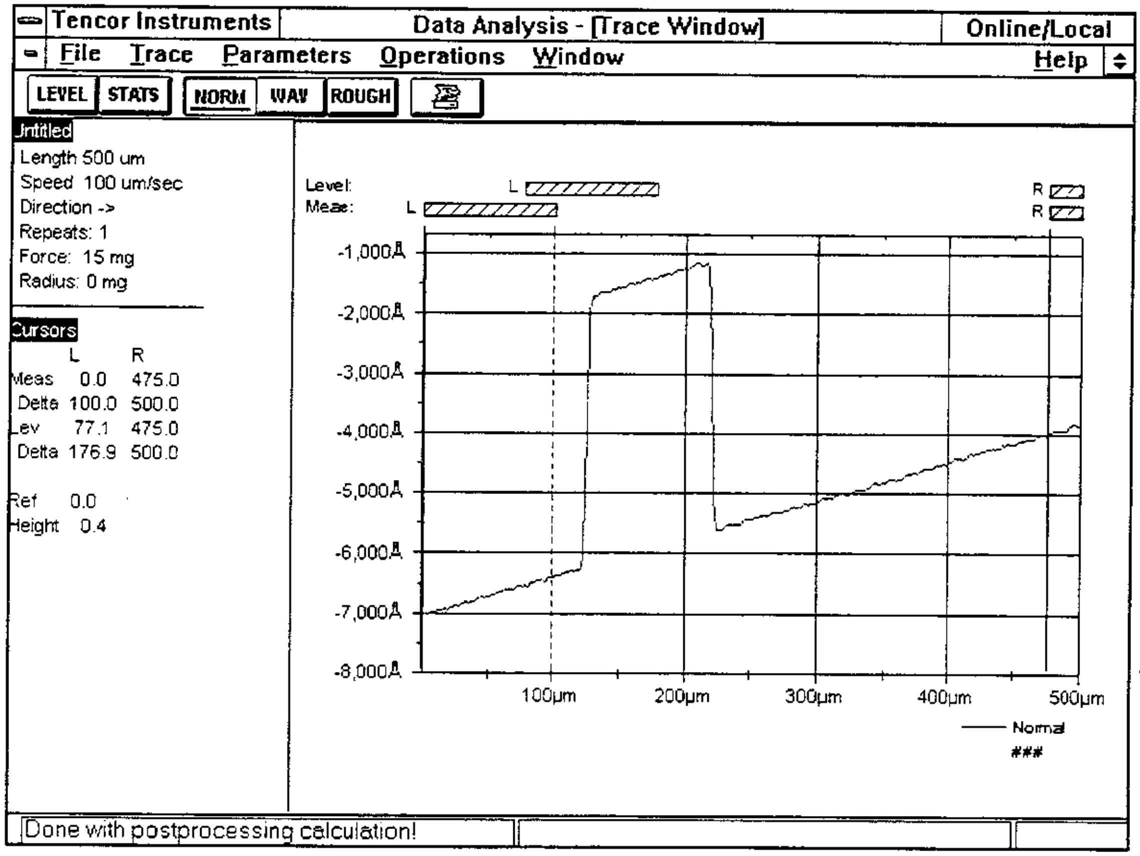


Figure 6-8 Data Before Leveling

Fortunately, you have complete control of the leveling cursors, so you can readjust them until they indicate two points that are at the same height. Then you have the computer replot the data with these new positions, and the result is something like the following figure.

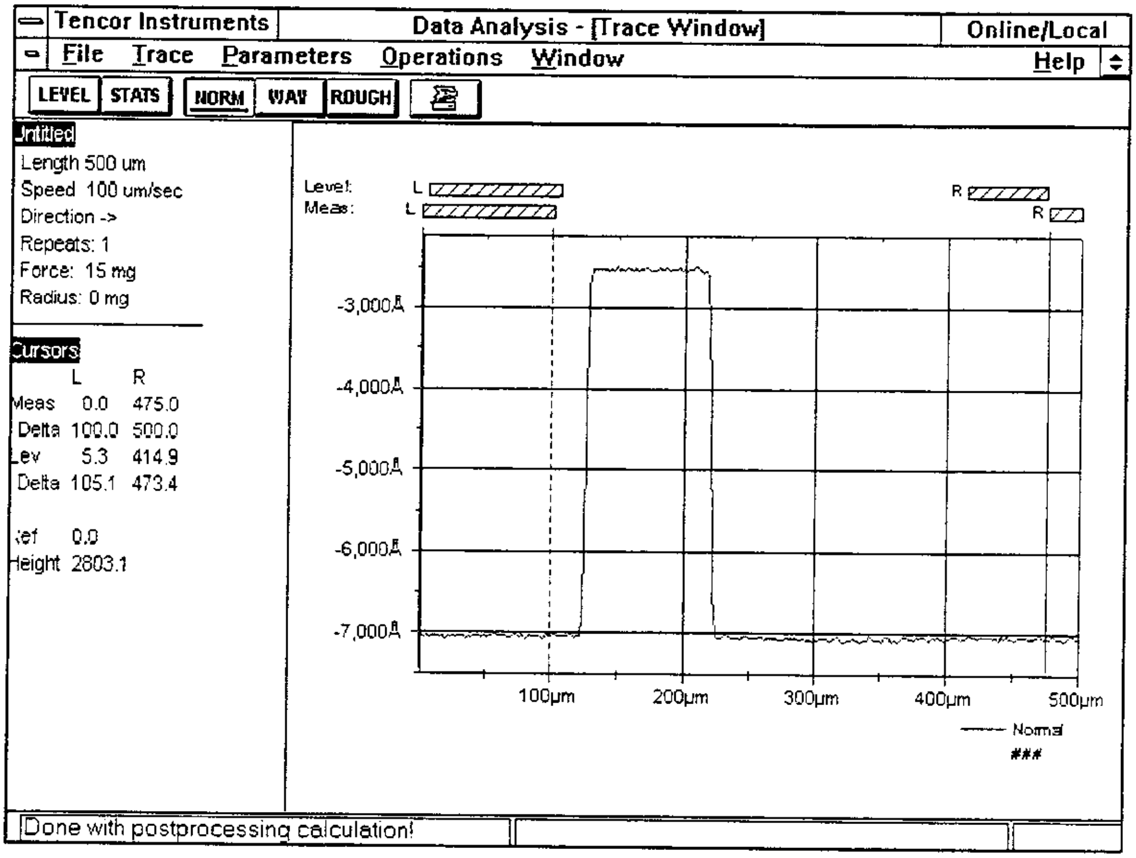


Figure 6-9 Data After Leveling

This Data Analysis window can now provide you with some meaningful measurements. Again, you need a way to indicate to the computer what you want to measure. For example, if you want to know the difference in height between two points, you need to be able to indicate those two points to the computer.

This is accomplished using another pair of vertical lines, the *measurement cursors*. The Data Analysis window appears with the measuring cursors set at the locations specified in the scan recipe.

Like the leveling cursors, the measurement cursors can be freely moved to any position. The displayed parameter values are recalculated whenever the measurement cursors are moved to new locations.

To set leveling or measurement cursors:

1. If you are going to set the leveling cursors:

   - Select Level Trace from the Operations menu, or click on the Level Trace button in the tool bar. This activates the leveling cursors. They are at the locations currently specified in the recipe, with the left cursor currently selected.

   If you are going to set the measurement cursors, they will normally be active, unless the leveling cursors have been activated

2. Press [<] or [>] or use the trackball to move the left cursor to the desired position.
3. Press the spacebar to select the right cursor and adjust its position with the arrow keys or the trackball. The cursors can also be set to move in tandem:

   - Press the spacebar twice quickly to select both the left and right cursors. Use the arrow keys or trackball to position them.

4. If you are leveling:

   - Once the cursors are positioned as desired, select Level Trace from the Operations menu, or click on the Level Trace button in the tool bar. The data is leveled and replotted. The leveling cursors become inactive and the measurement cursors become active.

   If you are setting the measurement cursors, the values of the displayed parameters are automatically updated each time you move the cursors.

You can also use the leveling cursors in *Delta Average* mode, where each cursor can be expanded to define a region. The average value of the height within the region is then used for leveling the data. On rough or noisy scans, you should use Delta Averaging for best results.

To set leveling or measurement cursors in Delta Average mode:

Press [∧] to activate Delta Averaging of the currently active cursor. A second vertical line appears to the right of the active cursor, defining a range. Adjust this range as follows:

- Hold down [∧] to expand the cursor range and release when the width is satisfactory.
- Press and hold down [∨] to reduce or eliminate the width and release when the width is satisfactory.
- Press the spacebar twice quickly to select both the left and right cursors and adjust their ranges in tandem if desired.

If desired, you can set the cursor positions stored in the recipe with the new positions of the cursors.

To save the current cursor positions in the Scan recipe:

Choose Recalc from the Operations menu.

6.3 USING FEATURE DETECTION

Consider a situation where you wish to compare the step heights from ten different instances of an artifact on a sample. It is difficult without taking extra care to start each of the ten scans at precisely the same location relative to the artifacts. Typically, the measurement cursor settings from the first scan will not precisely compare to the same locations relative to the feature on the subsequent scans. Therefore, you need to manually adjust the measurement cursors for each scan. This can be tedious and introduces some imprecision into the comparison, since it is difficult to locate the cursors manually in exactly the same way for all the scans.

Feature Detection makes it possible to automatically and reliably set the position of the measurement cursors relative to the rising or falling edge of a steplike feature, or the apex of an arclike feature. For each instance, then, you need not worry that you are starting the scan at precisely the same distance in front of each of the artifacts. This eliminates the need to manually adjust the cursors for each scan, facilitating comparison between two or more instances of an artifact.

Both the location of the edge (or the apex of an arc) and the step width can be calculated and displayed in the Data Analysis window.

For steplike features, Feature Detection distinguishes between rising or falling edges. Since steps are rarely perfectly vertical. Feature Detection also distinguishes between two types of edges. The following convention is used: the location at the *top* of the slope is called the edge, and the location at the *bottom* of the slope is called the base. The following figure shows this convention for a plateau and a valley.

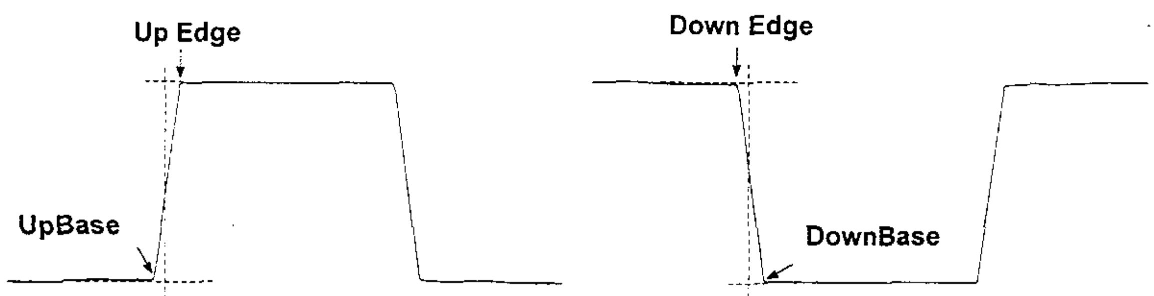


Figure 6-10 Edges of a Step

Feature Detection also distinguishes between convex (hill-like) and concave (valley-like) arcs (Fig 6-11).

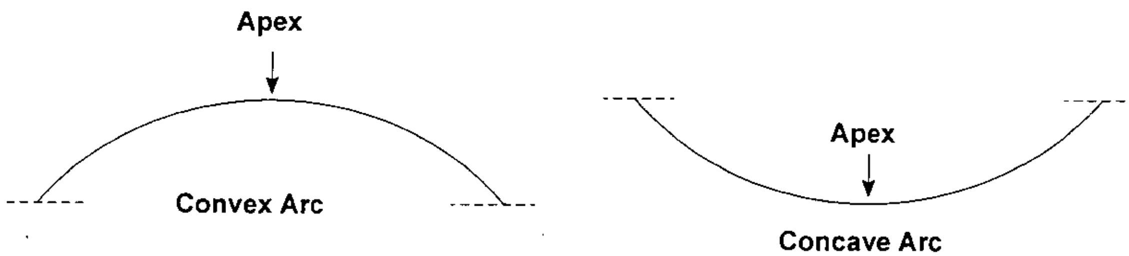


Figure 6-11 Convex and Concave Arcs

Feature Detection parameters are configured in the Recipe Editor window:

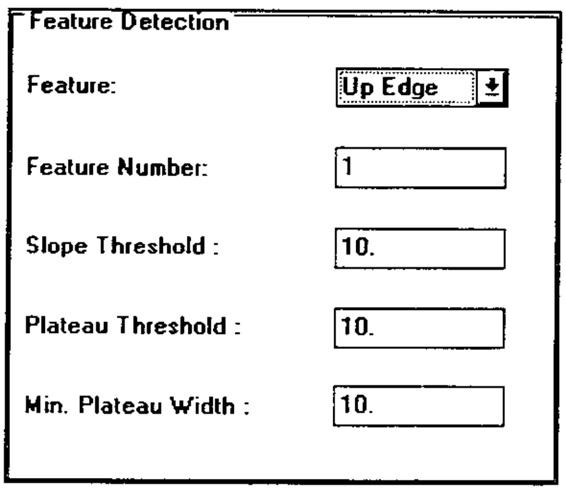


Figure 6-12 Feature Detection Dialog Box

You must set several values to specify the type of the step edge or apex feature that you are measuring. A description of these values follow.

Feature

The Feature field identifies the type of feature to be detected, or turns Feature Detection off. The selection box has seven possible choices:

- None (no Feature Detection)
- UpEdge (rising edge)
- DownEdge (falling edge)
- UpBase (rising base)
- DownBase (falling base)
- Convex (hill-like arc)
- Concave (valley-like arc)

If None is selected, the remaining fields in the dialog box are unavailable and appear dimmed.

Click anywhere in the selection box and click on the desired item in the list or double-click in the selection box and type the first letter or letter of the desired item in the list.

Feature Number

If there are multiple edges detected in a scan, Feature Number provides a way to select a particular edge for detection. Detected edges are numbered sequentially from 1 to n.

Slope Threshold

This factor sets the value at which an upward slope in the trace is considered to be preceding the step height edge or apex; that is, when an upward slope appears that rises significantly above the general roughness of the surface.

Valid values range between 0–50.000. When the artifact is much larger in comparison to the surrounding roughness of the surface, set the value higher. If the artifact is only a little larger than the surrounding roughness, set this value lower. Note that in this case, you might also need to set the Minimum Plateau Width (description follows) to avoid any ambiguity.

The concept of the Slope Threshold is very similar to a a signal-to-noise ratio. The best values for a given sample will depend on the relative scales of the artifact that you are examining and the surrounding surface roughness, as well as parameters such as scan speed, sampling rate, and so on. You might need to experiment to find appropriate values for Slope Threshold. The default values of 5.000 (for a step) and 1.000 (for an apex) are sufficient for most scans above 200Å.

Click in the Slope Threshold field and type the desired value.

Plateau/Apex Threshold

This factor affects the precise horizontal location calculated for the edge or arc. Since the edge of a step is rarely a perfectly defined location, this factor allows you to adjust the value to the left or right, depending on whether you consider the edge to be the bottom of the step, the top of the step, or somewhere in between.

For an edge, set this value to about the same value as the Slope Threshold. Valid values range between 0–50.000. Setting this threshold slightly greater than the Slope Threshold will move the precise location of the edge slightly to the left for an UpEdge or to the right for a DownEdge. Setting this threshold slightly smaller than the Slope Threshold will move the precise location of the edge slightly to the right for an UpEdge or to the left for a DownEdge. For UpBase and DownBase, the adjustment is the reverse. For a Concave or Convex arc, set this value to a very small number, between 0–1.000. You might need to experiment to find appropriate values for Plateau/Apex Threshold depending upon the relative scales of the artifact that you are examining and the surrounding surface roughness. The default values of 5.000 (for a step) and 0.000 (for an arc) are sufficient for most scans above 200Å.

NOTE:	**The Slope Threshold determines whether or not an edge is detected; the Plateau/Apex Threshold determines only the precise reported location of a detected edge.**

Click in the Plateau/Apex Threshold field and type the desired value.

Minimum Plateau Width

This value specifies the minimum horizontal length between a rising and falling edge, used in the feature detection calculation to determine the correct edge. This is useful in cases when the roughness of a surface might be large enough that it becomes difficult to adjust the Slope Threshold to find the correct feature without ambiguity. In such cases, narrow roughness peaks can extend above the height determined by the Slope threshold without causing the algorithm to identify them as the edge.

For steplike features, the Minimum Plateau Width specifies a plateau as follows:

- For ascending features (UpEdge, UpBase), the plateau is the one following the detected edge.
- For descending features (DownEdge, DownBase), the plateau is the one preceding the detected edge.

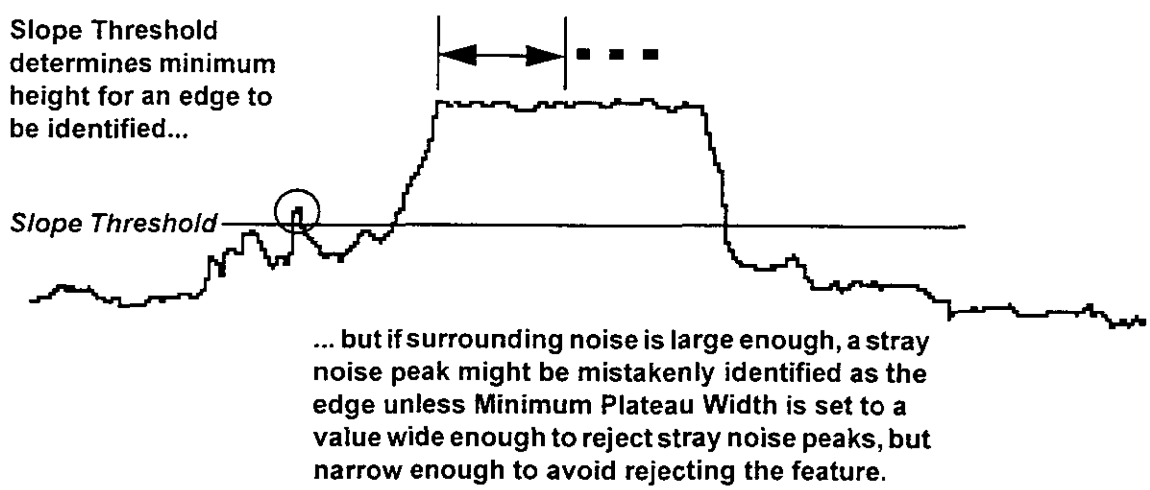


Figure 6-13 Feature Detection and Minimum Plateau Width

The Minimum Plateau Width can be used to reject such peaks that may otherwise cause failure to detect the correct edge. For UpEdge, DownEdge, UpBase, or DownBase features, set this value to be greater than the width of stray peaks, but always slightly less than the width of the step to be detected. Set this value to slightly less than the step width. Setting it too high will result in no edge being found. Valid values are in the range 0.005–1000.00 μm (0.0002–39.3701 mil).

NOTE:	**Minimum Plateau Width is not intended for use with Concave or Convex features. In cases of rough sample surfaces, though, it might be useful. For a Convex arc, the Minimum Plateau Width specifies a minimum width for the feature, and so can be used to reject narrow roughness peaks in the vicinity of the arc. For a Concave arc, the Minimum Plateau Width is used to specify a minimum size for a level section following a detected arc.**

Click in the Minimum Plateau Width field and type the desired value.

When Feature Detection is enabled, the following General Parameters are interpreted as follows.

Edge (Distance to Edge)

Depending on the setting of the Slope Threshold and the Plateau/Apex Threshold, this distance is either

- The distance between the beginning of the scan and the first rising or falling edge or base of a step; or
- The distance between the beginning of the scan and the apex of the first convex or concave arc.

StpWt (Width of Step)

The width of a step plateau; that is, the distance between the leading and trailing edges of the plateau. The StpWd value does not apply in the case of an arc.

NOTE:	**It is important that you can use the Feature Detection calculation reliably if you have set the thresholds appropriately for the particular type of feature you are scanning. Also note that the profile scan length must be long enough that the artifact is completely included, and that there is enough scan data on either side for the leveling cursors to be set reliably.**

The following figures (Figs. 6-14 through 6-16) demonstrate the usefulness of Feature Detection. The three scans were taken across the same section of the artifact, but the scans began and ended at different points along the profile. Delta Average cursors are used.

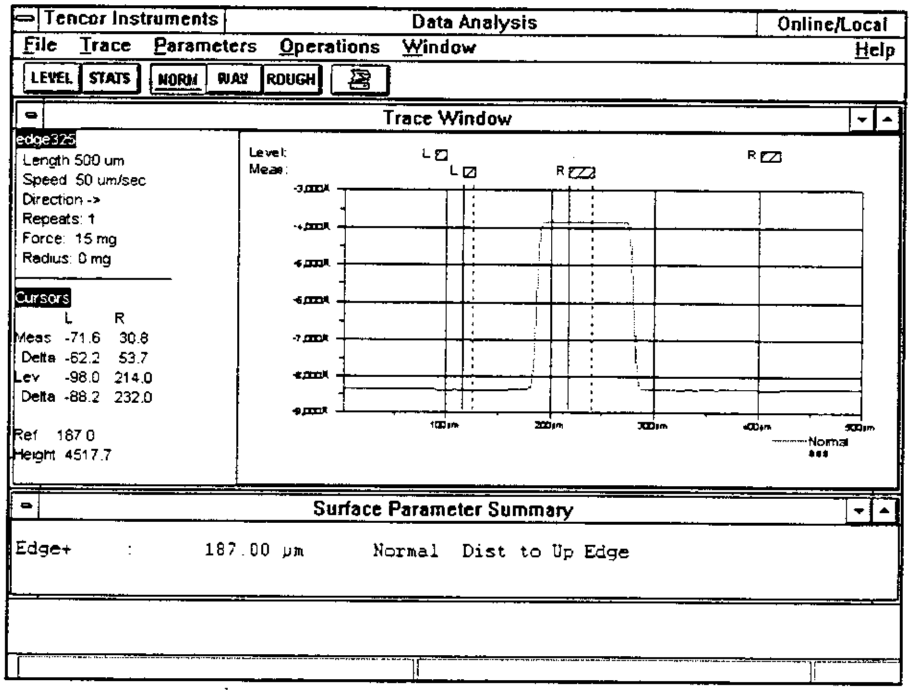


Figure 6-14 Scan 1 with Feature Detection Enabled

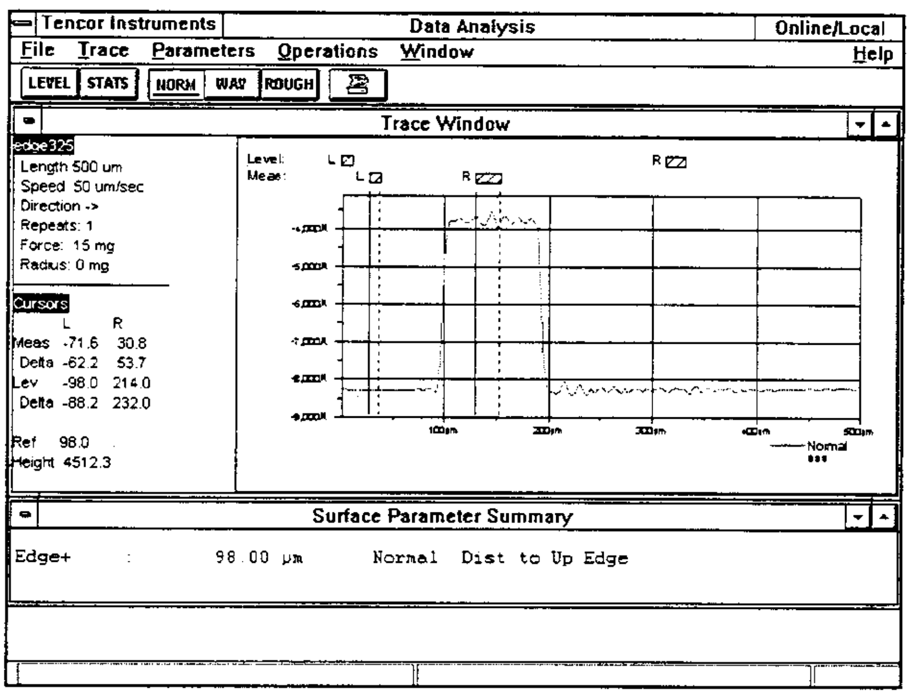


Figure 6-15 Scan 2 with Feature Detection Enabled

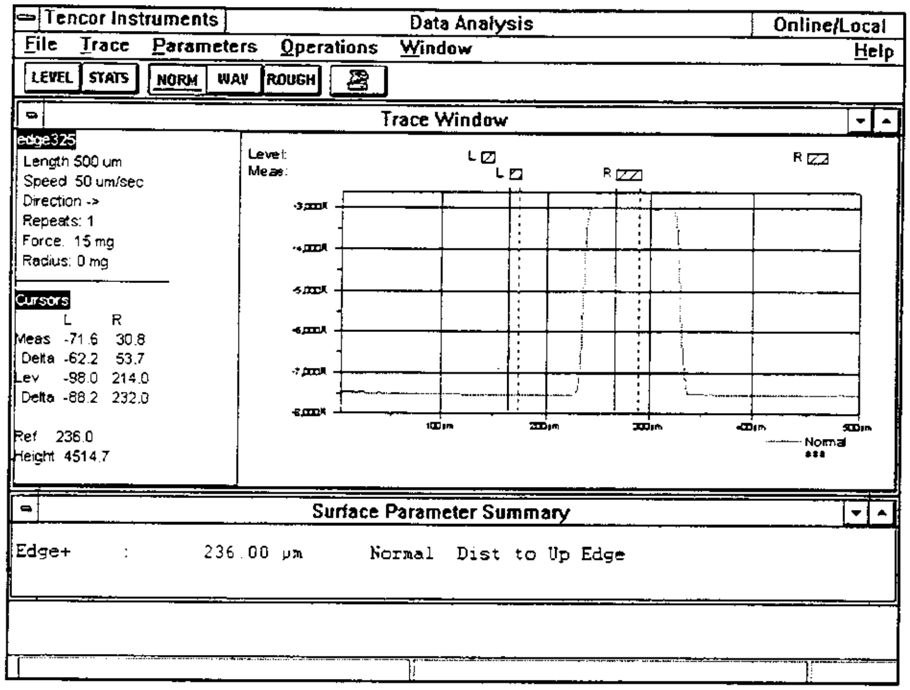


Figure 6-16 Scan 3 with Feature Detection Enabled

6.4 USING CUTOFF FILTERS

The Tencor P-20 scan data does not come directly from the sensor, but instead is filtered through three stages:

- an analog hardware filter
- a digital decimation filter
- digital software filtering

The sensor output is filtered by the analog hardware filter so that it can be digitized with minimal distortion. The filter also reduces noise by attenuating higher frequencies. It has a fixed cutoff frequency of 18 Hz.

The signal then passes through an analog-to-digital (A/D) converter. The A/D converter has a nominal sampling frequency of 200 Hz (100 Hz at the 1 µm/s and 2 µm/s scan speeds).

Next, the signal passes into the digital decimation filter. This step is necessary to reduce the signal sampling rate from the original 200 Hz (or 100 Hz) down to the sampling rate selected in the recipe by the user. If you select the maximum sampling rate in the recipe, no decimation is done.

Along with reducing the sampling rate, the decimation filter also affects the cutoff frequency of the scan data. At 100 Hz, the cutoff frequency is not significantly reduced, but at 50 Hz, the cutoff frequency is reduced to 14 Hz.

The cutoff wavelength depends on the scan speed by the following equation:

$$\textit{Cutoff Wavelength} = \frac{\textit{Scan Speed}}{\textit{Cutoff frequency of combined filters}}$$

For example, with a scan speed of 100 μm/s, and a sampling rate of 200 Hz or 100 Hz, the cutoff wavelength is 5.6 μm. With this same scan speed, however, at a sampling rate of 50 Hz, the cutoff wavelength is 7.1 μm.

The action of a cutoff filter can be illustrated by plotting the percentage of signal transmission as a function of wavelength (usually plotted as the logarithm of wavelength). Note that there is always some slope in the transmission curve of a cutoff filter; that is, the transmission percentage is not exactly zero for all values on one side of the cutoff value and exactly 100 for all values on the other side of the cutoff value. The cutoff wavelength of a filter is defined by that wavelength at which 50% of the signal is passed.

The following figure shows the transmission curve of the combined analog and decimation filters. For every factor of ten in scan speed, the curve moves to the right by a factor of ten in wavelength.

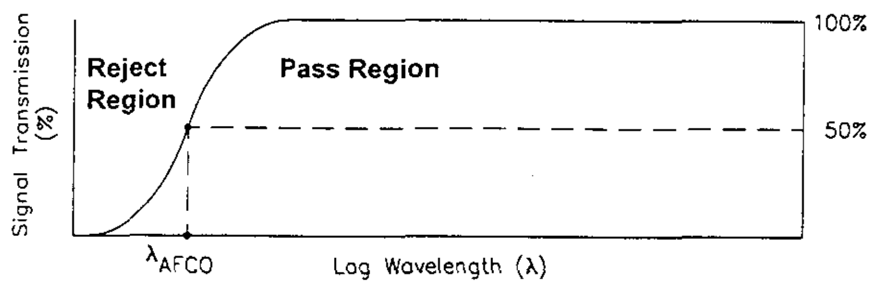


Figure 6-17 Effect of the Analog Filter and Decimation Filter on Signal Transmission

Two adjustable software cutoff filters allow you to control the range of wavelengths collected in your scan data. You might wish to filter data to

- reduce the effect of small surface irregularities or environmental noise
- remove large-scale waviness and form error so that roughness can be evaluated unambiguously
- isolate specific frequency bands, allowing determination of intermediate components of roughness or waviness

The *short wave cutoff* (or long wave pass) filter, as the name implies, cuts off the short wavelengths in the data (those below the filter's *cutoff value*), passing the longer wavelengths.

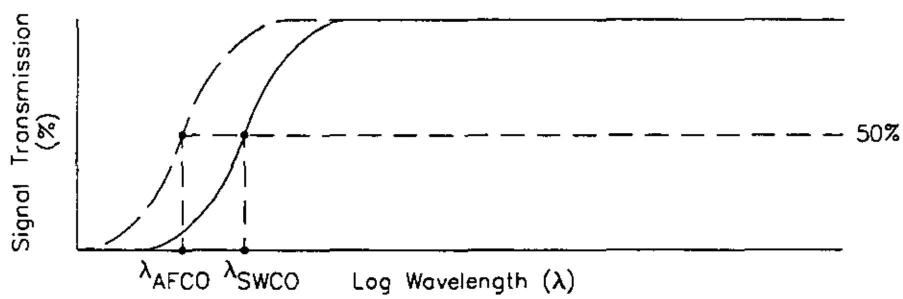


Figure 6-18 Effect of the Short Wave Cutoff Filter

Conversely, the *long wave cutoff* (or short wave pass) filter cuts off the higher wavelengths in the data (those above the filter's cutoff value), passing the shorter wavelengths.

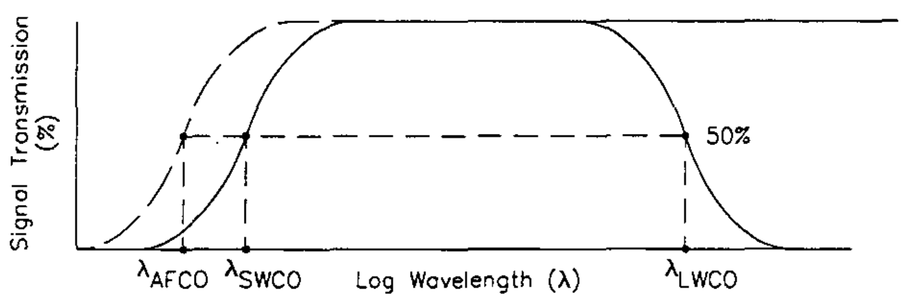


Figure 6-19 Effect of the Long Wave Cutoff Filter

You can use the two filters separately, or together to form a *band pass* filter that cuts off all short wavelengths below the short wave cutoff value *and* all long wavelengths above the long wave cutoff value. Note that the software will not allow setting a short wave cutoff that is larger than the long wave cutoff, which of course would result in a zero-width band of wavelengths, attenuating all of the data.

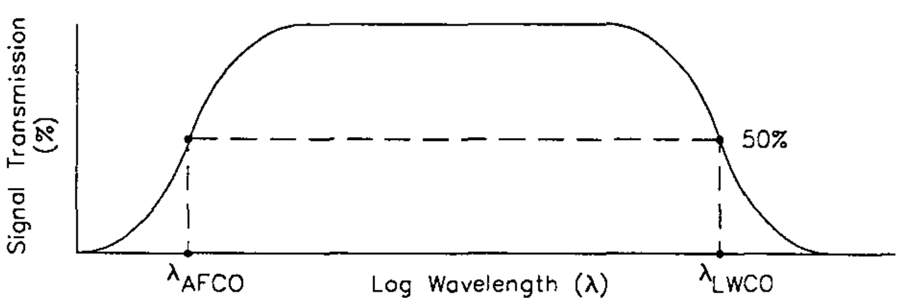


Figure 6-20 Defining a Pass Band with the Short Wave and Long Wave Cutoff Filters

To set the short wave filter cutoff values:

Click on the drop-down box to choose a value from the range of short wave cutoff filters provided, or use the default setting. The full range of selectable values are listed in Table 6-1.

Table 6-1 Short Wave Cutoffs

µm	mil	µm	mil	mm	mil
Default[1]	–	14	.56	1.4	56
0.25	.01	25	1.0	2.5	100
0.45	.02	45	1.8	4.5	180
0.80	.03	80	3.0	–	–
1.4	.06	140	5.6	–	–
2.5	.10	250	10.0	–	–
4.5	.18	450	18.0	–	–
8.0	.30	800	30.0	–	–

[1]Refer to Table for default short wave cutoff values.

Up to nineteen possible settings (including the default) are available depending on the scan speed. You are prevented from mistakenly entering a short wave cutoff that is longer than the currently selected long wave cutoff, or shorter than the value of the analog cutoff. For scan speeds greater than 5 µm/s, the shortest short wave cutoff selection turns off the short wave cutoff filter.

If subsequent changes to the scan speed or scan length cause the short wave cutoff setting to become invalid, the cutoff is automatically changed to the nearest available valid value (possibly the default).

The default cutoff depends on the scan speed and sampling rate. The full range of default short wave cutoffs are listed in Table 6-2.

Table 6-2 Default Short Wave Cutoffs

Speed (µm/s)	Sampling Rate (Hz)	Short Wave Cutoff Frequency (Hz)	Short Wave Cutoff Wavelength (µm)
2	50	4	0.50
	100	7.5	0.27
	200	12	None available
5	50	4	1.25
	100	7.5	0.67
	200	12	0.42
10	50	4	2.50
	100	7.5	1.33
	200	12	0.83
20	50	4	5.00
	100	7.5	2.67
	200	12	1.67
50	50	4	12.50
	100	7.5	6.67
	200	12	4.17
100	50	4	25.00
	100	7.5	13.33
	200	12	8.33
400	50	4	100.00
	100	7.5	53.33
	200	12	33.33

To set the long wave filter cutoff values:

Click on the drop-down box to choose a value from the range of cutoff filters provided, or turn off the filter. Selectable values are listed in Table 6-3.

Table 6-3 Long Wave Cutoffs

µm	mil	µm	mil	mm	mil
4.5	0.18	80[1]	3.0[1]	1.4	56
8.0	0.30	140	5.6	2.5	100[1]
14	0.56	250[1]	10.0[1]	4.5	180
25	1.0	450	18.0	–	–
45	1.8	800[1]	30.0[1]	–	–

[1]Cutoffs specified in ANSI B46.1-1985

Up to sixteen filter choices are available depending on the scan speed. You are prevented from mistakenly entering a long wave cutoff that is shorter than the currently selected short wave cutoff or the value of the analog cutoff.

If subsequent changes to the scan speed or scan length cause the long wave cutoff setting to become invalid, the cutoff is automatically changed to the nearest available valid value.

The following figures show the effect of different cutoff filter settings on the same set of scan data.

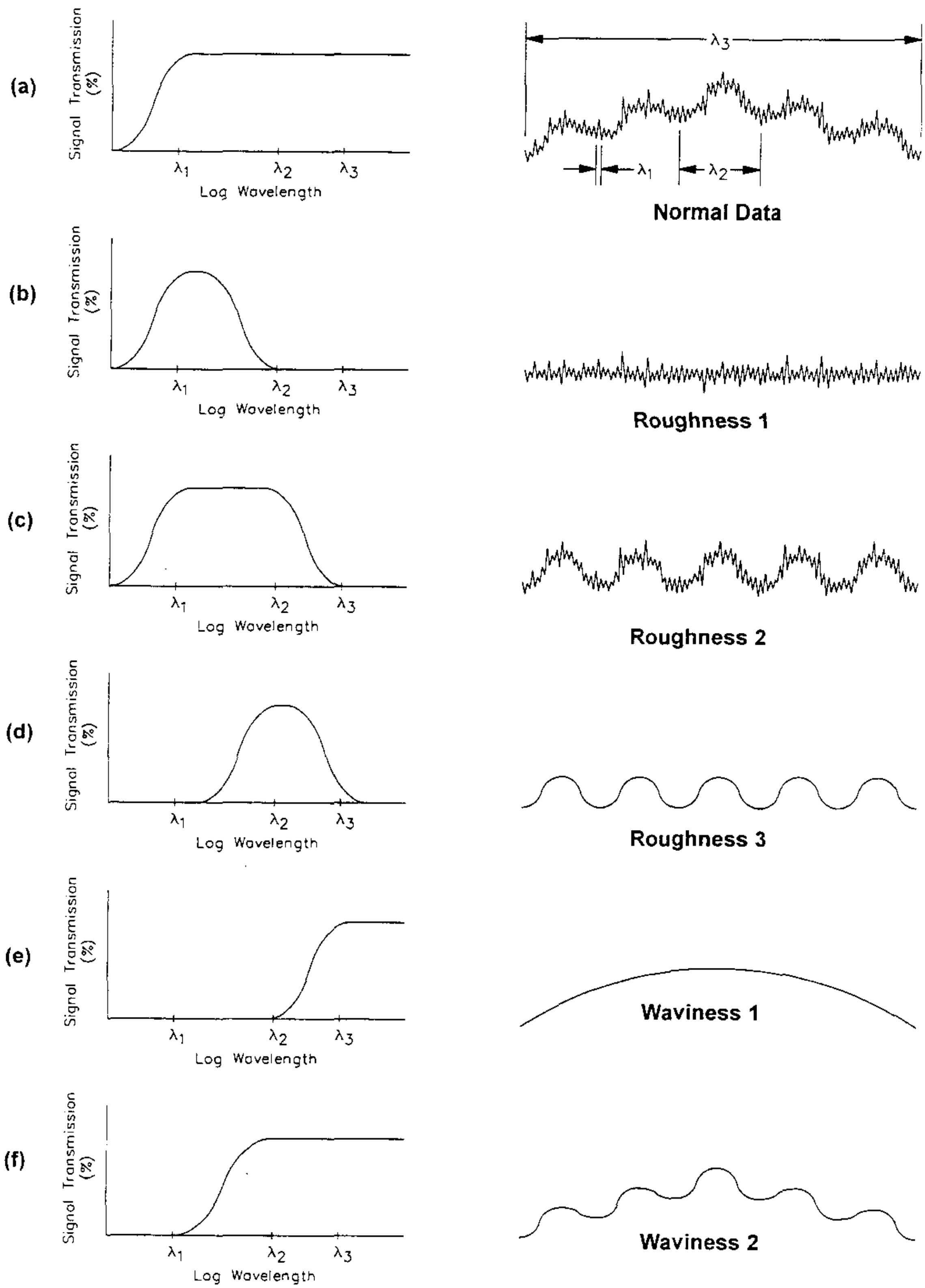


Figure 6-21 Signal Transmission Curves and Their Effects on Scan Data

In Figure 6-21(a), only the analog filter acts on the data. Three wavelengths, labeled λ_1, λ_2, and λ_3, are identified.

In Figure 6-21(b), the long wave cutoff filter is applied with a cutoff value just higher than λ_1. The resulting data trace shows only features of the scale of λ_1; higher wavelengths, including λ_2 and λ_3, are suppressed.

In Figure 6-21(c), a different long wave cutoff value is applied, this time just higher than λ_2. The resulting data trace shows features of the scale of $\lambda_1$to λ_2; higher wavelengths, including λ_3, are suppressed.

In Figure 6-21(d), a short wave cutoff filter with a cutoff just higher than λ_1 is applied in addition to the long wave cutoff from Figure 6-21(c). The resulting data trace shows only features of the scale of λ_2; higher wavelengths, including λ_3, and lower wavelengths, including λ_1, are suppressed.

In Figure 6-21(e), the short wave cutoff filter is applied with a cutoff value just lower than λ_3. The resulting data trace shows only features of the scale of λ_3; lower wavelengths, including λ_1 and λ_2, are suppressed.

Finally, in Figure 6-21(f), the short wave cutoff filter is applied with a cutoff value just lower than λ_2. The resulting data trace shows features of the scale of λ_2 and λ_3; lower wavelengths, including λ_1, are suppressed.

6.5 RADIUS MEASUREMENT ON CURVED SURFACES

The average radius of a circular segment defined by the measurement cursors is calculated from a data set using the least squares fit method. This method is capable of high precision. It is useful over a range from 0.5 µm (20 µin.) to 200 mm (7.9 in.), provided that the sample will fit into the instrument.

You should keep in mind that the radius of the measurement stylus is added to the sample radius in the measurement. While the radius of a 2-µm stylus added to a 20-mm radius sample might be considered negligible (0.01%), that of a 5-µm stylus added to a 1-mm radius is a 0.5% error, which is probably not acceptable.

This consideration disappears if the instrument is calibrated with a high precision cylindrical standard whose radius is within a factor of 5 of the sample to be measured. For the highest accuracy, we recommend that you perform this calibration.

Note that this calibration is only effective when radius measurement is enabled by setting the Radius parameter to Display or Yes in the Scan recipe. This means also that the radius measurement should be disabled by setting the Radius parameter to No in the Scan recipe when the instrument is used for other types of measurements.

For maximum precision, the height of the measured arc and the size of the included angle must be within certain limits. These limits depend on the type of measurement head you are using. The height of the measured arc should be limited to 77% of the vertical range of the measurement head, and the included angle to 90°. Measurements can be made up to 90% of the vertical range of the measurement head in arc height and 110° in included angle with a small loss of precision.

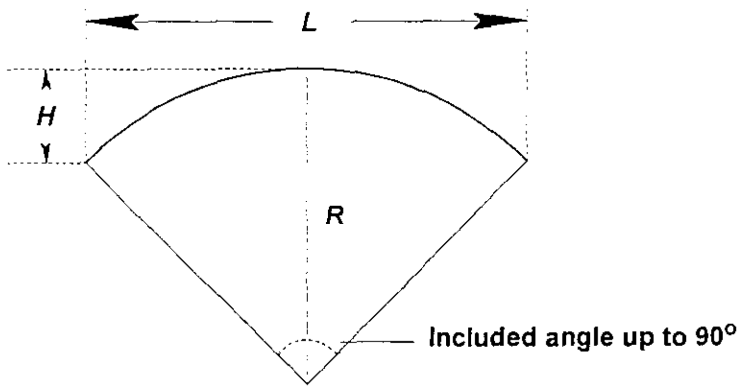


Figure 6-22 Arc Segment Dimensions

Precise measurement is also restricted to arc segments that are symmetric to the radial axis of the measured artifact. To measure another portion of the radius, the sample must be physically rotated about the radial axis.

Scan length and scan speed are dependent on the radius of the sample and the arc height allowed by the measurement head and its vertical range. For a given radius *R* and optimum arc height *H* (Fig. 6-22) the optimum scan length *L* can be determined by the following formula:

$$L = 2\sqrt{2RH - H^2}$$

Scans taken at the lowest possible horizontal resolution for the optimal scan length generally yield the most repeatable and precise radius measurements. To achieve the lowest horizontal resolution, you might have to try various combinations of scan speed and sampling rate. Start with a 200 Hz sampling rate, then set the scan speed to get a scan time that is as close as possible to 25 s without exceeding it. If the longest scan time possible under these restrictions is 12 s or less, set the sampling rate to 100 Hz, and then set the scan speed so that the scan time is as close as possible to 50 s without exceeding it.

Use the center bias profile type if the arc height *H* is less than about 40–45% of the range available with your measurement head. Otherwise, use either the peak bias (for convex or hill-like radii) or the valley bias (for concave or valley-like radii), as appropriate.

The stylus force needed depends on the arc height *H* and on the profile type (peak, valley, or center bias). You must set the stylus force high enough for the stylus to reach the lowest points of the scan. If, while measuring a radius, the trace flattens out and no "data out of range" message is displayed, try a higher stylus force setting.

A 1-σ repeatability (precision) of 0.002% of the radius is routinely obtained when you follow a few simple rules:

- Do not use software leveling on the scan data (that is, set both leveling cursors to zero).
- Preset the position of the measurement cursors.

These rules are followed when the Scan recipe is set up as follows:

Recipe Field	**Setting**
Scan Length	See formula earlier in this section.
Scan Speed	See discussion earlier in this section.
Sample Rate	200 Hz if possible (see discussion earlier in this section).
Surface Parameters	Enable display of Radius and Distance
Stylus Force	See discussion earlier in this section.
Profile Type	See discussion earlier in this section.
Vertical Range	To range necessary to accommodate sample.

Cursors (relative)	**Left**	**Right**
Measurement	$L = 2\sqrt{2RH - H^2}$	$L = 2\sqrt{2RH - H^2}$
Leveling	0	0
Delta Meas	0	0
Delta Lev	0	0

For convex radii, the cursors automatically adjust whenever the Edge and Radius parameters are selected in the Scan recipe, and Feature Detection (set for Apex) is enabled.

For 0.002% repeatability, adjust the measurement cursors in the Data Analysis window so that the height values for the cursors are equal within 0.5 µm (20 µin.) for radii larger than 2.5 mm (0.1 in.).

6.6 FIT AND LEVEL

The Tencor P-20 software is capable of accurately measuring step heights on curved surfaces (such as lenses or glass optical fibers), or in the case of a bow in a profile that has been leveled in the normal manner. This capability is enabled or disabled in the Scan recipe.

> NOTE: **The software can remove a simple convex or concave curve from the data, but not more complex curves like waves.**

To activate Fit and Level:

Enable the Fit and Level check box in the Feature Detection dialog box of the Recipe Editor.

6.7 SAVING AND MAINTAINING SCAN DATA

Scan data can be saved for reviewing at a later time.

To save scan data:

1. Choose Save Data from the File menu. The following dialog box appears:

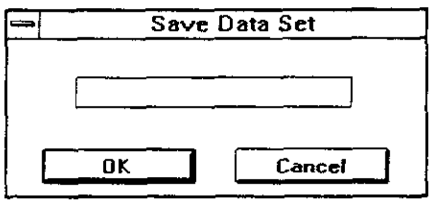


Figure 6-23 Save Data Set Dialog Box

2. Type a name for the data set, then click on OK, or click on Cancel to abort the Save operation. The data set name must be a valid DOS filename. Valid DOS filenames
   - Can contain a maximum of eight characters
   - Have a three-character extension supplied by the system
   - Are not case-sensitive
   - Can contain only the letters A–Z, the numbers 0–9, and the following special characters: tilde (~), exclamation point (!), at sign (@), number sign (#), dollar sign ($), percent sign (%), caret (^), ampersand (&), left parenthesis, right parenthesis, underscore (_), hyphen (-), left brace ({), right brace (}), single quotation mark (`), and apostrophe ('). No other special characters are acceptable
   - Cannot be identical to the name of another existing data set

Once a data set has been saved, it is added to the Scan Data catalog. The Scan Data catalog window allows you to select individual data sets for reviewing. You can also delete unwanted data sets.

To view the Data catalog:

From the Catalog window, click on the Scan Data button on the left side of the screen. The Scan Data Catalog window appears:

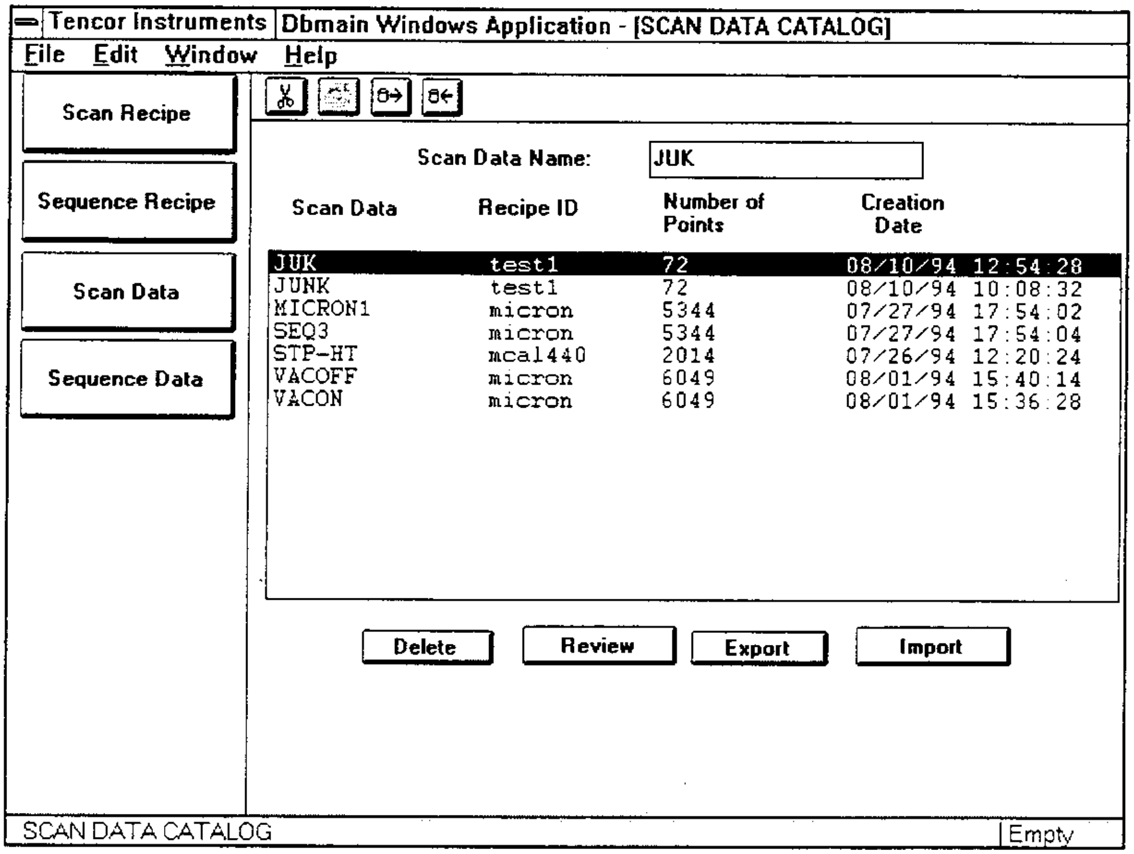


Figure 6-24 Scan Data Catalog Window

To review a data set:

Select the desired data set from the list in the catalog, and click on the Review button, or double-click on the desired data set.

To delete, import, and export data, see Chapter 8, "Using the Database."

7 SEQUENCING

The Tencor P-20 allows you to write a *sequence*, which instructs the instrument to take a series of scans rather than you taking them all manually one by one. A sequence is like a script that links specific scan sites on a sample (or on a number of samples) with specific scan recipes to be performed at each site. The capability of automating repetitive measurements greatly enhances the productivity of the instrument.

This chapter covers

- Sequencing capabilities of the P-20
- The Sequence Editor window
- Sequence Editor fields
- A simple sequence example
- Sequencing with Manual Deskew and Pattern Recognition Deskew
- Sequencing with the wafer handler
- Saving and maintaining sequences

7.1 SEQUENCING CAPABILITES

The Sequencing provides the following measurement capabilities:

- Combine as many artifact sites and recipes as desired
- Set reference points for correcting for translational and rotational variation between wafers (deskew)
- Deskew can be set manually or automatically using Pattern Recognition
- Set Pattern Recognition options to search locally for a match when a match is not found in the camera's field of view at deskew sites
- Set the wafer handler to load, scan, and unload up to 26 wafers without operator intervention
- In Multi Analysis mode, apply different recipes to a single scan
- Automatically display, print, and save statistics or raw data for all sites
- Teach scan sites and alignment reference points interactively

7.2 SEQUENCE EDITOR WINDOW

The Sequence Editor window contains the controls for writing and editing sequence programs, setting various sequence options, and running the sequence program. The Sequence Editor is started from the Sequence Recipe Catalog. (See Section 4.1.1, "Scan Recipe Catalog Menu Bar," and Section 4.1.2, "Scan Recipe Catalog Tool Bar," for a description of the menus and tool bar buttons that appear in the Sequence Recipe Catalog window.)

To view the Sequence Editor window:

1. From the Top-Level menu, double-click on the Scan icon. The Sequence Recipe Catalog window appears:

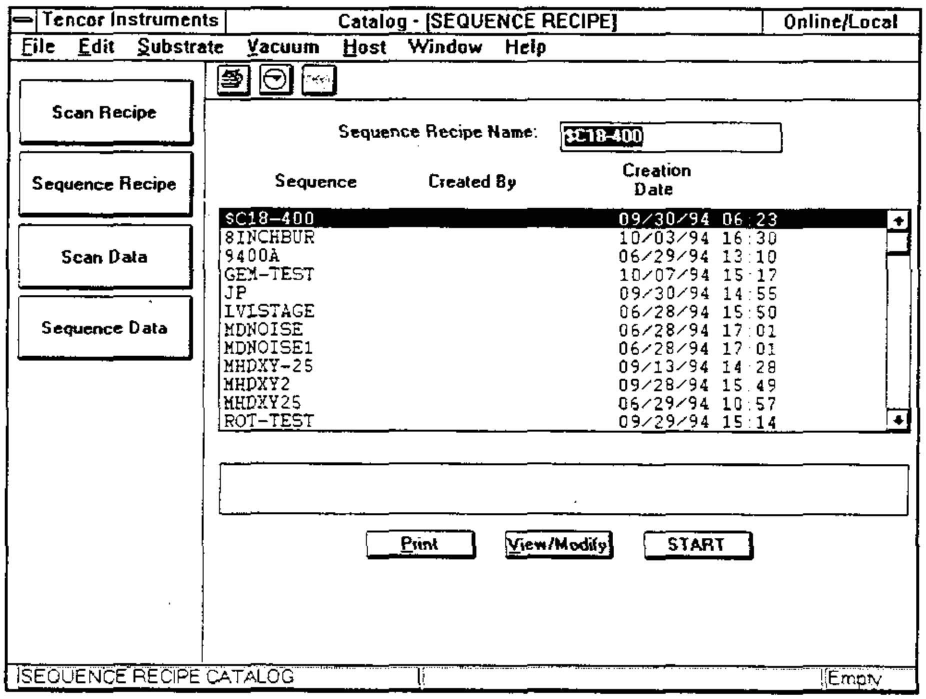


Figure 7-1 Sequence Recipe Catalog Window

2. Click on the View/Modify button below the list of sequence recipes, or double-click on any of the sequence recipes in the list. The Sequence Editor window appears (Figure 7-2).

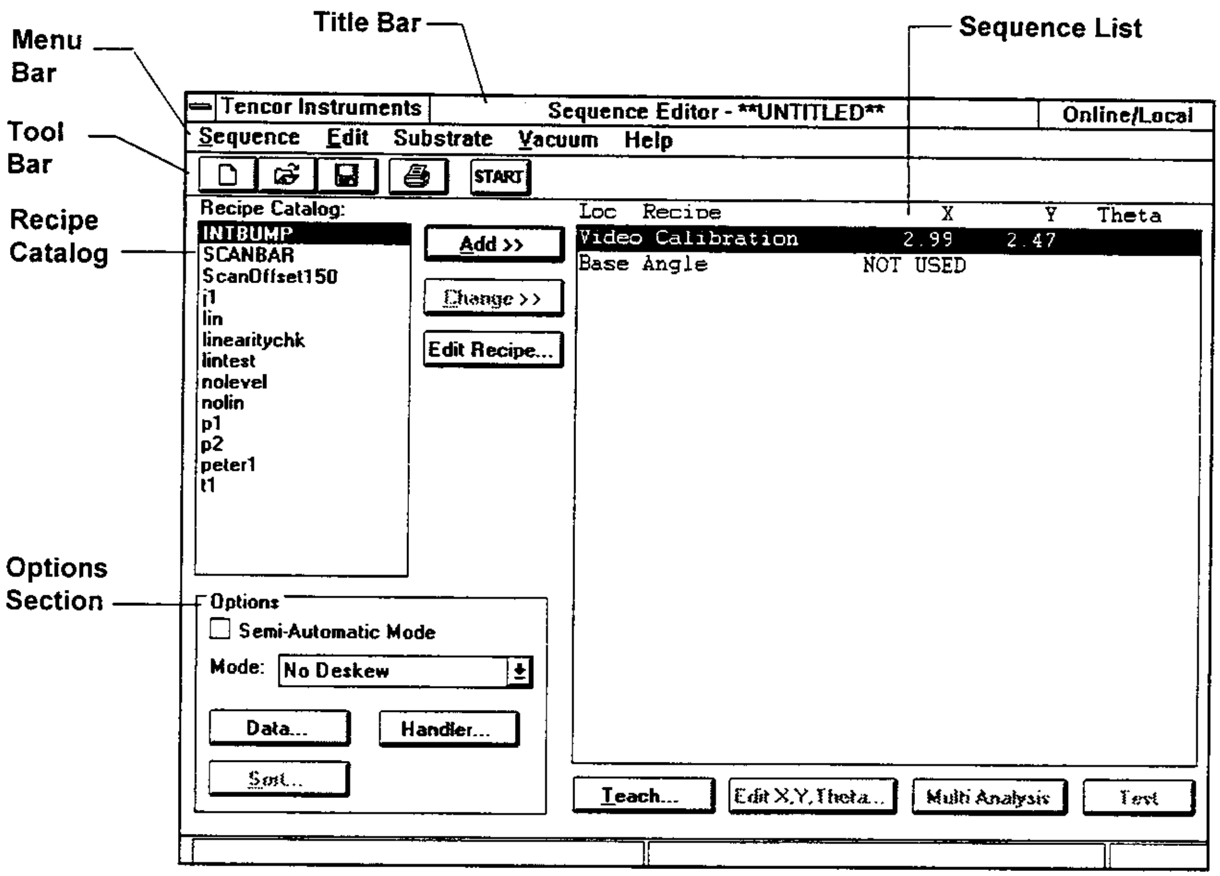


Figure 7-2 Sequence Editor Window

The Sequence Editor window consists of the following elements:

- Menu bar
- Tool bar
- Recipe catalog for selecting from available recipes
- Options section for setting sequence options
- Control buttons for sequence programming
- Sequence list, linking sites with recipes

7.2.1 SEQUENCE EDITOR MENU BAR

The Sequence Editor menu bar provides access to commands through its menus. You can view menus by clicking on the titles in the menu bar, or by pressing ALT+*l*, where *l* is the letter that appears with an underscore in the desired title in the menu bar. You can choose menu items by clicking on a menu entry or by typing the letter that appears with an underscore in the desired menu item.

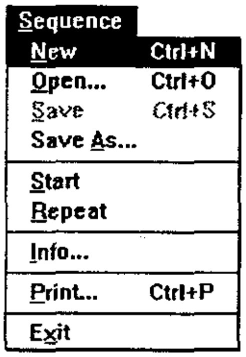


Figure 7-3 Sequence Menu

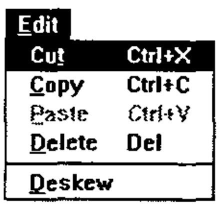


Figure 7-4 Edit Menu

Figure 7-5 Substrate Menu

Figure 7-6 Vacuum Menu

7.2.2 SEQUENCE EDITOR TOOL BAR

The Sequence Editor tool bar contains a row of icons that resemble buttons. Clicking on these icons provides an alternative way to access commonly used functions.

Each icon suggests the function of the button. For example, the Print button resembles a printer. Buttons that appear dimmed are unavailable.

The Sequence Editor tool bar contains the following buttons:

Button	Action
	Loads a new default sequence
	Displays the File Open dialog box
	Saves the current sequence
	Displays the Print dialog box
	Starts a scan using the current Sequence

7.2.3 SEQUENCE INFORMATION DIALOG BOX

The Sequence Information dialog box displays the title, author, the date and time of creation (or modification) of the sequence, and a section for annotating the sequence with comments.

To display the Sequence Information dialog box:

Choose Info from the Sequence menu.

The Sequence Info dialog box also appears when you are saving a sequence.

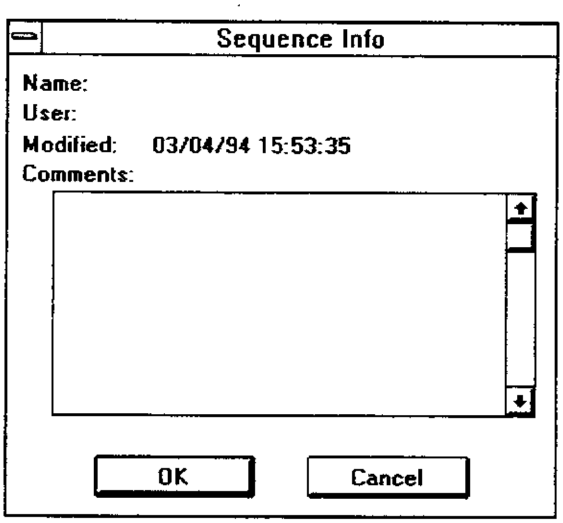


Figure 7-7 Sequence Information Dialog Box

The Name, User, and Modified fields are supplied automatically by the system. These fields cannot be edited.

To enter Comments:

1. Click in the Comments text box or press TAB← or TAB→ until the Comments text box is highlighted.
2. Type the desired text.

7.2.4 SEQUENCE EDITOR RECIPE CATALOG

The Sequence Editor Recipe catalog is a list box that allows selecting from the available recipes. It has a vertical scroll bar to allow display of all currently available stored recipes.

To select a recipe:

Locate the desired recipe name. If the name is not visible in the window, use the scroll bar to find it, or click on any of the recipe names and then press [∧] or [∨] to move the selection bar up or down.

7.2.5 OPTIONS

The Options section allows selecting the sequence mode and setting the Data, Handler, and Sort options for the sequence. You can also select to run the sequence in Semi-Automatic mode.

SEMI-AUTOMATIC MODE

The Semi-Automatic mode causes a sequence to display the trace data after each scan and pause before proceeding to the next step. Each step can be verified and, if needed, the scan sites can be adjusted and the scan retaken before proceeding to the next step. In Pattern Rec Deskew mode, you can manually adjust the position of the stage in case the deskew site does not appear in the field of view when the sequence begins.

Enable the Semi-Automatic mode by clicking on the check box. An X in the check box indicates that the Semi-Automatic mode is enabled; a clear check box indicates it is disabled.

Mode

Select the Sequence mode from the drop-down list. The available modes are

No Deskew	The sequence contains no deskew points for alignment.
Manual Deskew	Sequence deskew points are set much like scan sites.
Pattern Rec. Deskew	Sequence deskew points are set using the Pattern Recognition option.

DATA OPTIONS DIALOG BOX

Set the Data options by clicking on the Data Options button in the bottom of the Options dialog box. The Data Options dialog box appears:

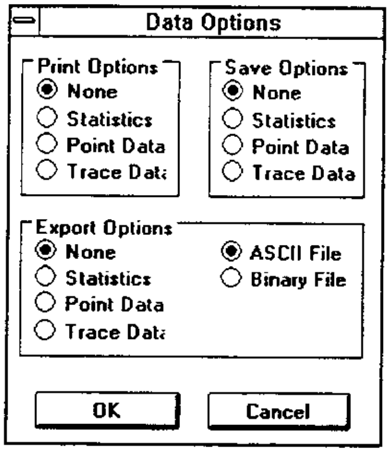


Figure 7-8 Data Options Dialog Box

Make a selection from Print, Save, and Export options, click on the appropriate radio button. When finished, click on OK to set the options and close the dialog box, or Cancel to close the dialog box without changing the previous settings.

Each group has the following possible settings:

None Prints, saves, or exports no data.

Statistics Prints, saves, or exports only the statistics for the specified parameters, the recipe ID, part ID, and sequence ID. The results for each parameter at each measurement site are not printed, saved, or exported. Statistics are calculated for scans taken with the same recipe and are saved only if two or more scans are taken with that recipe.

Point Data Prints, saves, or exports the results for each parameter, the recipe ID, part ID, sequence ID, and X, Y, and θ coordinates at each site. This option also saves statistics automatically.

Trace Data Prints, saves, or exports everything, including the recipes used, the raw data points for each scan, parameter results, and the statistics.

The Export Options also contain a choice of export file type:

ASCII File Data is exported in ASCII representation.

Binary File Data is exported in binary representation.

HANDLER OPTIONS DIALOG BOX

Set the Handler options by clicking on the Handler Options button at the bottom of the Options dialog box. This displays the Handler Options dialog box (Fig. 7-18).

The settings under the Handler Options dialog box are described in Section 7.8, "Sequencing with the Wafer Handler."

SORT OPTIONS DIALOG BOX

The Sort Option dialog box is not implemented in this version.

7.3 WRITING A SEQUENCE

This section covers the basic outline of a sequence. The sections that follow discuss in more detail some of the operations outlined in this section.

The steps that follow are in no specific order, except for the following:

- The Sequence Editor needs to be opened first.
- The sequence sites must be taught before the sequence can be saved.

Not all steps might be necessary. For example, you might not need to edit the sequence.

To write a sequence:

1. Open the Sequence Editor by choosing View/Modify from the main Scan window. You can start a new sequence by choosing New from the Sequence menu, or edit an existing sequence by choosing Open from the Sequence menu and selecting the desired sequence from the dialog box.
2. Add the desired recipes to the sequence list on the right side of the window by selecting a desired recipe and clicking on the Add>> button.
3. Set the desired options. Enable or disable Semi-Automatic mode, select the Sequence mode, set the Data Options for saving, printing, and exporting data, and set the Handler Options if needed.
4. Load a wafer or sample.
5. Teach the Base Angle if used.
6. Teach the sequence sites. If Deskew is used, teach the two Deskew Sites first, then the steps.
7. Edit the sites if needed. Select the desired site and click on the Edit X,Y, Theta button. Or, manually enter or modify the coordinates.
8. Save the sequence by selecting Save As from the Sequence menu.

To run a sequence:

- Start the sequence by clicking on the Start button in the tool bar, or choosing Start from the Sequence menu.

To stop a sequence:

- Stop the sequence by clicking on the Stop Scan button in the Scan window (handler-equipped instruments will also automatically unload the wafer).

7.4 A SIMPLE SEQUENCE EXAMPLE

This section provides a brief tutorial example describing the process of writing, setting up, and running a simple sequence on a single sample without deskew and without the handler.

The example used throughout this tutorial follows a continuous sequence of steps. By carefully following the instructions, the windows that appear on your screen should be very similar to the example windows reproduced in this chapter.

To work through this section, you will need

- A sample to profile
- One or more recipes

We recommend a step-height standard for this purpose. You can use any recipe and modify it as you proceed.

To write the sequence:

1. Bring up the Sequence Editor window (Fig. 7-1) by choosing View/Modify from the Sequence menu of the Scan Application window.
2. To make sure you begin with a blank sequence, choose New from the Sequence menu. Two entries, Video Calibration and Base Angle, appear in the sequence list on the right side of the window. The mode is set as No Deskew and the Data, Handler, and Sort options are set to their defaults. A Video Calibration step appears at the beginning of every sequence to assure accurate results for scan length teaching and for pattern recognition. It is only necessary if the optical magnification (zoom) has been changed. Base Angle is an offset angle relative to the wafer's flat or notch.
3. Select one of the designated recipes in the Recipe Catalog list box.
4. Click on the Add button, or press ENTER. The name of the selected recipe appears as site 1 in the sequence list.
5. Select another one of the designated recipes in the Recipe Catalog list box, or use the same one again, and add it to the sequence list in the same way.
6. Add one more recipe to the sequence list in the same way. You now have three sites in the sequence list, each of which uses the chosen recipe(s) to control the scan and calculate the results for that site. Next, you need to specify X and Y coordinates to each site (θ coordinates are only necessary if a stage rotation is incorporated into a sequence; this capability is not implemented in the current version).
7. Select the first site by clicking anywhere on the site 1 line in the sequence list, or use [$\wedge$] and [$\vee$] to move the selection bar to site 1.

8. Click on the Teach control button, or double-click on the selected sequence step. The Teach Location window appears:

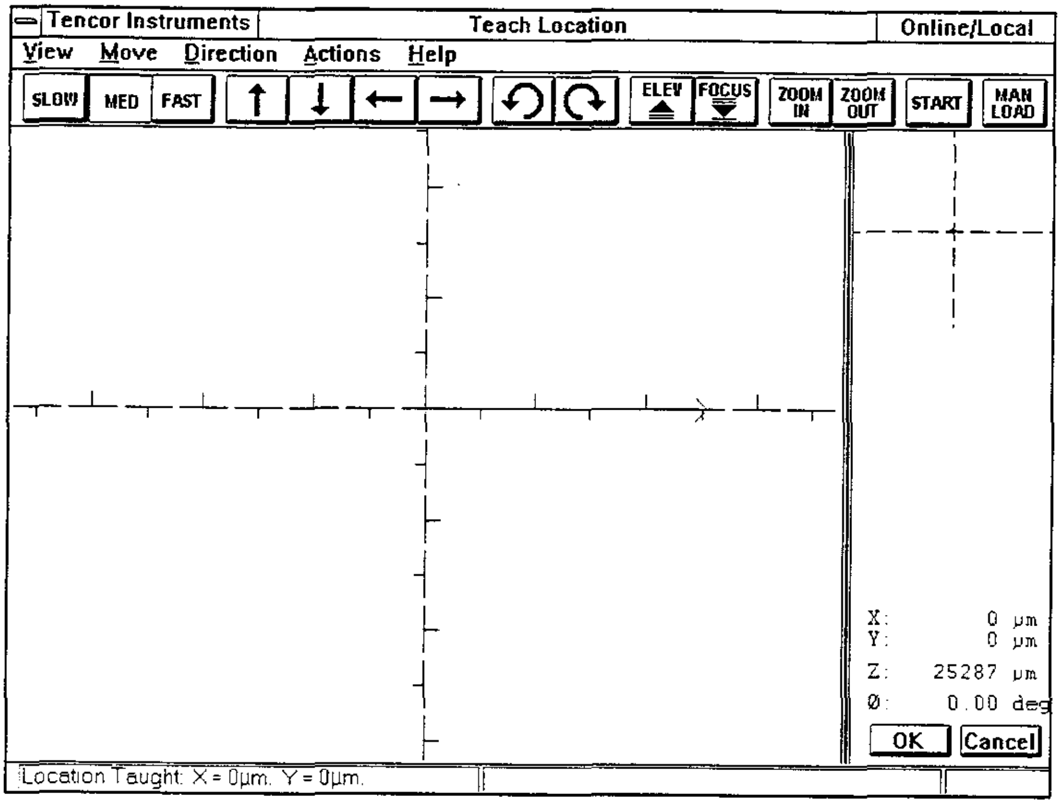


Figure 7-9 Teach Location Window

9. In the Teach Location window, the blue arrow superimposed on the cross hairs indicates the scan length and direction as defined in the recipe. The center of the cross hairs indicates the start-of-scan position. Locate an appropriate position to start a scan as follows:
   - Move the stage using the arrow buttons in the tool bar, or clicking in the round stage position control on the right of the video window.
   - When the desired feature is in the field of view, indicate the position to start the scan by clicking there on the video image.
10. Click on OK, or press ENTER, to return to the Sequence Editor window. Note that the X and Y coordinates of the cross hair now appear to the right of the recipe name in the sequence step for site 1.
11. Repeat the teach process for each of the other sites in the sequence list, moving to a different place on the sample for each. When you are finished, you should have a sequence list with the following lines: the optional Video Calibration step, the Base Angle step (not used here), and three scan sites with specific recipes and X and Y coordinates.
12. Save the sequence by selecting Save As from the Sequence menu.

To run the sequence:

Start the sequence by selecting Start Sequence from the Sequence menu, or by clicking on the Start button in the tool bar.

The Run application window appears, and the stage moves to the first site. The stylus descends to the sample surface and the first scan begins. When the scan completes, the stylus lifts, the stage moves to site 2, and the second scan begins. When this scan completes, the stage moves to site 3 and the third and final scan begins.

At the end of the final scan, the stage returns to its initial position. On the display, the Data Analysis window appears (Figure 7-10), displaying the Trace window and the Sequence Parameter window for the first step in the sequence. Both windows can be resized, moved, minimized or maximized, as well as tiled in any of the standard ways. See Section 2.6.9, "Moveable and Resizeable Windows."

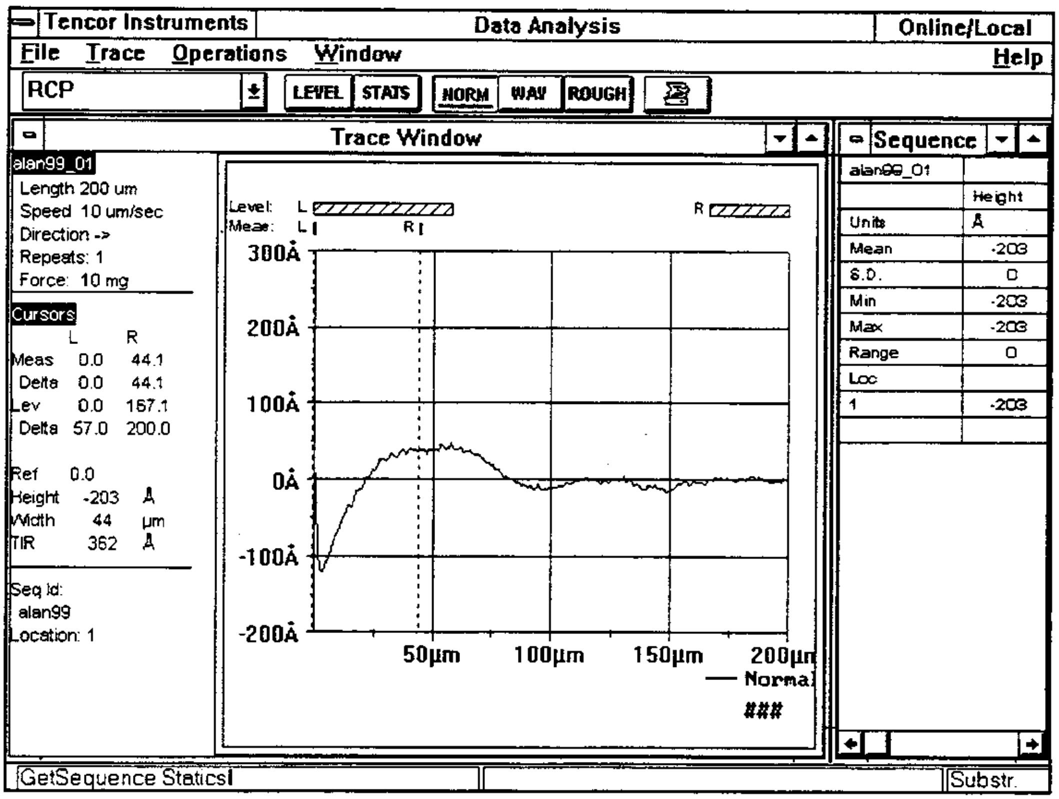


Figure 7-10 Sequence Data Analysis Window

7.5 VIEWING WAFER SUMMARY DATA

The Sequence Parameter Data window displays the results of a sequence based on an individual wafer within a cassette, as well as across a sequence of wafers for the entire cassette. This information includes detailed data about one or more sites scanned on a single wafer.

To display the wafer summary data:

Select Sequence Parameter Data from the Window menu of the Data Analysis window, as shown in Figure 7-11.

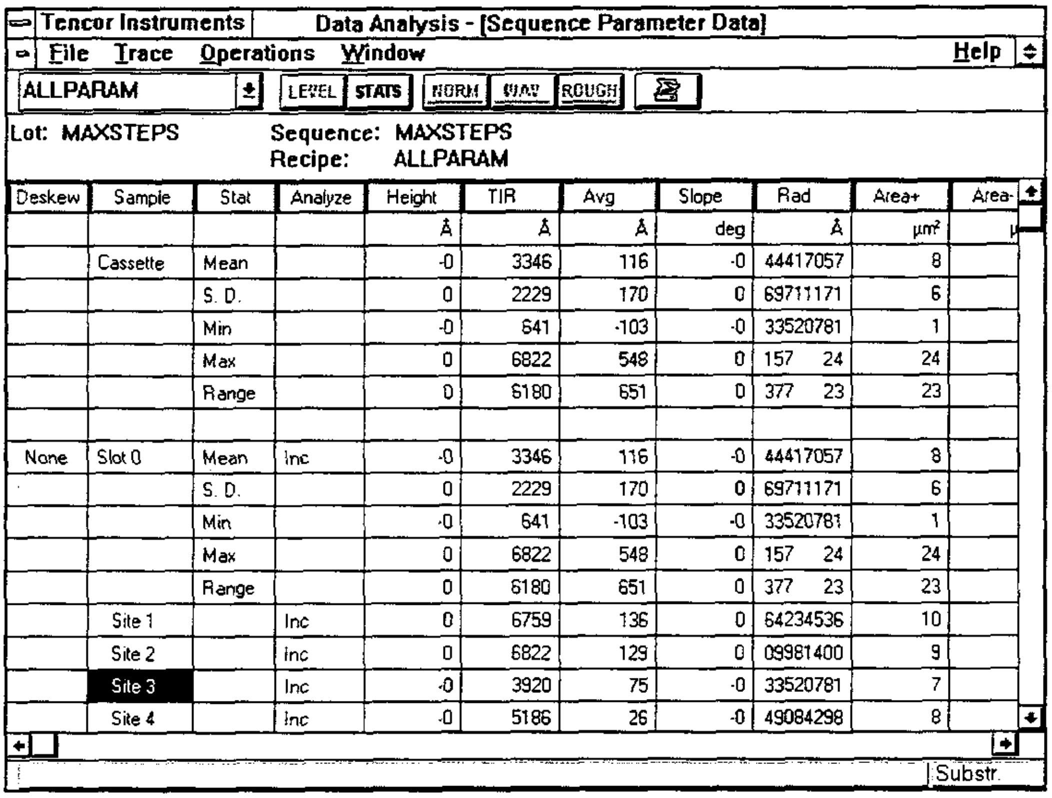


Figure 7-11 Sequence Parameter Data Window

To view the entire Sequence Parameter Data screen from the Trace window, you need to maximize the Sequence Parameter Data window.

Using the Sequence Parameter Data window, you can select recipes from the pull-down list on the left of the tool bar. This pull-down list displays all recipes that are included in the sequence.

To specify data on the Sequence Parameter Data window:

Select Sequence Summary Options from the Operations menu of the Data Analysis window, as shown in Figure 7-12 below.

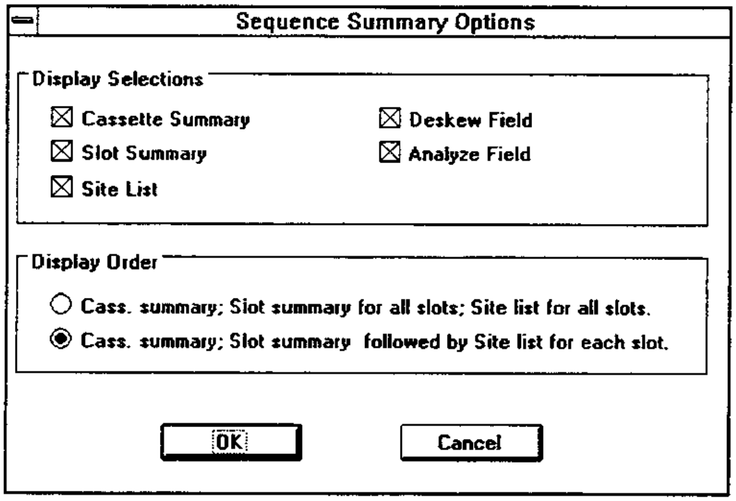


Figure 7-12 Sequence Summary Options Window

The Sequence Summary Options window lets you specify the information on the Sequence Parameter Data window, including data for each site scanned on a slot (wafer) for the entire cassette or for an individual wafer within a cassette.

You can view the Trace window for any of the sequence steps by clicking on the appropriate site number in the Sequence Parameter Data window.

7.6 TEACHING THE BASE ANGLE

The Base Angle is an offset angle relative to a wafer's flat or notch. It is used to align scans with the wafer geometry. The Base Angle is fixed for all scans in the sequence. You can program this offset in the Teach Location window.

To teach the Base Angle:

1. Double-click on the Base Angle step in the sequence list. The Teach Location window appears (Figure 7-9).
2. Locate a line or die grid pattern to use for a reference.
3. Click on the clockwise or counterclockwise rotation buttons in the tool bar until the cross hairs are aligned with the reference feature. You might have to move the stage keep the reference feature in the field of view as you rotate.
4. Click on OK, or press ENTER, to return to the Sequence Editor window. Note that the Base Angle now has a value instead of the phrase "not used."

When you run a sequence with a non-zero Base Angle, the stage will rotate to that position immediately after the Video Calibration step (if used) and before taking scans.

7.7 SEQUENCING WITH MANUAL DESKEW

The reason for programming a sequence is to speed up a repetitive series of measurements on one or more samples. The example in Section 7.4, "A Simple Sequence Example," contains all of the essential features of a sequence.

However, its usefulness is limited by the fact that no specific reference points were established. This might not be a problem if a precision locator is being used to position each sample on the stage and if the features being measured are relatively large.

Without a locator or some sort of fixture, or without using the wafer handler, you would run into problems reusing this first sequence to measure another of these samples. Without fixturing, you cannot reliably put the second and subsequent samples on the stage in the same position and with the same alignment as the first. You can still use the sequence you have written, but you would have to manually find each of the scan sites and reteach them before running the sequence.

Deskew enables you to identify two points on a sample to use as reference points prior to the start of a sequence. These points are then used to correct mathematically for translational (X, Y) and rotational (theta) error in sample positioning.

Note, however, that though a coordinate transformation is made, there is no stage rotation to compensate for the small rotational error in sample placement unless you set the deskew options to perform a second deskew. See Section 7.8, "Deskewing Twice to Align Theta," for more information.

Note also that any rotational error will be magnified when you traverse a long distance across a large wafer. This might cause the deskew site to be outside the field of view when a wafer is loaded.

NOTE:	**To minimize positioning error, space the deskew points approximately one-half the diameter of the sample. Do not set the deskew points parallel to the X- or Y-axis, but instead use two points on a diagonal line. If the deskew points are identical, the sequence aborts.**

When programming sites, choose a logical progression to reduce the total distance traveled and save time, as in the following figure.

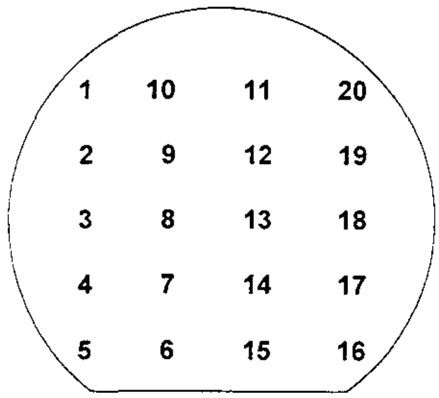


Figure 7-13 Logical Order of Sequence Sites

To set up a sequence with Manual Deskew:

1. Bring up the Sequence Editor window by choosing View/Modify from the Sequence menu of the Scan Application window.
2. To make sure you begin with a blank sequence, choose New from the Sequence menu. Two entries, Video Calibration and Base Angle, appear in the sequence list on the right side of the window. The mode is set as No Deskew and the Data and Handler options are set to their defaults. (A Video Calibration step appears at the beginning of every sequence to assure accurate results for scan length teaching and for Pattern Rec. Base Angle is an offset angle relative to the wafer's flat or notch.)
3. Set the Deskew mode to Manual Deskew. Note that two deskew steps now appear in the sequence list on the right side of the window.
4. Select the first deskew site by clicking anywhere on the Deskew Site 1 line in the sequence list, or use [∧] and [∨] to move the selection bar to Deskew Site 1.
5. Click on the Teach control button, or double-click on the selected sequence step. The Manual Deskew Teach window appears (Figure 7-14).

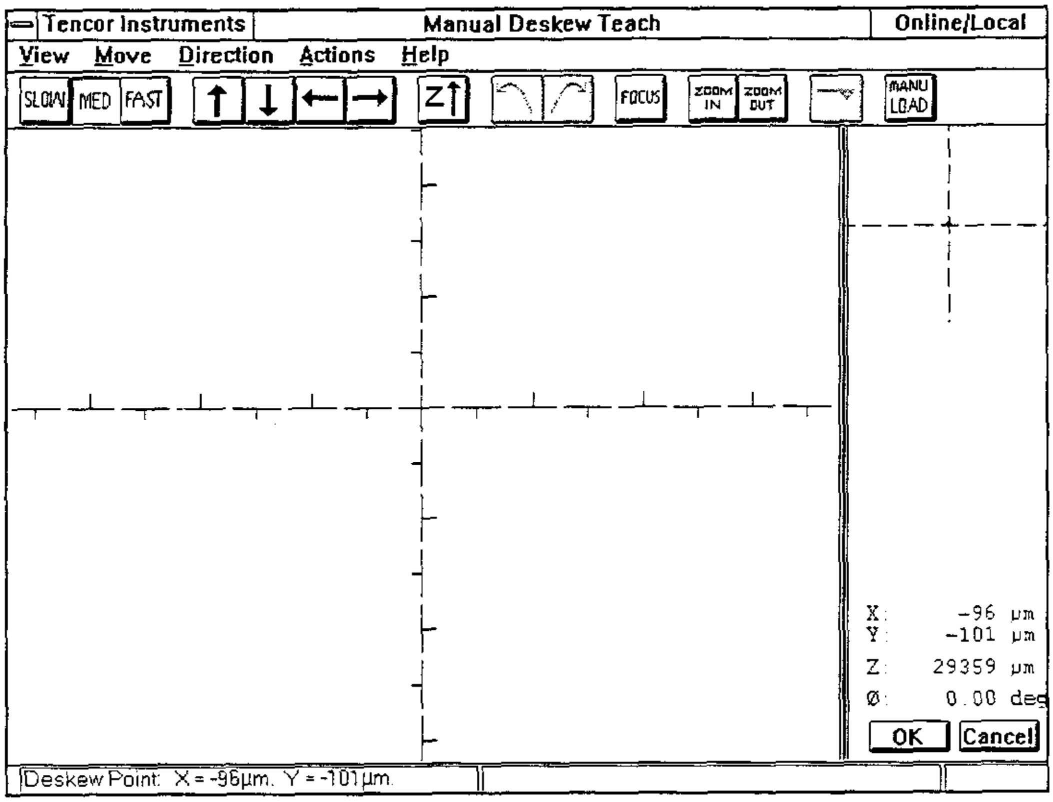


Figure 7-14 Manual Deskew Teach Window

6. Choose a site for the first deskew point. Choose an obvious point, such as the corner of an easily identifiable rectangle. Click on the chosen position. The stage will move so that the cross hairs are centered on the selected site.
7. Click on OK. The Sequence Editor window reappears, with the X and Y coordinates of the selected site entered in the Deskew Site 1 step.
8. Select Deskew Site 2 and repeat steps 5–7 for the second deskew site.
9. Once the deskew sites have been successfully established, proceed to programming the rest of the sequence steps.
10. Run the sequence. After each deskew operation, the instrument pauses and waits for you to accept the deskew sites by clicking on OK.

7.8 DESKEWING TWICE TO ALIGN THETA

With a single deskew operation, there is no stage rotation to compensate for the small rotational error in sample placement. You can choose to perform a second deskew to compensate for this error by enabling this option in the Deskew Options dialog box. This allows accurate sample rotations within a sequence.

To set deskew options to perform a second deskew to align theta:

1. From the main Configuration window, click on the Deskew Options button. The Deskew Options dialog box appears:

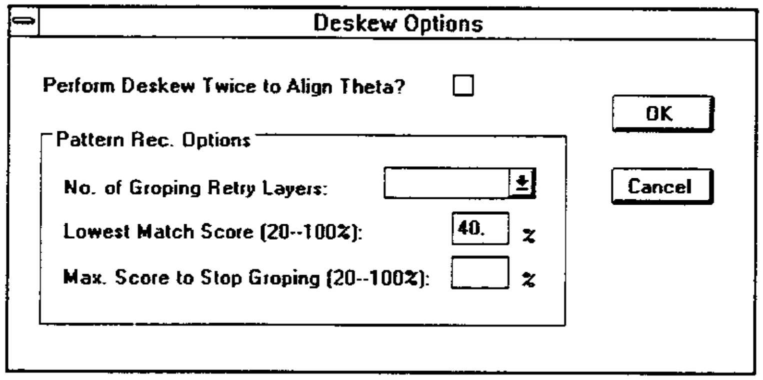


Figure 7-15 Deskew Options Dialog Box

2. Click on the check box to enable or disable the second deskew.
3. When finished, click on OK to set the options and close the dialog box, or Cancel to close the dialog box without changing the previous settings.

7.9 SEQUENCING WITH PATTERN RECOGNITION DESKEW (PATTERN RECOGNITION OPTION ONLY)

The Pattern Recognition option allows greater throughput in sequence operation by automating the precise setting of deskew points at the beginning of a sequence.

A pattern rec. deskew site is a unique pattern of wafer features visible within the instrument's field of view. The size and shape of the pattern must be uniquely different from other wafer features visible in the field of view to ensure that the instrument can locate the sites without ambiguity.

Some examples of good patterns are

- Alphanumeric characters
- Circular or rectangular pads that appear singly
- Crosses
- Alignment marks
- Other polygon shapes

Some examples of bad patterns are

- Sections of a repetitive grid
- Circular pads or rectangular pads that repeat in or near the field of view

When choosing patterns, keep the following points in mind:

- *Search time depends on pattern size.* The larger the pattern, the faster the instrument computer can recognize the pattern. Note: Larger patterns require more accurate initial positioning within the camera's field of view because the search area is reduced. Note: You can set the Pattern Recognition options so that the system will perform a pattern search if the pattern is not found within the field of view. See Section 7.10, "Pattern Recognition Deskew Options," for information.
- *When using rectangular pads, use the entire rectangle.* If only two corners are used, other rectangles in the field of view could confuse the pattern recognition system.
- *The pattern should be unique and as simple as possible.* However, uniqueness cannot be sacrificed for simplicity.
- *Choose symmetric patterns.* They are less sensitive to image rotation. Circular patterns are rotationally symmetric and therefore are good patterns. Similarly, the best polygon patterns have the most sides.
- *High contrast features make pattern recognition matches easier.* When available, choose high contrast features. Noise will not have as much effect on the pattern recognition match. The pattern colors are important because the pattern recognition system reads the black and white image, not the color image. A pattern with good color contrast might not have good black and white contrast. For example, avoid yellow-on-white or white-on-yellow patterns, since these color combinations have almost zero black and white contrast.
- *Avoid patterns with rough surfaces.* By using edge enhancement, the instrument computer emphasizes the fine features present on a rough surface. Because roughness is random, these features add noise to the system and make the pattern recognition system less reliable.

It is generally a good idea to avoid fixed dust particles in the field of view as well. Avoid selecting wafer-specific defects or features as patterns, or you might confuse the instrument computer. This includes dust particles, partially etched areas near the edge of the wafer, and so on.

Semi-Automatic mode allows you to manually adjust the position of the stage in case the deskew site does not appear in the field of view when the sequence begins.

To set up a sequence with Pattern Rec. Deskew:

1. In the Sequence Editor window, select Pattern Rec. Deskew from the Mode drop-down box.
2. Double-click on the DESKEW1 entry near the top of the sequence list or highlight the DESKEW1 entry and click on Teach. The Pattern Rec. Deskew Teach window appears and the stylus automatically nulls on the sample surface.

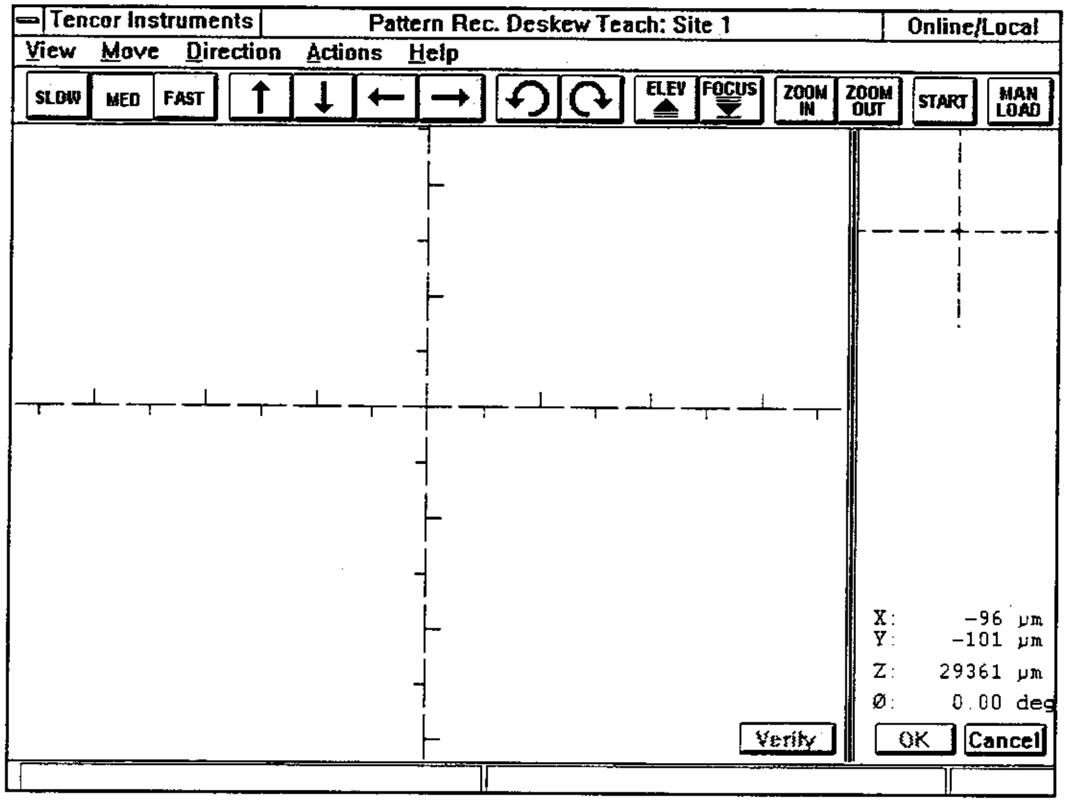


Figure 7-16 Pattern Rec. Deskew Teach Window

3. Choose a pattern to use for pattern recognition. As a rule of thumb, select something that is simple and easily recognizable, like an alphanumeric character or an alignment mark. Something that looks much like another feature that is also within the field of view does not work reliably because the wrong site might be identified.
4. Define a rectangular area that encloses the chosen pattern as follows:
   - Press the left trackball button at one corner of the desired rectangle.
   - Move the trackball toward the opposite corner of the desired rectangle. A blue box appears that follows the trackball cursor as it moves.
   - When satisfied with the desired rectangular area, release the trackball button.

   The instrument computer processes the image information defined by the rectangle. If the rectangle was too small, a message box appears. Click on the OK button and reteach the pattern.
5. The blue box remains on the window with a darker blue dot in the center. The stage moves until the selected feature is centered in the cross hairs (Fig. 7-17).

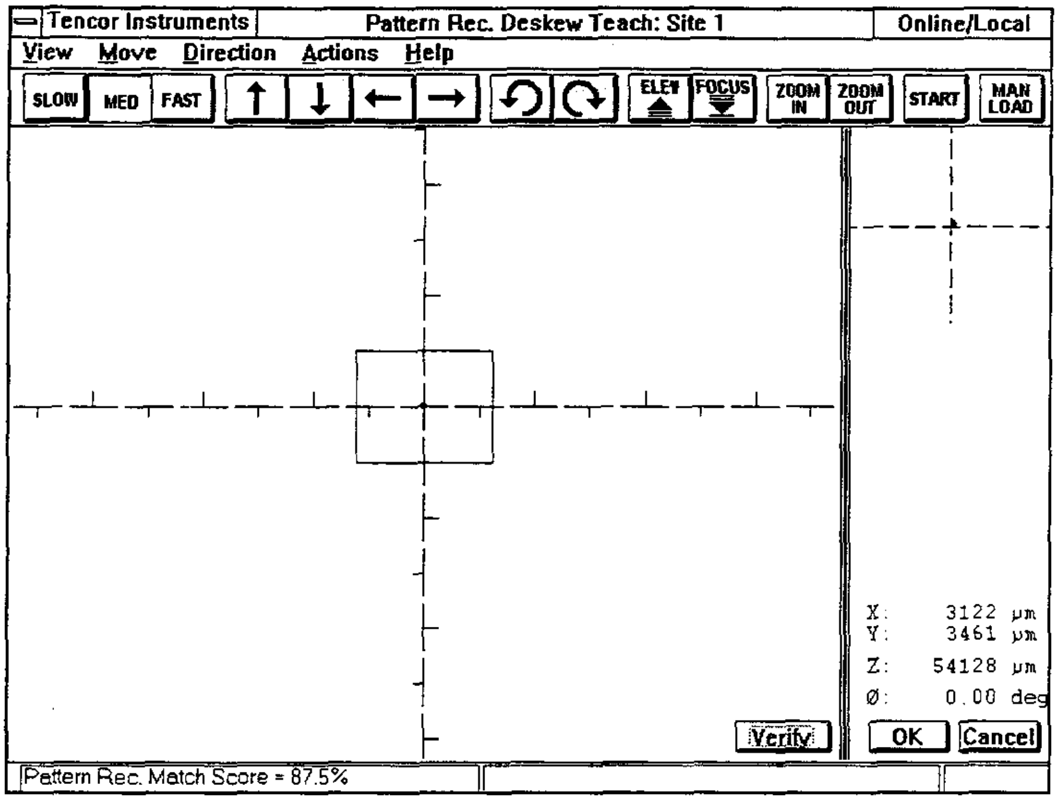


Figure 7-17 Pattern Rec. Deskew Teach Window After Teach

6. Move the stage a small distance, then click Verify to test whether the system can accurately find the feature you have taught. A box is drawn around the feature when it is found. If recognition fails, repeat Step 3 and retry.
7. Click on OK to accept the taught pattern, or click on Cancel to quit the Teach Pattern Rec. Deskew window without saving the taught pattern.
8. Repeat for the DESKEW2 step to establish the second deskew point.
9. Once the deskew sites have been successfully established, proceed to programming the rest of the sequence steps.
10. Run the sequence.

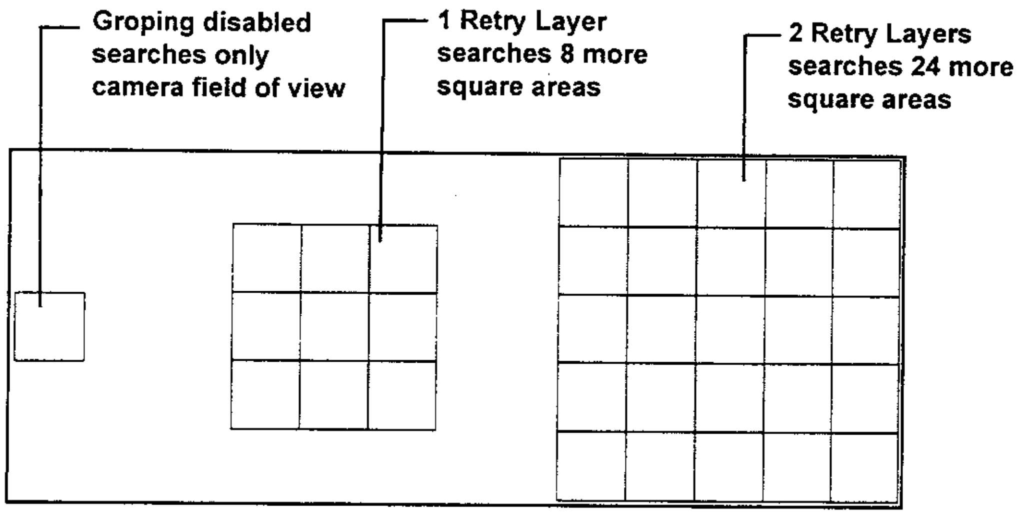
7.10 PATTERN RECOGNITION DESKEW OPTIONS

You can set Pattern Recognition options so that the system performs a pattern search if the pattern is not found within the field of view when the sample is positioned at the deskew site. This search is called *groping.*

The three groping parameters are described below.

NUMBER OF GROPING RETRY LAYERS

This parameter controls how much of the area around the deskew site is searched for the pattern. Each layer consists of a square area constructed by evenly surrounding the deskew site with squares the size of the camera field of view (Figure 7-15):



Similarly for 3 and 4 Retry Layers (48 and 80 square areas)

Figure 7-18 Groping Retry Layers

Available choices are

- Disabled (the default)
- 1 (8 Sites)
- 2 (24 Sites)
- 3 (48 Sites)
- 4 (80 Sites)

First, the deskew site field of view is searched. If the pattern is not found, the stage moves to one corner of the next layer and searches the field of view there. This continues until the pattern is found or until all search sites have been examined. If the pattern is still not found, the stage moves to one corner of the next layer and continues.

Note that if it takes 10 s to move the stage, null the stylus, and search one such area, 8 search sites (1 layer of retry) takes as long as 90 s, 24 sites (2 layers) takes as long as 250 s, and so on.

LOWEST MATCH SCORE

This parameter allow you to adjust the threshold at which the pattern recognition system will conclude that it has found a candidate for the desired deskew site. If the pattern does not show up in the original field of view, the search begins, and if any matches score greater than the Lowest Match Score, the pattern recognition system concludes that the best of these is the correct site for the deskew site (unless it finds a match equal to or greater than the Maximum Score to Stop Groping). Allowed values range between 20–100%.

MAXIMUM SCORE TO STOP GROPING

If the pattern recognition system is groping to find the desired pattern, sometimes the matching pattern is found with little ambiguity. Usually a large number such as 90% means that the pattern has been found. In this case, there is no reason to continue searching the retry layer. If a score equal to or better than the Maximum Score to Stop Groping occurs, the searching process stops and the deskew site is placed.

Allowed values range between 20–100%. If no matches are found that are as good as this setting, the search continues until the retry layer areas are all searched, and the best score above the Lowest Match Score setting determines the placement of the deskew site.

To set Pattern Recognition deskew options:

1. From the main Configuration window (Figure 5-26), click on the Deskew Options button. The Deskew Options dialog box appears (Figure 7-15).
2. Edit the fields.
3. When finished, click on OK to set the options and close the dialog box, or Cancel to close the dialog box without changing the previous settings.

7.11 SEQUENCING WITH THE WAFER HANDLER

This section discusses sequences using the wafer handler with sequences. The wafer handler makes it possible to measure a sequence on as many as 26 individual wafers without operator intervention.
The wafer handler can be configured to load wafers of four different sizes:

- 100 mm (4 in.)
- 125 mm (5 in.)
- 150 mm (6 in.)
- 200 mm (8 in.)

The standard system configuration includes one cassette locator for 200-mm wafers. A second locator is available as an option. For 100-, 125-, or 150-mm wafers, an additional locator plate for each size attaches by thumbscrew on top of the 200-mm locator.

For satisfactory operation the handler chuck must be installed (see Section 2.5, "Installing a Precision Locator," in the *Tencor P-20 Long Scan Profiler Reference Manual*) and the elevator limit properly set (see Section 5.8.4, "Lowest Elevator Position").

Before operating the wafer handler for the first time, read Section 2.7.1, "Protecting the Wafer Handler," for important information on protecting the wafer handler and wafer from damage.

NOTE:	**Cassettes should be the same size and type that Tencor Instruments Field Service taught the wafer handler. Cassettes that have been used in chemical processing, which causes distortion, can make it difficult for the handler to center the wafers on the vacuum puck and stage. Dedicated machine cassettes are best.**

Before using the handler, check the following:

- The vacuum chuck is installed on the stage table.
- The handler parameters are set up properly.
- The wafer size is properly set for the aligner.

The instrument is shipped with the vacuum chuck installed if your instrument comes with the wafer handler. If a vacuum chuck has to be installed, a new lowest elevator position must be set (see Section 5.8.4, "Lowest Elevator Position").

CAUTION:	**Do not use a precision locator when using the handler to load wafers; you could damage the instrument.**

To set handler parameters:

1. From the Top Level menu, double-click on Configuration. From the main Configuration window, click on System Configuration. The Machine Configuration dialog box appears:

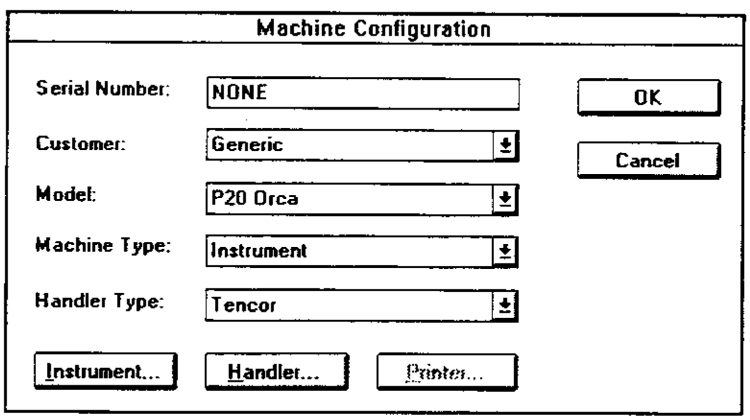


Figure 7-19 Machine Configuration Dialog Box

2. Click on the Handler button. The Handler Setup dialog box appears.

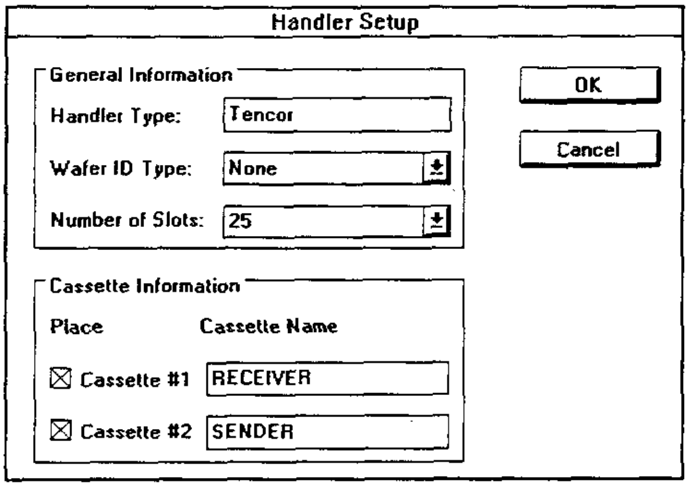


Figure 7-20 Handler Setup Dialog Box

3. Edit values as needed. When finished, click on OK to keep the changes, or Cancel to close the dialog box and leave the setup in its original state.

Handler parameters are set up in the Configuration window. Values for the handler parameters are set as follows:

Handler Type

Handler Type can be either Tencor or None.

Wafer ID Type

Wafer ID Type can either be None or OCR.

Number of Wafers

This field identifies the capacity of the wafer cassettes used. The possible choices are 25 or 26.

Cassette Information

These fields specify the number of cassettes used by the handler and how they are used. An X in the check box for a cassette indicates that the particular cassette is present on the instrument. The Cassette Name fields identify the particular cassette is either the Sender, Receiver, or Both. (If only one cassette is available, it must serve as both the receiver and the handler.)

To set the wafer size on the aligner:

Turn the wafer size selector dial on the aligner (Figure 7-21) until it displays the appropriate wafer diameter.

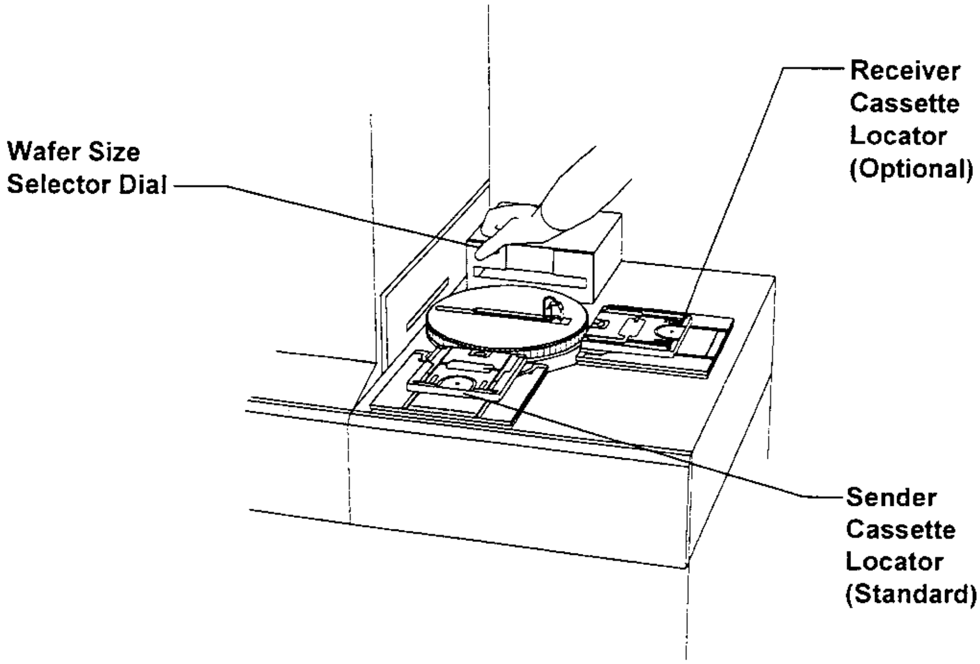


Figure 7-21 Setting the Wafer Size Selector

To prepare for loading wafers using the handler:

1. Place the wafers in the slots of a cassette of the appropriate size. Load the wafer right side up. The bottom slot of the cassette is number 1.
2. Place the cassette on the sender cassette locator (Figure 7-21) as follows:
   - Tilt the cassette back slightly and place the bottom rear corners of the cassette in the grooves on the locator. The grooves are marked with wafer sizes (100 mm, 125 mm, 150 mm, and 200 mm).
   - Tilt the cassette forward until it fits securely in the grooves of the cassette locator. The H-bar across the bottom of the cassette must trip the limit switch in the slot on the locator.

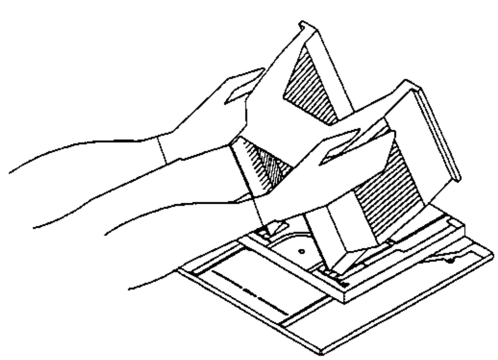


Figure 7-22 Placing a Cassette on a Locator

3. If you have two cassette locators, you can use the second one to receive wafers.

NOTE:	**Cassettes placed on both locators must be the same size. Otherwise, wafers could be damaged and handler performance could be affected. Reinitialize the handler each time the cassette size is changed.**

4. In the Sequence Editor, click on Handler Options. The following dialog box appears:

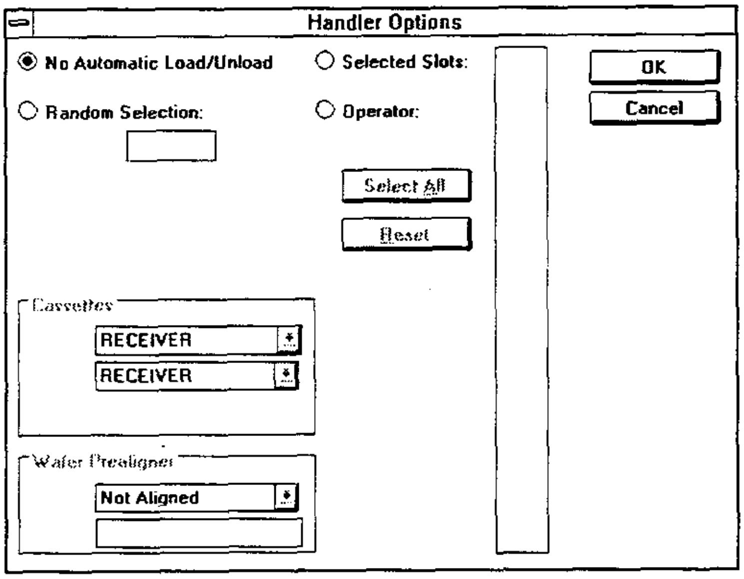


Figure 7-23 Handler Options Dialog Box

The Handler Options include wafer selection settings, cassette selection, and wafer prealignment settings. When finished choosing options in this window, click on OK to set the options and close the dialog box, or Cancel to close the dialog box without changing the previous settings.

The Handler options are described as follows.

Wafer Selection Settings

To select a setting for wafer selection, click on the appropriate radio button. The available choices are

No Automatic Load/Unload The sequence does not automatically load and unload wafers; loading and unloading are performed manually.

Random Selection A specified number of wafers are randomly selected from the cassette. The desired number (1–25 or 1–26) is typed into the text box just below the Random Selection radio button. Wafers are loaded and unloaded without operator intervention. This can only be selected with a full cassette of wafers.

Selected Slots A specified number of wafers, in specific cassette slots, are loaded and unloaded.

To select or unselect specific wafers, click on the numbers in the tall list box to the right of the Selected Slots radio button. You can also click on the Select All button to select all 25 wafers, or click on the Reset button to clear all selections.

Operator Similar to Selected except that at the start of the sequence, the Handler Options dialog box appears to allow the operator to modify the original slot selection before the sequence commences.

Additionally, the Operator mode allows you to enter Slot ID, Lot ID, and Operator ID. Figure 7-24 shows a 10-slot cassette.

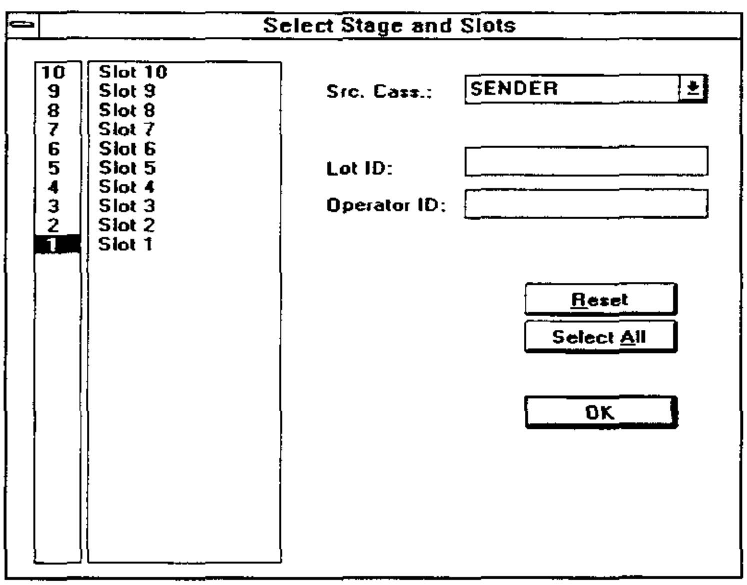


Figure 7-24 Select Stage and Slots Screen

Slot # is the slot identification that the user enters, Lot ID is the cassette name, and the Operator ID is any valid user name. This information appears on the Analysis report and printouts.

If Random Selection, Selected Slots, or Operator is chosen, the Handler Options window takes on a slightly different appearance.

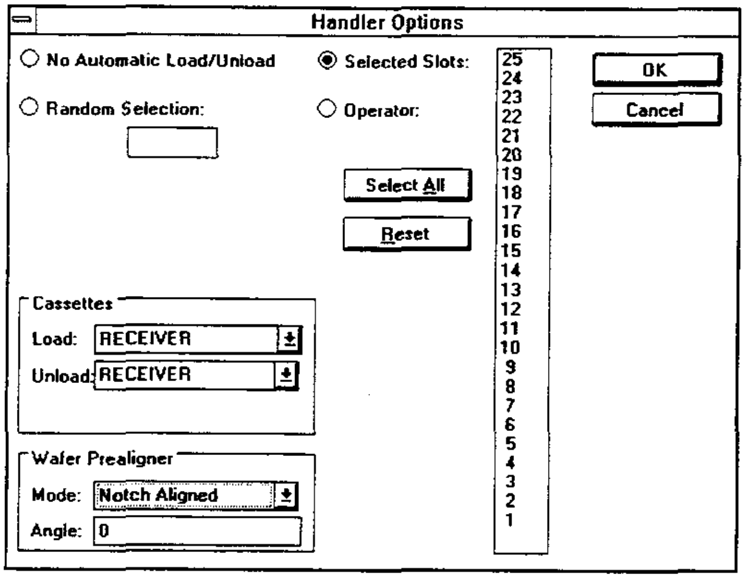


Figure 7-25 Handler Options Dialog Box with Slot Selection Enabled

When finished, click on OK to set the options and close the dialog box, or Cancel to close the dialog box without changing the previous settings.

Cassettes

The Cassettes section allows you to select which cassettes to use for loading and unloading wafers. The Load and Unload fields have the following possible settings:

Sender Designates the Sender cassette as the wafer source or destination.

Receiver Designates the Receiver cassette as the wafer source or destination. Note: The Receiver cassette locator is optional. Instruments without a Receiver cassette locator use the Sender cassette locator for both source and destination.

Wafer Prealigner

The Wafer Prealigner section contains configuration settings for the handler to prealign the wafers before placing them on the handler chuck.

The Mode field has the following possible settings:

Flat Orients the wafer by its major flat.

Notch Orients the wafer by its alignment notch.

None Turns Wafer Prealignment off. The handler bypasses the aligner when it loads wafers. Bypassing the aligner increases throughput but it can also reduce the accuracy of centering the wafer on the stage.

If the Wafer Prealigner Mode is set to Flat or Notch, the Angle field is active and can accept any angle from 0°–360°. The Angle field specifies the position, in degrees, of the flat or notch when it is placed on the puck. A value of 0 causes the wafer to be placed on the handler chuck with the flat or notch to the front of the instrument, that is, the 6 o'clock position. When a wafer is loaded into a cassette, the flat or notch is rotated 90° and is at the 9 o'clock position.

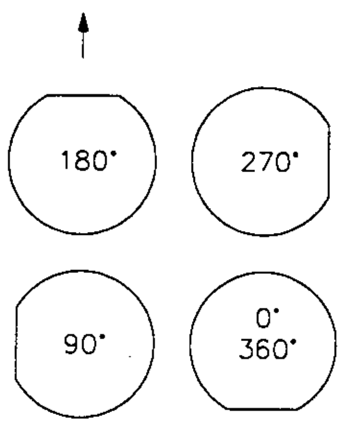


Figure 7-26 Wafer Orientation

7.12 SAVING AND MAINTAINING SEQUENCES

Once you have written a sequence that you want to keep for future use, you need to save it on the hard disk.

To save a previously saved sequence:

Choose Save from the Sequence menu.
Or click on the Save button in the tool bar.

To save a new sequence:

1. Choose Save As from the Sequence menu. The following dialog box appears:

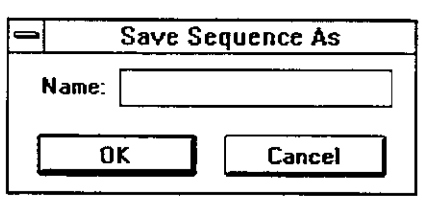


Figure 7-27 Save Sequence Dialog Box

2. Type a name for the sequence, then click on OK, or click on Cancel to abort the Save operation.

Sometimes you might want to edit an existing sequence, make a few minor changes, and save the result with a new name.

To save a sequence under a new name:

1. Choose Save As... from the Sequence menu. The Save Sequence As dialog box (Figure 7-27) appears.
2. Type a name for the sequence. The sequence filename must be a valid DOS filename. Valid DOS filenames
   - Can contain a maximum of eight characters
   - Have a three-character extension supplied by the system
   - Are not case-sensitive
   - Can contain only the letters A–Z, the numbers 0–9, and the following special characters: tilde (~), exclamation point (!), at sign (@), number sign (#), dollar sign ($), percent sign (%), caret (^), ampersand (&), left parenthesis, right parenthesis, underscore (_), hyphen (-), left brace ({), right brace (}), single quotation mark (‘), and apostrophe (')
   - Cannot be identical to the name of another existing sequence or scan recipe
3. Click on OK, or click on Cancel to abort the Save operation.

To load a sequence into the Sequence Editor:

1. In the Sequence Editor window, select Open from the Sequence menu. The following dialog box appears (Figure 7-28):

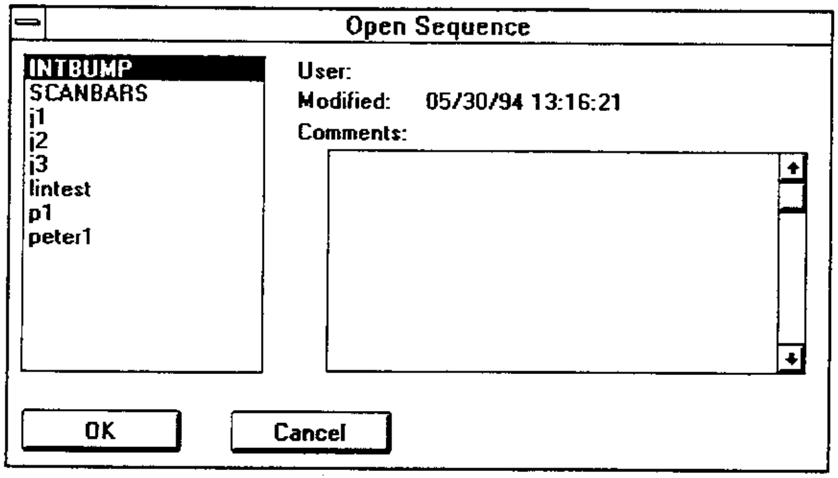


Figure 7-28 Open Sequence Dialog Box

2. Select the desired sequence from the list of sequences on the left side.
3. Click on the OK button.

7.13 SAVING AND MAINTAINING SEQUENCE SCAN DATA

Sequence scan data can be saved for reviewing at a later time.

To save sequence scan data:

1. Choose Save Data from the File menu. The following dialog box appears:

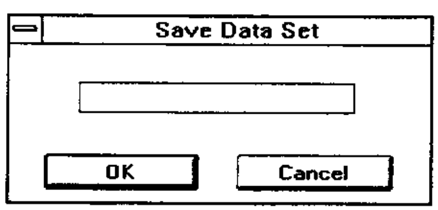


Figure 7-29 Save Data Set Dialog Box

2. Type a name for the data set, then click on OK, or click on Cancel to abort the Save operation. The data set filename must be a valid DOS filename. Valid DOS filenames
   - Can contain a maximum of eight characters
   - Have a three-character extension supplied by the system
   - Are not case-sensitive

- Can contain only the letters A–Z, the numbers 0–9, and the following special characters: tilde (~), exclamation point (!), at sign (@), number sign (#), dollar sign ($), percent sign (%), caret (^), ampersand (&), left parenthesis, right parenthesis, underscore (_), hyphen (-), left brace ({), right brace (}), single quotation mark (‘), and apostrophe (')
- Cannot be identical to the name of another existing data set

Once a data set has been saved, it is added to the Sequence Data catalog. The Sequence Data catalog window allows you to select individual data sets for reviewing. You can also delete unwanted data sets.

To view previously saved sequence data:

From the Catalog window, click on the Sequence Data button on the left side of the screen. The Sequence Data Catalog window appears:

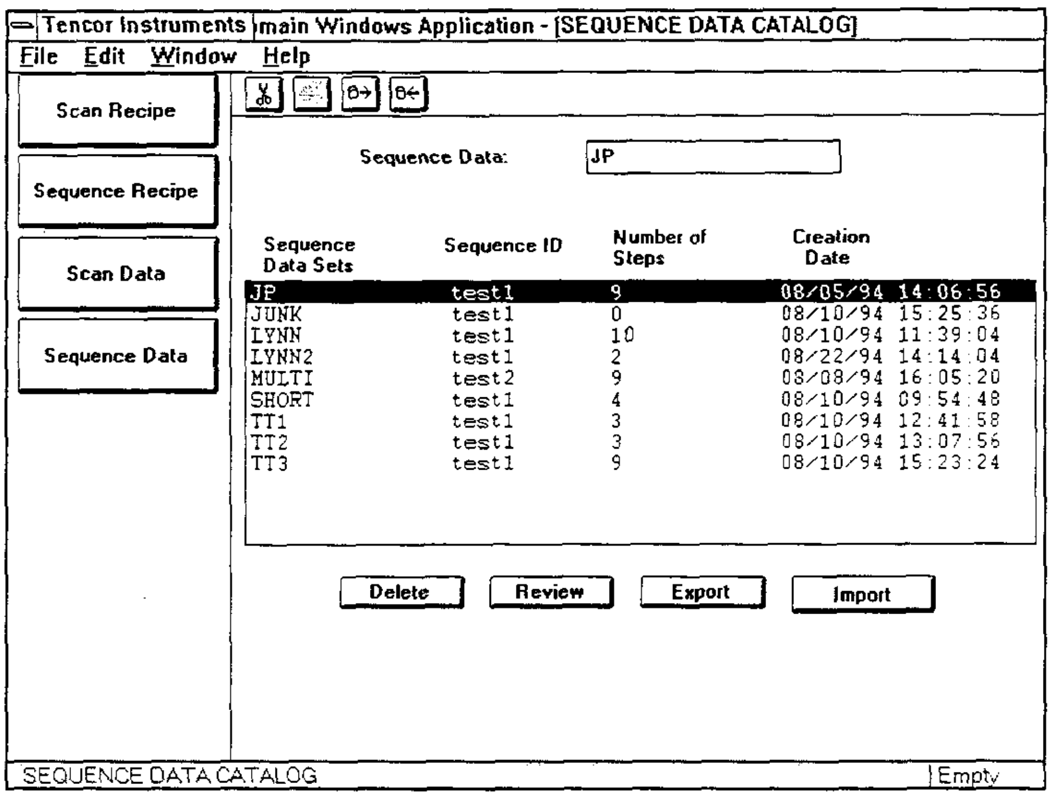


Figure 7-30 Sequence Data Catalog Window

To review a data set:

Select the desired data set from the list in the catalog, and click on the Review button, or double-click on the desired data set.

To delete, import, and export sequences, see Chapter 8, "Using the Database."

8 USING THE DATABASE

The Tencor P-20 database allows management of recipes and data. From the Database window, you can

- View the catalogs
- Delete files
- Print listings of files (recipe files only)
- Review recipes or data
- Export and import files (data files only)

8.1 DATABASE WINDOW

To open the Database window, use the Database menu accessed by clicking on Database icon on the Top Level menu (Fig. 3-2).

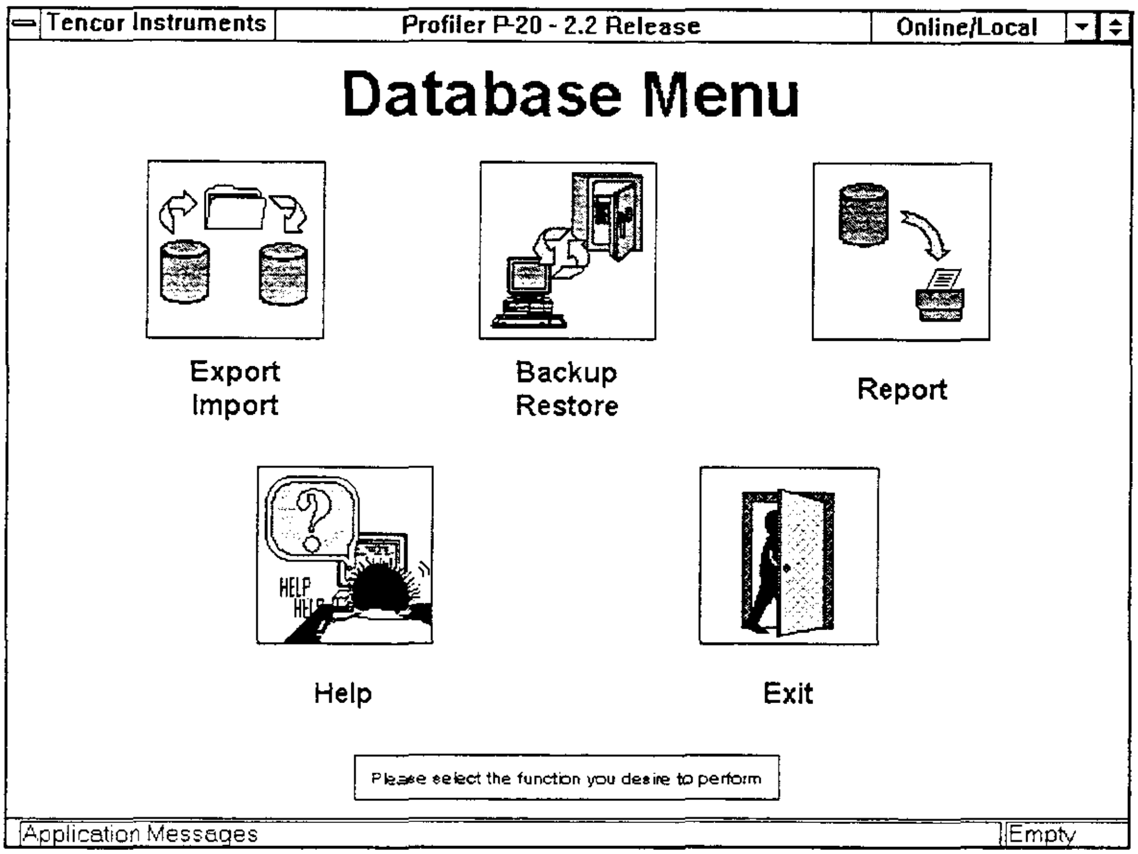


Figure 8-1 Database Menu

To access the main Database window:

Click on the Import/Export icon in the Database menu.

The main Database window appears with the Scan Recipe Catalog active. The Database window consists of the following elements:

- Menu bar
- Tool bar
- Secondary tool bar with a set of command buttons used to select which of the four database catalogs to display
- Main area of the window, displaying currently selected catalog and a series of command buttons

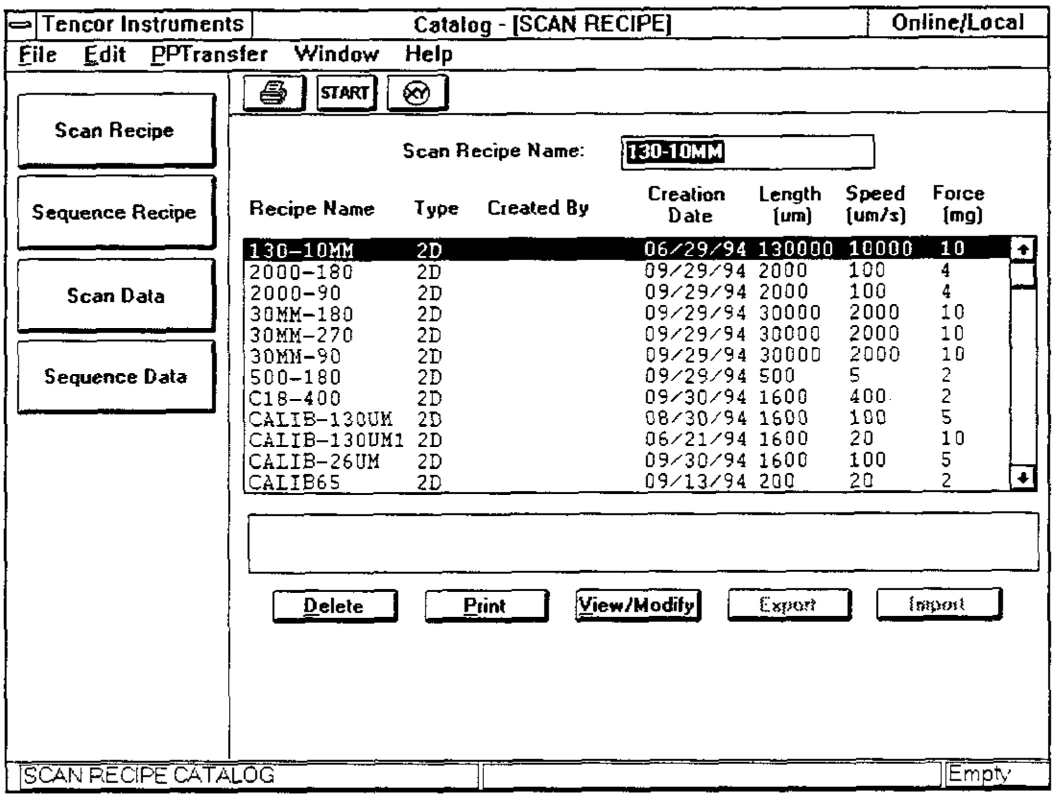


Figure 8-2 Database Window with Scan Recipe Catalog

8.1.1 DATABASE WINDOW MENU BAR

The Database window menu bar provides access to commands and allows easy navigating through the four subwindows.

The Database window menu bar provides the following menus. You can view menus by clicking on the titles in the menu bar, or by pressing ALT + *l*, where *l* is the letter that appears with an underscore in the desired title in the menu bar. You can choose menu items by clicking on a menu entry or by typing the letter that appears with an underscore in the desired menu item. Some menu items have hot keys assigned to them.

Figure 8-3 File Menu

Figure 8-4 Edit Menu

Figure 8-5 PPTransfer Menu

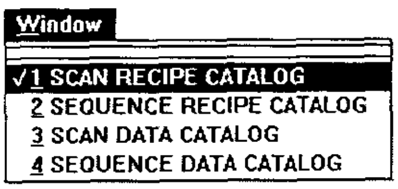


Figure 8-6 Window Menu

8.1.2 DATABASE WINDOW TOOL BAR

The Database window tool bar contains a row of icons that resemble buttons. Clicking on these icons provides an alternative way to access commonly used functions.

Each icon suggests the function of the button. For example, the Print button resembles a printer. Buttons that appear dimmed are unavailable.

The Database window tool bar contains the following buttons:

Button	**Action**
	Deletes the indicated recipe or data set
	Sends the indicated Scan or Sequence recipe to the printer
	Displays the Export dialog box
	Displays the Import dialog box

8.1.3 DATABASE WINDOW COMMAND BUTTONS

You choose which database catalog to maintain by selecting one of the four command buttons on the left side of the window. These buttons are visible at all times in the Database window and allow you to quickly change catalogs.

The following command buttons appear:

Button	**Action**
Scan Recipe	Switches the main window to the Scan Recipe catalog
Sequence Recipe	Switches the main window to the Sequence Recipe catalog
Scan Data	Switches the main window to the Scan Data catalog
Sequence Data	Switches the main window to the Sequence Data catalog

To select a group of parameters to view and edit:

Click on the appropriate command button, or select the appropriate catalog from the Window menu. The right side of the window displays the selected catalog.

8.2 DELETING DATABASE ITEMS

You can delete Scan and Sequence recipes and data from the appropriate catalog.

To delete a database item:

1. Display the desired catalog by clicking on the appropriate command button on the left side of the window.
2. Select the item you wish to delete by clicking or scrolling with the arrow keys.
3. Click on the Delete button below the catalog, or the Delete icon in the tool bar. The following dialog box appears.

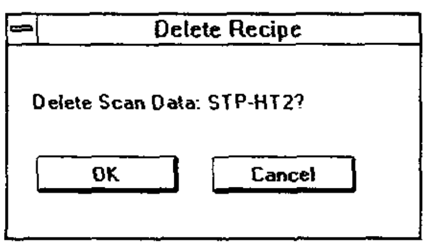


Figure 8-7 Delete Recipe Dialog Box

4. Click on OK to delete, or Cancel to leave the selected item in the catalog.

8.3 PRINTING DATABASE ITEMS

You can print a listing of Scan or Sequence recipes from the appropriate catalog.

To print a Scan or Sequence recipe to the currently active printer:

1. Display the Scan Recipe or Sequence Recipe catalog by clicking on the appropriate command button on the left side of the window.
2. Select the recipe you wish to print by clicking or scrolling with the arrow keys.
3. Click on the Print button below the catalog, or the Print button in the tool bar.

To print a Scan or Sequence recipe to a selected printer:

1. Display the Scan Recipe or Sequence Recipe catalog by clicking on the appropriate command button on the left side of the window.
2. Select the recipe you wish to print by clicking or scrolling with the arrow keys.
3. Select Print from the File menu. The Print dialog box appears.
4. Select the desired printer from the list box and click on OK.

For more information on printing, see Section 2.3.2, "Setting Up Printers," in the *Tencor P-20 Reference Manual*.

8.4 REVIEWING DATABASE ITEMS

You can select an item in any of the available catalogs to review. This opens the appropriate window with the selected item displayed.

To review a database item:

1. Display the desired catalog by clicking on the appropriate command button on the left side of the window.
2. Select the item you wish to delete by clicking or scrolling with the arrow keys.
3. Click on the Review button below the catalog. The appropriate window appears with the selected item displayed:
   - From the Scan Recipe catalog: the Recipe Editor
   - From the Sequence Recipe catalog: the Sequence Editor
   - From the Scan Data catalog: the Data Analysis window
   - From the Sequence Data catalog: the Sequence Data window

From the Editor windows, you can edit recipes and save the changes before returning to the Database window. See Chapter 4, "Recipes," and Chapter 7, "Sequencing," for information on using the Recipe and Sequence editors.

8.5 EXPORTING DATA

You can export Scan or Sequence data to floppy diskettes, or to another directory on the instrument computer's hard disk.

Recipe export is not supported in this release. However, if you have the GEM/SECS Option, both data and recipes can be exported by uploading to a host computer. See Section 9.5, "Downloading Data and Recipes," for more information.

You can export data in two formats:

- ASCII format for transferring data to other applications such as spreadsheets, word processors, desktop publishing or presentation software
- Binary format for use on another Tencor P-20, or for backing up and archiving data in its original format

To export Scan or Sequence Data:

1. Display the Scan or Sequence Data catalog by clicking on the appropriate command button on the left side of the window.
2. Select the recipe you wish to print by clicking or scrolling with the arrow keys.
3. Click on the Export button below the catalog, or the Export button in the tool bar. The following dialog box appears (Fig. 8-8).

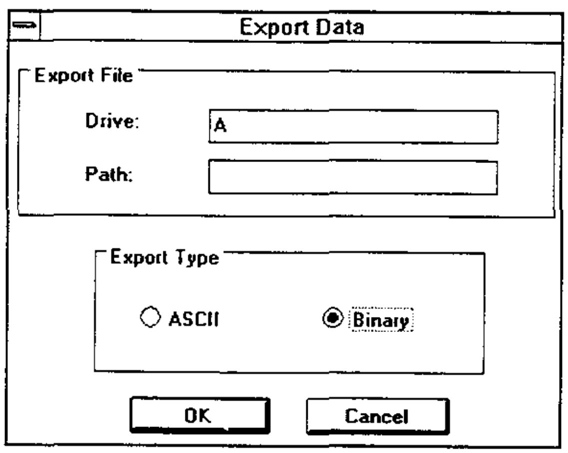


Figure 8-8 Export Data Dialog Box

4. In the Drive field, type a if exporting to a floppy diskette, or c if exporting to another directory on the hard disk.
5. In the Path field, type the desired path name, if any.
6. If a different filename is desired, type it in the Filename field.
7. Choose whether to export the file in ASCII or Binary form by clicking on the corresponding radio button.
8. Click on OK to export the file, or Cancel to close the dialog box without exporting.

8.6 IMPORTING DATA

You can import Scan or Sequence data from floppy diskettes, or from another directory on the instrument computer's hard disk. Data can only be imported in Tencor P-20 binary format.

Recipe import is not supported in this release. However, if you have the GEM/SECS Option, recipes can be imported by downloading from a host computer. See Section 9.4, "Uploading Recipes," for more information.

To import Scan or Sequence Data:

1. Display the Scan or Sequence Data catalog by clicking on the appropriate command button on the left side of the window.
2. Click on the Import button below the catalog, or the Import button in the tool bar. The following dialog box appears (Fig. 8-9).

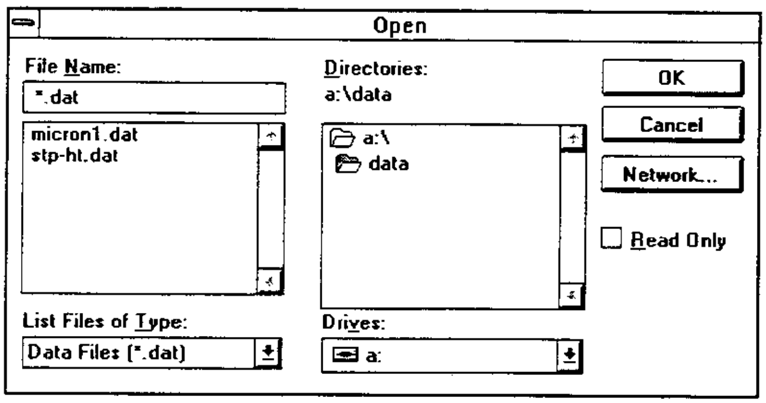


Figure 8-9 Open Dialog Box

3. On the right side of the dialog box, select the drive from the Drives pull-down list, and the directory from the Directories list box.
4. A list of available files with the extension .DAT appears in the list box beneath the File field on the left side of the dialog box. If you want to see a list of files with other extensions, select All Files (*.*) from the List Files of Type pull-down list.
5. Select the desired file, then click on Open. The following dialog box appears:

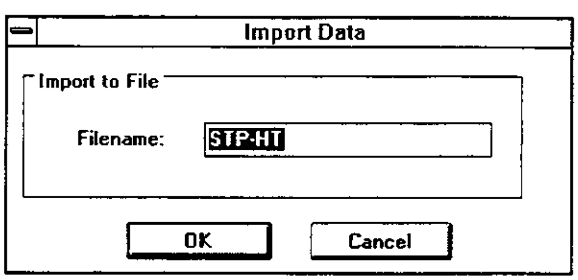


Figure 8-10 Import Data Dialog Box

6. If you want to rename the file, type the desired name; otherwise, leave the default name.
7. Click OK. The file is imported into the default Scan or Sequence data subdirectory.

9 GEM/SECS OPTION

The GEM/SECS Option allows the uploading of scan measurement data from the Tencor P-20 to a host computer. The capability also supports alarms, data collection, equipment states, error messages, initialization, clock, and process program upload and download.

This chapter describes

- The GEM/SECS window
- Enabling SECS communications
- Checking communication status
- Configuring GEM parameters
- Uploading data and recipes
- Downloading recipes

For detailed information about the GEM/SECS Option, see the *Tencor P-20 SECS Interface Manual.*

9.1 GEM/SECS WINDOW

To open the GEM/SECS window, use the Top Level menu (Fig. 3-2).

To access the GEM/SECS window:

Click on the GEM+SECS icon in the Top Level menu. The GEM User Interface window appears:

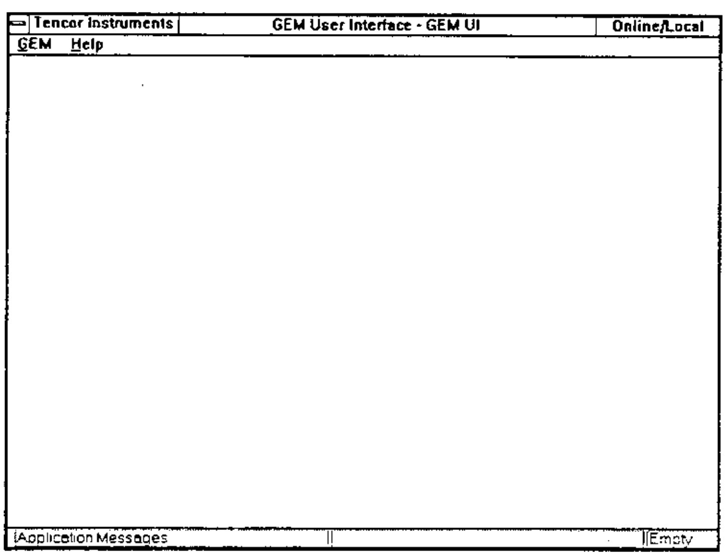


Figure 9-1 GEM User Interface Window

9.1.1 GEM/SECS WINDOW MENU BAR

The GEM User Interface menu bar provides the following menus. You can view menus by clicking on the titles in the menu bar, or by pressing ALT + *l*, where *l* is the letter that appears with an underscore in the desired title in the menu bar. You can choose menu items by clicking on a menu entry or by typing the letter that appears with an underscore in the desired menu item. Some menu items have hot keys assigned to them.

Figure 9-2 GEM File Menu

9.2 ENABLING SECS COMMUNICATION

To enable/disable SECS communication:

Select Enabled from the GEM menu to toggle between states. When communications is enabled, a check appears next to the menu selection.

To check the GEM status:

From any window, the current control state is displayed in the upper right corner of the window in the menu bar. For more complete information, double-click on the on the displayed control state, and the following message box appears:

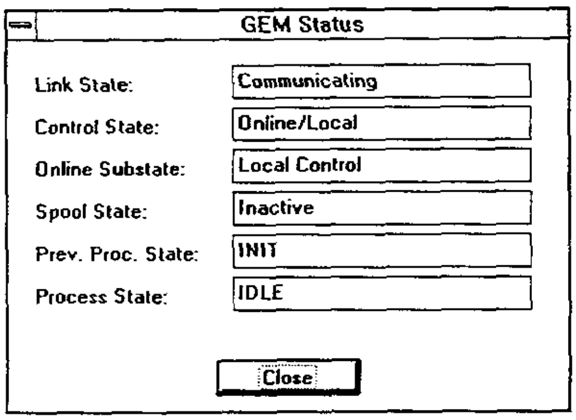


Figure 9-3 GEM Status Message Box

9.3 GEM CONFIGURATION

GEM parameters can be configured by the operator or host. The GEM Configuration dialog box enables configuration of the GEM-related parameters (configuration, initial states, S1F2 message items, optional W-bit use, and host connect retry delay).

To change the default GEM parameters:

1. From the Top Level menu, double-click on the GEM+SECS button. Select Config... from the GEM menu. The GEM Configuration dialog box appears:

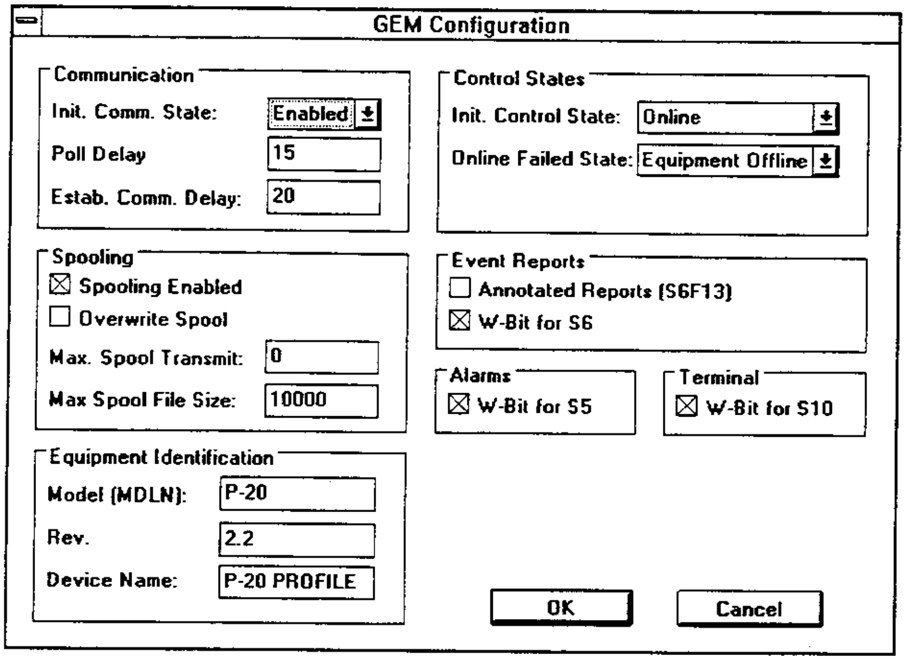


Figure 9-4 GEM Defaults Window

2. Change the parameters as appropriate. When finished, click on the OK button. These values are saved to the hard disk so that when the instrument is reset or powered on again, these new values are displayed.

   You can also click on Cancel to close the GEM Configuration window without changing the parameters.

9.4 UPLOADING RECIPES

With the GEM/SECS Option, you can *upload* (export) data and recipes to a host computer.

To upload data and recipes to a host computer:

1. From the appropriate catalog window, select the recipe or data set you wish to upload.
2. Select Upload from the PPTransfer menu. The following dialog box appears (Fig. 9-5).

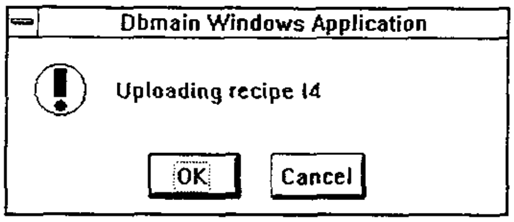


Figure 9-5 Upload Dialog Box

Click on OK to proceed with the upload, or Cancel to abort the operation.

9.5 DOWNLOADING DATA AND RECIPES

With the GEM/SECS Option, you can *download* (import) recipes (but not data) from a host computer.

NOTE:	**You can import Tencor P-20 data files (in binary format) from floppy diskettes. See Section 8.6, "Importing Data," for more information.**

To download recipes from a host computer:

1. From the Recipe or Sequence catalog, select Download from the PPTransfer menu. The following dialog box appears:

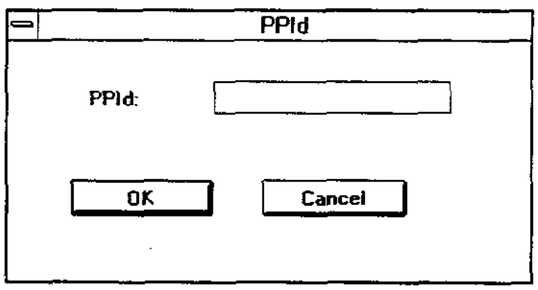


Figure 9-6 PPID Dialog Box

2. Type the PPID of the recipe that you wish to download, then click on OK to proceed. After a few moments, the recipe appears in the list.

10 WAFER STRESS APPLICATION OPTION

10.1 OVERVIEW

It is important to monitor thin film stress so that thin film stress data can be used to reduce process variations. Stress is generated in the film and substrate during thin film deposition. The deformation of the thin film can be accommodated by the bending and compressing or expanding (depending on the curvature) of the substrate.

The Tencor P-20 Wafer Stress application Option enables you to calculate the stress in a deposited film by measuring the wafer deflection or curvature that stress induces on the substrate.

The program determines the curvature of the sample by calculating the least square fit of the trace data. The equation for stress is as follows:

$$\sigma = \frac{1}{6R} \frac{E}{(1-v)} \frac{t_s^2}{t_f}$$

where

$\frac{E}{(1-v)}$ = substrate elastic constant

t_s = substrate thickness

t_f = film thickness

R = radius of curvature

The program calculates the radius of curvature by using a least square fitting method. This equation assumes that the chord length is much larger than the bow (that is, the wafer deflections are smaller compared to its radius of curvature).

Note: The program results can be verified by using the following equation for the radius of curvature (R):

$$R = \frac{L^2}{8B}, \text{ if } L \gg B$$

where

B = bow (maximum between trace and its chord)
L = chord length (scan length)

Note: Geometric dimensions are in the same units.

The Tencor P-20 program calculates the following stress values:

- Average Stress derived from the least square fit of the entire profile across the entire chord
- Maximum Stress based on the maximum of *n* overlapping sections of one-third of the length and offset across the wafer, where *n* is a number selected by the user
- Center Stress computed at the center third of the profile

10.2 USING THE WAFER STRESS

Use the Wafer Stress application to compare pre- and postprocessing traces. This comparison calculates the curvature caused solely by the processing-induced stress. For details see Section 10.6.1, "Measuring a Difference Stress."

You also can take a single stress measurement without comparing it to an earlier measurement. You may want to take this measurement when you have no prestress data for a wafer. For details see Section 10.6.2, "Measuring a Single Trace Stress."

Only the pre- and poststress traces and summaries are saved. Stress values are not saved but recalculated each time from the raw traces. To recalculate the stress values, both the pre- and poststress traces must be present in the Scan Data catalog.

10.2.1 ENTERING SCAN IDS

You enter a name for each scan that you take. You can use any given scan for either the pre- or the postscan.

For example, if you have a two-process step and take three scans, the middle scan is the postscan for the first scan, but it is the prescan for the second scan.

10.2.2 SAVING DATA

To recompute and display difference measurements, both pre- and poststress raw data must be saved. Also, saving the raw and summary data allows you to recalculate the stress value with different parameters.

10.3 THE STRESS WINDOWS APPLICATIONS

To access Tencor's Wafer Stress application, click on the Stress icon on the Top Level Menu of the P-20 Profiler. The Stress Windows Applications screen displays, as shown below.

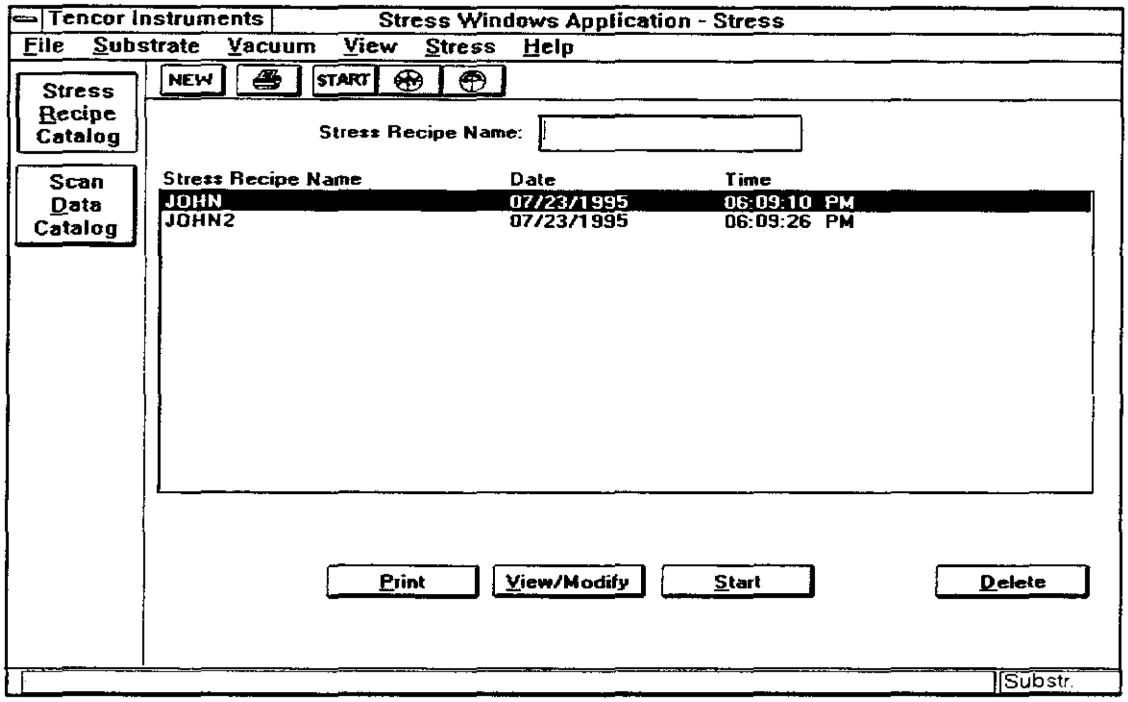


Figure 10-1 Stress Windows Application Screen

The Stress Windows Application screen provides you with two catalogs of stress recipes and scan data. The Stress Recipe Catalog lists the currently available stress recipes saved on the hard disk by name and date. The Scan Data Catalog lists the existing scans saved on the hard disk by scan ID, stress recipe used, X-, Y-coordinates of the scan, and the date and time the scan was taken.

10.3.1 STRESS WINDOWS APPLICATION MENU BAR

The Stress Windows Applications menu bar provides the following menus:

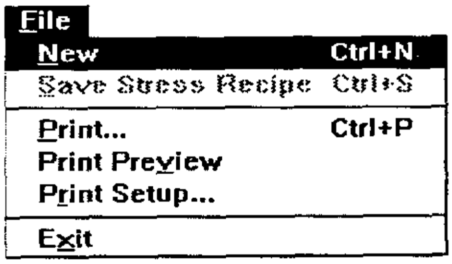


Figure 10-2 File Menu

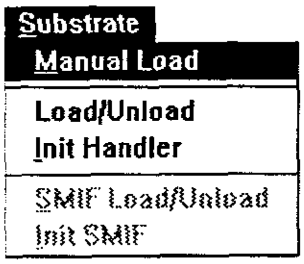


Figure 10-3 Substrate Menu

Figure 10-4 Vacuum Menu

Figure 10-5 View Menu

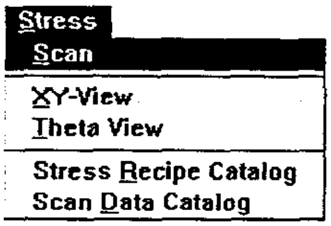


Figure 10-6 Stress Menu

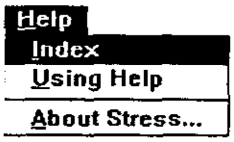


Figure 10-7 Help Menu

10.3.2 STRESS WINDOWS APPLICATIONS TOLL BAR

The Stress Windows Application tool bar contains a row of icons that resemble buttons. Clicking on these icons provides an alternative way to access commonly used functions.

Button	Action
	Invokes the Stress Recipe Editor to add a new stress recipe.
	Displays the Print dialog box to print data for the current page.
	Starts a scan using the current recipe.
	Switches to the XY view window.
	Switches to the Theta view window.

10.4 SELECTING, MODIFYING, AND ADDING A SCAN RECIPE

To select a recipe:

Click on the Stress Recipe Catalog of the Stress Windows Application screen. A list of available recipes displays in a list box, as shown in Figure 10-8. Select an existing receipt from this list.

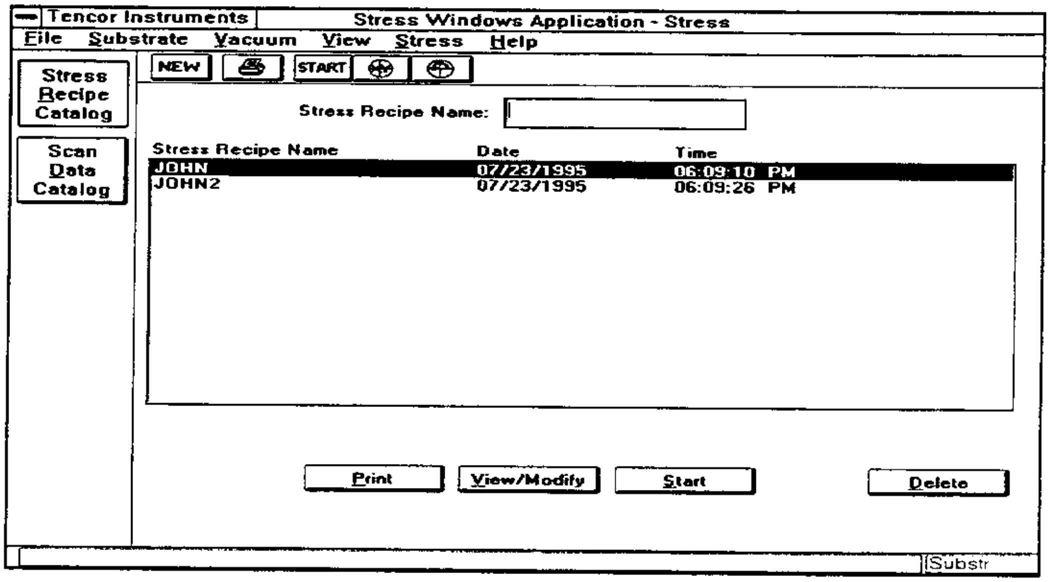


Figure 10-8 Stress Recipe Catalog

To modify a recipe:

Once you have selected a recipe from the Stress Recipe Catalog, you can edit that recipe by selecting the View/Modify button to invoke the Stress Recipe Editor screen (Fig. 10-9).

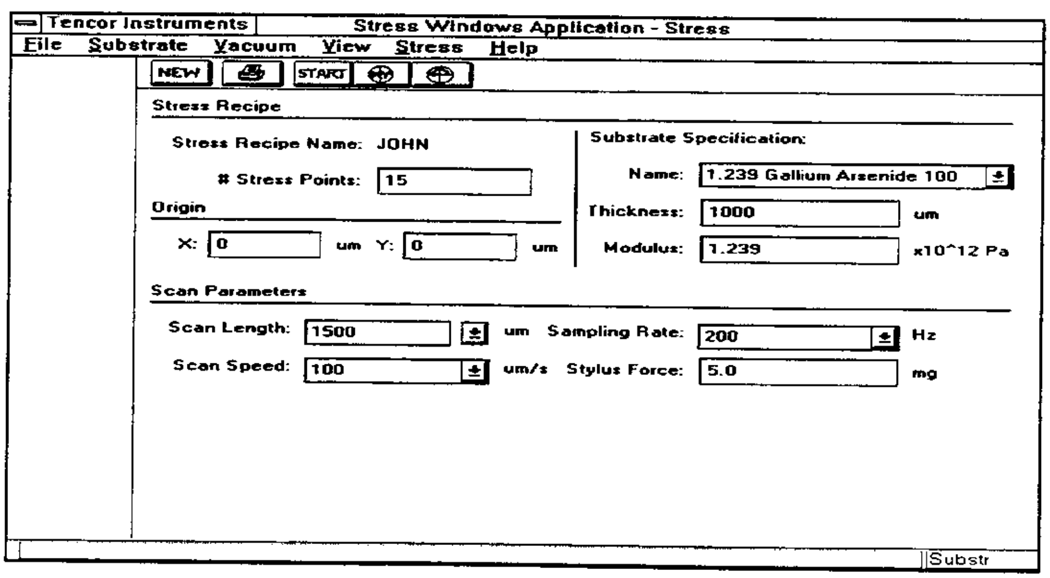


Figure 10-9 Stress Recipe Editor

To add a new stress recipe:

From the Stress Windows Application screen choose the View/Modify button. At the Stress Recipe Editor screen click on the New button to start writing the new recipe.

To print a stress recipe:

Click on the Print button to print the currently selected stress recipe.

To save a stress recipe:

To save the currently selected stress recipes, select the Save Stress Recipe menu item from the File menu. Use the ESC key to return to the Stress Windows Applications screen. The XY button switches to the learning mode.

10.4.1 ENTERING STRESS RECIPE VALUES AND PARAMETERS

There are several fields in the Stress Recipe Editor window that you need to enter to complete writing a new recipe. Among these values, you need to enter the film thickness and specify the substrate for the sample.

To enter stress parameters:

1. In the Thickness field, type the thickness (in microns) of the substrate.
2. In the Substrate Specification field, select a desired substrate with its elastic constant. Table 10-1 lists the available substrates and their elastic constants.

Table 10-1 Elastic Constants for Commonly Used Thin Film Substrates

Material	Orientation	Elastic Constants (10^{12} Pa)
Aluminum	*	1.030
Aluminum Oxide (Al_2O_3)	+	3.835
Aluminum Oxide (Al_2O_3)	+	4.895
Aluminum Nitride (AlN)	+	4.367
Beryllium Oxide (BeO)	+	4.367
Borophosphosilicate (BPSG) glass	+	1.500
Gallium Arsenide (GaAs)	111	1.741
Gallium Arsenide (GaAs)	100	1.239
Germanium (Ge)	111	1.837
Germanium (Ge)	100	1.420
Phosphosilicate (PSG) glass	+	0.988
Silicon	111	2.290
Silicon	100	1.805
Sodalime glass (Corning microsheet 0211)	+	0.973

* polycrystalline
\+ amorphous

<Other> Allows the user to enter a substrate that does not exist on the list.

10.5 LOADING AND POSITIONING THE SAMPLE

For information on loading and positioning the sample, refer to Section 6.3, "Loading the Sample," and Section 6.4, "Viewing and Positioning the Sample." Before loading a sample, check that it meets the following requirements:

- The sample has been processed.
- It was scanned before the processing.
- The scan is in the database.

To position the sample to measure stress by comparing pre- and postprocessing traces:

NOTE:	**Position the sample exactly as it was positioned for measuring stress on a single trace scan.**

1. Use the wafer stress precision locator, which is the locator with the three support points. Be sure that you position the sample the same way it was positioned for the prestress scan.

NOTE:	**If you are using the wafer handler to load wafers, make sure the wafer stress chuck is installed on the stage before starting stress measurements. See below for details. See Section 10.5.1 "Tencor P-20 Handler Wafer Stress Chuck."**

   The precision locator has fittings that locate wafers of various sizes in X, Y, and θ positions. It supports the wafers in a way that minimizes gravitational distortions but also ensures that the residual gravitational distortion is the same for both pre- and poststress scans.

2. You can program the instrument so that the load position moves the stage to exactly the right scan position. See Section 6.3, "Loading the Sample."

10.5.1 TENCOR P-2 HANDLER WAFER STRESS CHUCK

The wafer stress chuck (Fig. 10-10) is designed to support the wafer during wafer stress measurements. The instrument is shipped with the vacuum chuck installed if your instrument comes with the wafer handler. To replace the vacuum chuck with the wafer stress chuck, use the instructions provided in Section 2.5, "Installing a Precision Locator," in the *Tencor P-20 Long Scan Profiler Reference Manual.*

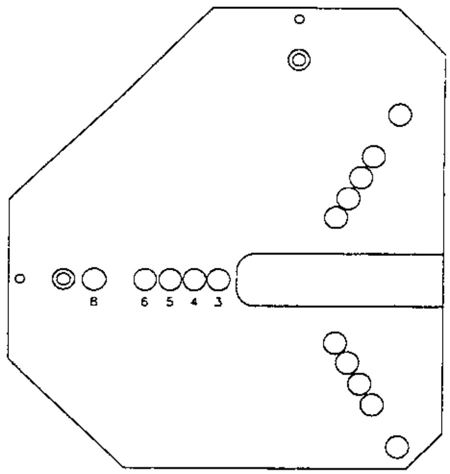


Figure 10-10 Wafer Stress Chuck

The handler controls the placement of the wafer by centering it on the locator. The three wafer support pins can be located for wafers of nominal sizes 3 to 8 in. See Appendix D, "Precision Locators," in the *Tencor P-20 Long Scan Profiler Reference Manual.*

- If the wafer is loaded using the wafer handler, make sure the wafer is loaded using the aligner. Also the angle used for alignment must be the same for the prestress and poststress loading.
- If the sample is loaded manually, note the position of the sample when you load it on the stage table. To compare pre- and poststress measurements, you must duplicate this scan position for the poststress measurement.

10.5.2 TAKING A SCAN

A single, poststress measurement measures the current curvature of the sample. In its calculations, the program assumes that the sample was flat before being stressed.

To take a single, poststress measurement:

1. Load the sample.
2. Choose a recipe from the list box (or create a new recipe).
3. Position the sample for the scan.
4. Display either the Stress Windows Applications screen or the Stress Recipe Editor screen if you are modifying an already existing recipe or creating a new recipe.
5. Enter film and substrate information for the sample.
6. Press the START key either from the Stress Windows Applications screen or from the Stress Recipe Editor screen.

10.5.3 DISPLAYING A LIST OF SCANS

Selecting the Scan Data Catalog button of the Stress Windows Application screen displays a list of currently existing data scans on the hard disk by scan ID, scan recipe used, X-, Y-coordinates of the scan, and the date and time the scan was generated. The Scan Data Catalog is shown in Figure 10-11.

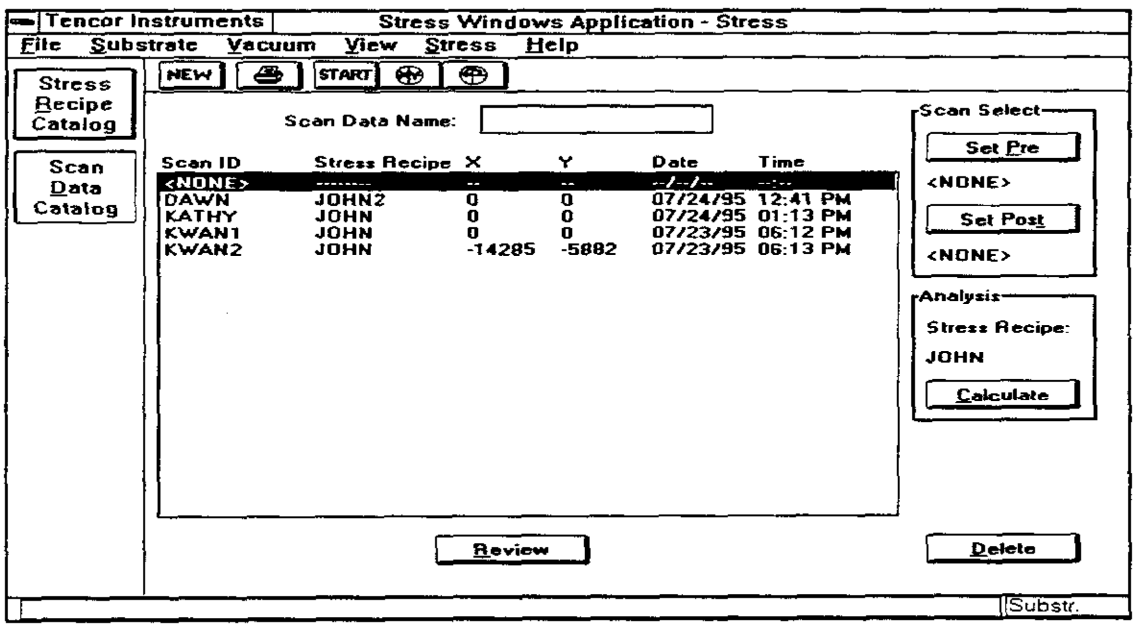


Figure 10-11 Scan Data Catalog Screen

You can remove a scan from this list simply by selecting the scan, then processing the DELETE key. Using the ESC key in this screen takes you back to the Stress Windows Application screen.

10.5.4 VIEWING SCAN RESULTS

The Stress application provides you with two ways that you can use to access the Scan Results window (Fig. 10-12) to view a particular scan without performing analysis on the scan.

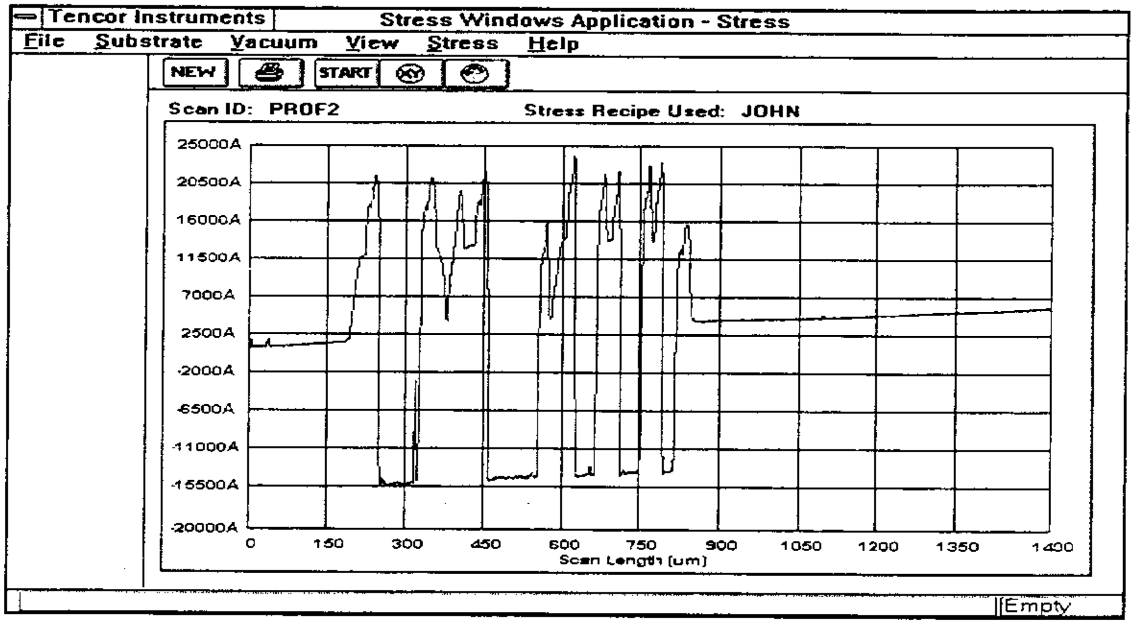


Figure 10-12 Scan Results Window

To view a scan results from the Stress Recipe Catalog:

1. If you have the Stress Recipe Catalog displayed and choose the START key to perform a scan, you see the display of the scan.
2. Use the ESC key to return to the Stress Recipe Catalog screen where you can start another scan.

To view a scan results from the Scan Data Catalog:

1. If you are in the Scan Data Catalog and have selected a particular scan, simply enter the REVIEW key to display the scan (Fig. 10-10).
2. Use the ESC key to return to the Scan Data Catalog screen.

10.6 ANALYZING THE STRESS RESULTS

You can calculate both a *difference* measurement that compares the poststress data in the current trace with prestress data from an earlier scan, as well as a *poststress* measurement on a single trace.

10.6.1 MEASURING A DIFFERENCE STRESS

The Stress application enables you to perform analysis on pre- and postprocessing traces. To accomplish this, you need to assign a particular scan of your choice that you select from the list box as a prestress scan and then select another scan from this list and assign that scan as the poststress scan.

To measure a difference stress:

1. To assign scans as prescan and postscan, use the Stress Windows Application screen (Fig. 10-13).

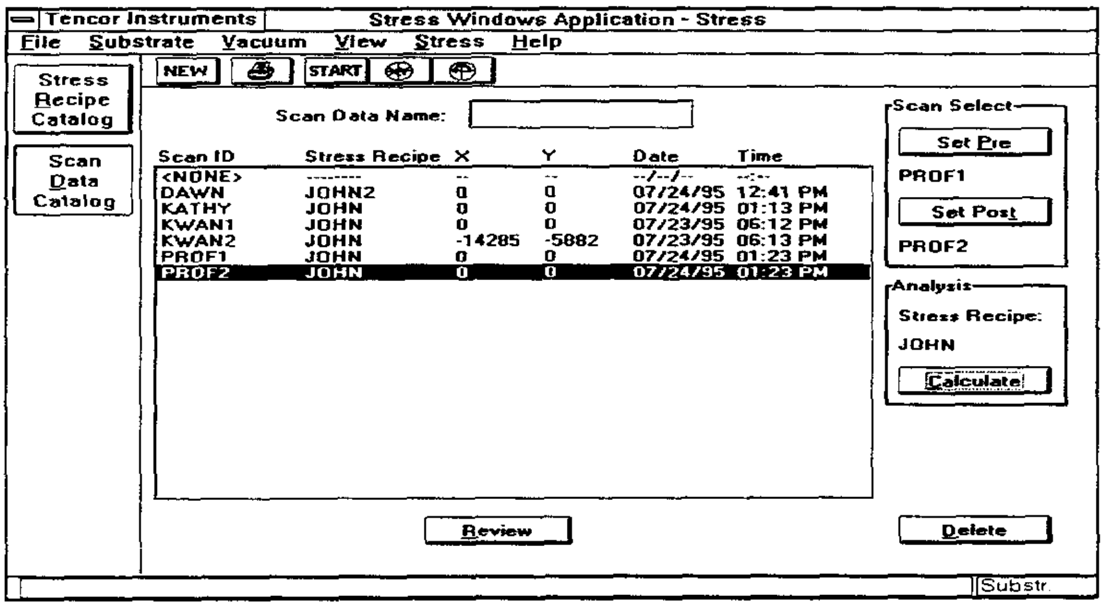


Figure 10-13 Stress Results Display

2. Select the Scan Data Catalog button.
3. Selected a scan from the list box or enter a scan name in the Scan Data Name field.
4. Choose the Set Pre button to assign that scan as a prestress scan.
5. Similarly, select another scan of your choice from the list box.
6. Reselect the Set Post button to assign that scan as the poststress scan.

   Note: As you make these assignments, notice that the scan ID of the scan you have selected appears below the Set Pre and Set Post buttons.

7. If you wish to assign another scan as a prestress scan or a poststress scan, simply select another scan from the list box and then hit the Set Pre or the Set Post button.

8. After selecting the two scans, choose the Calculate button to calculate and view the results (Fig. 10-14).

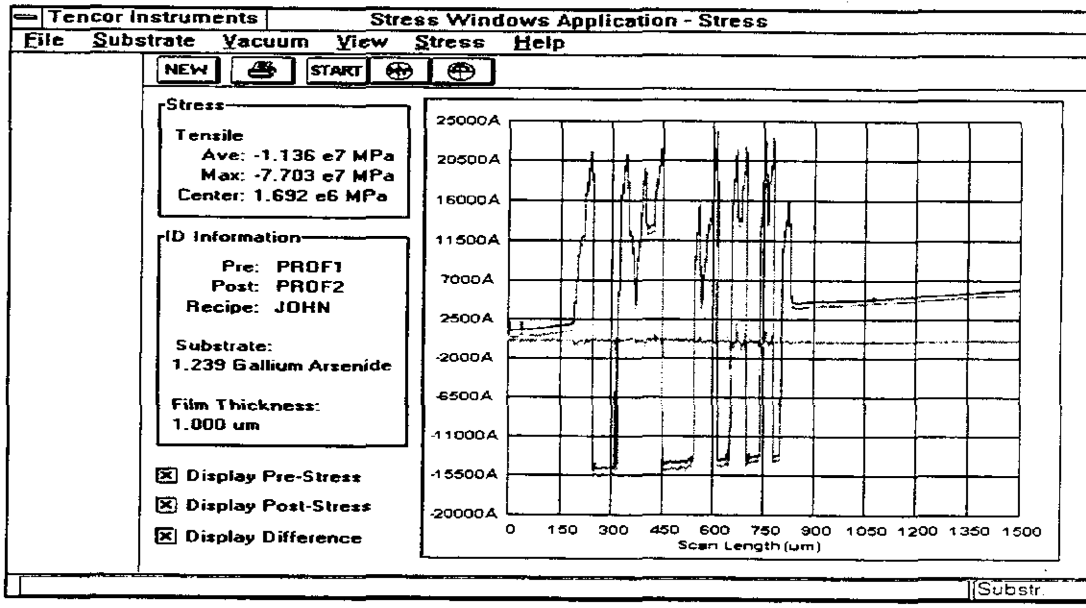


Figure 10-14 Stress Results Display

10.6.2 MEASURING A SINGLE TRACE STRESS

In addition to comparing pre- and poststress processing traces, you also can take a single stress measurement without comparing it to an earlier measurement. You may want to take this measurement if you do not have or choose not to use any prestress data for a wafer.

To measure a single trace stress:

1. Select the NONE scan ID from the Scan Data Catalog list box (the first choice in the box).
2. Choose the Calculate button on the Scan Data Catalog screen to calculate and view the results. This brings up the Stress Recipe Display screen.

10.6.3 ANALYZING THE RESULTS

The Stress Results Display (Fig. 10-14) lets you display the Prestress, Poststress, and the Difference deflections. Each of these traces has a corresponding check box labeled as Display Pre-Stress, Display Post-Stress, and Display Difference.

The Stress Results Display shows the three traces in three different colors. If you have not specified any prestress trace, that line appears as a flat line.

This screen also displays the results of the calculation (Fig. 10-14) as well as the IDs of the prestress and poststress scans and the stress recipe name used.

NOTE:	**If you specify two scans by using different scan recipes, the Stress application calculates the stress by giving the best estimate over the region where data is available for both scans. For regions with conflicting sets of data, the program displays a zero stress.**

11 SIGNAL LIGHT TOWER OPTION

11.1 OVERVIEW

A Signal Light Tower is a highly visible indicator of a tool's status. The multi-light device can be used to signal that an instrument is in production or to indicate the reason that it is not in production.

The implementation of the Signal Light Tower Option available in the current release of the Tencor P-20 allows you to specify custom definition corresponding to specific instrument states. This approach involves some relatively simple hardware and new Profiler software that translates instrument statues into commands to the new hardware.

11.2 ACCESSING SIGNAL LIGHT TOWER

To invoke the Signal Light Tower window, click on the Configuration icon of the top level menu of the P-20 Profiler software. The Configuration window display appears (Fig. 11-1).

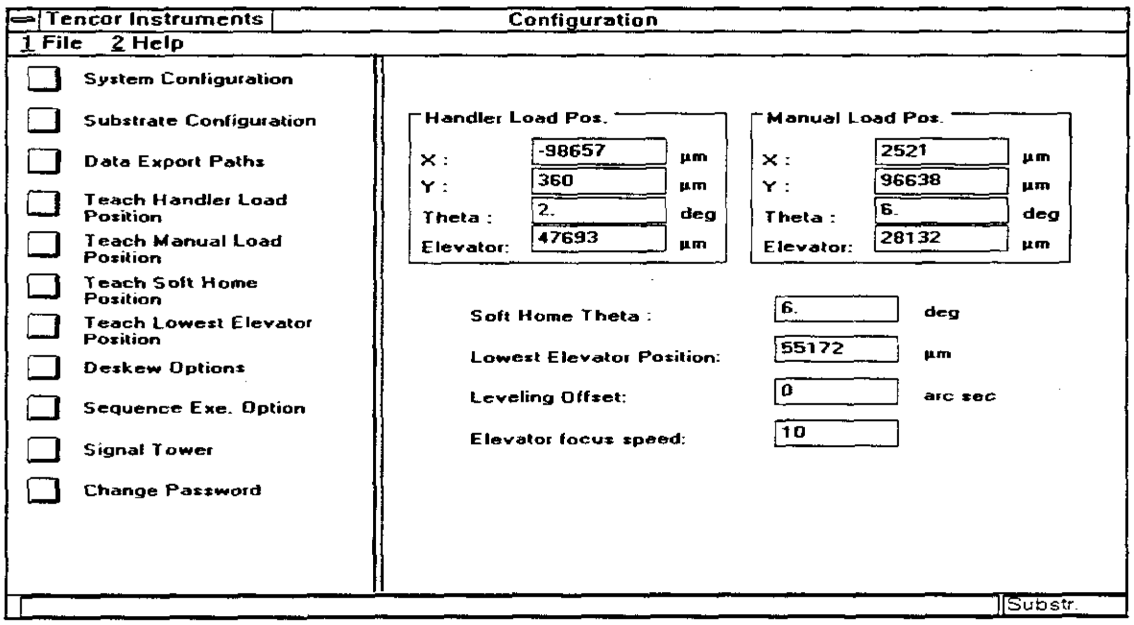


Figure 11-1 Configuration Window

11.2.1 SYSTEM CONFIGURATION

A check box has been added to the Configuration window, titled as Signal Tower. When this button is pressed, the Signal Light Tower Configuration Editor Utility window appears (Fig. 11-2).

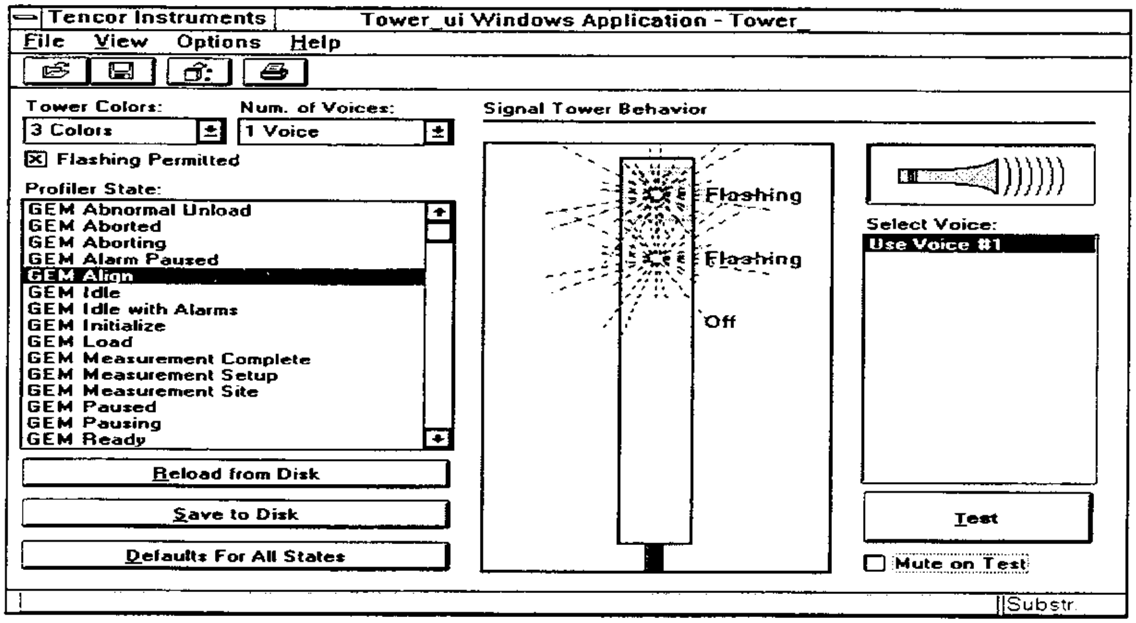


Figure 11-2 Signal Light Tower Configuration Editor Window

11.2.2 SIGNAL TOWER WINDOWS APPLICATION MENU BAR

The Signal Tower Windows Applications menu bar provides the following menus:

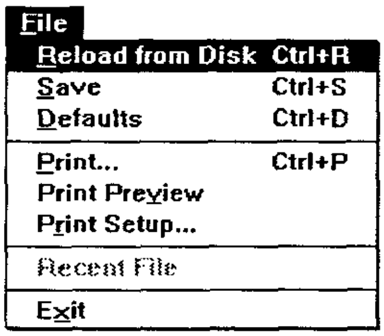


Figure 11-3 File Menu

Figure 11-4 View Menu

Figure 11-5 Options Menu

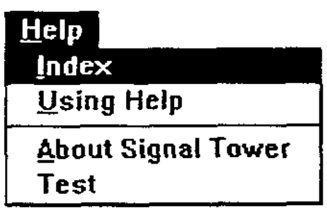


Figure 11-6 Help Menu

11.6.1 SIGNAL TOWER WINDOWS APPLICATIONS TOOL BAR

The Signal Tower Windows Application tool bar contains a row of icons that resemble buttons. Clicking on these icons provides an alternative way to access commonly used functions.

Button	Action
	Load all states. Equivalent to the Reload from Disk button.
	Save the changes to all states. Equivalent to the Save to Disk button.
	Return all states to factory default settings. Equivalent to the Defaults for All States button.
	Displays the Print dialog box to print current states and definitions.

11.6.2 LIGHTING OPTIONS

The Signal Light Tower allows you to specify any of the five lights: red, yellow, green, blue, and white. You can set these lights independently of each other. Lights can be turned off, constantly on, or set to flashing. All lights can be turned off or cleared simultaneously. The tower displays the proper behavior as appropriate for the settings that are current for that Profiler state (Fig. 11-2).

You can edit the tower behavior by using the mouse. If you click on a given light, the light toggles its state. This means that if the light was off, it goes to flashing next. If the light was flashing, it goes to on next. If the light was flashing, it turns off any other light since this control prevents illegal behavior such as two lights being on at the same time.

To reach the state where all lights are set to off, click on a blank space, away from any light or just go to the light that is on and toggle its state until the light is off.

11.6.3 LIGHTING EXAMPLES

The following is a list of examples for lighting corresponding to the instrument states.

Light	Description
Red, flashing	Indicates failure, abort, immediate assistance is required.
Red, steady	Indicates the equipment is not fully capable. An alarm has been acknowledged but not corrected.
Yellow, flashing	Indicates that the alarm is not acknowledged and needs assistance, for example, during unload cassette, completion or run, PM, and so on.
Green, flashing	Indicates the equipment is capable of performing all functions but no product is running.
Green, steady	Indicates that the equipment is fully capable and is running wafers.

11.6.4 VOICE OPTIONS

The voice custom control is a two-state button (Fig. 11-2). It toggles between on and off. When voices are permitted and it is in the *on* state, an appropriate picture shows a speaker with sound waves.

When the voice option is in the *off* state, another picture shows a speaker without sound waves.

If sounds are not permitted by the current tower, the button shows the alarm clock with a red X across it indicating that there is no sound capability.

The choices for the number of voices are NONE, and 1 through 16. NONE specifies towers without sound capabilities.

11.6.5 STATUS INFORMATION

Selected portions of the current status of the P-20 profiler are always available to the Signal Light Tower control software. This part of the software informs the user of any changes in the status of the instrument at the time the changes occur.

The list box on the Signal Light Tower window contains a descriptive list (Fig. 11-2). You can edit the behavior of the signal tower for a particular state by selecting that state from the list box. At that point, the current behavior for that state is shown with two custom controls, one for the tower voice and one for the tower lights.

You can test a state after editing it by selecting the Test button. This action immediately places the tower into that state so that you can see and hear what the state appears like.

You can then proceed and edit other states by selecting them from the list box and edit them as shown above.

Once you have completed editing the behavior of a state, you can select the Save to Disk button to save the settings for that state. You can cancel the changes to the states by selecting the ESC key and leaving the application without saving to the disk. After you have already saved the changes to the states, you can undo the changes by selecting the Defaults for All States button that returns all states to factory defaults.

You are then prompted for a password, if you have set any. If the password that you enter is invalid, the changes to the state cannot be saved.

The system initially starts with *Welcome* as the password the first time it is run.

GLOSSARY

2-D Data
Two-dimensional data.

3-D Data
Three-dimensional data.

ASCII Data
ASCII (American Standard Code for Information Exchange) codes are used to represent characters for storage in a computer's memory.

Application
A software program such as the Tencor P-20 Scan application.

Application icon
Graphic symbol representing a software application. The Tencor P-20 Top Level menu displays application icons.

Application window
The main window opened by an application.

Area
See Total Area.

Area+
See Area of Peaks.

Area-
See Area of Valleys.

Area of Peaks (Area+)
Total area bounded by the leveled baseline and the profile above the baseline.

Area of Valleys (Area-)
Total area bounded by the leveled baseline and the profile below the baseline.

Arrow keys

The arrow keys on the operator keypad. These keys can be used to highlight a menu item or dialog box option or to move a text or graphics cursor.

Average Height (Avg)

The average height of all data points between the measurement cursors relative to the leveled baseline.

Avg

See Average Height.

Back up

To save data from the Tencor P-20 hard disk to diskettes or a network drive (if available). The data can be restored at a later time.

Base

Used (with prefix Up- or Down-) to identify the bottom of the sloping side of a step, to distinguish it from the top of the slope, called the *edge*. See UpBase, DownBase.

Bearing Ratio (t_p)

A reference line is drawn parallel to the mean line and at a preselected or predetermined distance (cutting depth) below the highest peak of the roughness trace within the sampling length. This reference line intersects the roughness trace in one or more subtended lengths. The bearing length is the sum of these subtended lengths. The bearing ratio is the ratio of the bearing length to the sampling length. Also called Bearing Length Ratio.

Centerline

The center-line divides the profiles such that all areas above it are equal to all areas below it.

Choose

To pick a menu item or other item that starts an action. You can choose an item using the mouse or keypad.

Click

Pressing and releasing the left or right mouse button without moving the mouse. Clicking the left button on a menu title, on an icon, on a dialog box option or command button, or in a window selects the item. Left and right buttons have different functions when clicking. *Compare to* double-click.

Concave

Describes an arc that curves inward from a level reference plane; a valley-like arc.

Contact Speed
Contact speed defines the stylus drop speed at contact with the substrate.

Convex
Describes an arc that curves outward from a level reference plane; a hill-like arc.

Cursor
An object on the screen that can be moved with the mouse or arrow keys and that allows the user to locate or edit data. *See* limit cursor, particle cursor, and text cursor.

CutDp
See Cutting Depth.

Cutoff Length
The cutoff length is the wavelength on the filter transmission curve that corresponds to 75% transmission. According to the ANSI B46.1-1985 standard, 800 μm is the preferred cutoff for most surfaces.

Cutting Depth (CutDp)
A preselected or predetermined distance below the highest peak of a sample. *See* Bearing Ratio.

D_q
See Root-Mean-Square Slope.

Database
A collection of data organized by records. The Tencor P-20 database can contain data summaries, maps, user IDs, system log records, recipe records, and other data.

Delta Average Mode
The measurement or leveling cursors are expanded into a region, either independently or in tandem, and the data points within the delta width are averaged.

Deskew
Deskew is a feature of the Tencor P-20 that compensates for any translational or rotational errors between different substrates by allowing you to select manually two fixed reference points to be used for calculating stage coordinate values.

Dialog box

A rectangular box on the screen that can contain a combination of lists, options, data entry fields, and command buttons. A dialog box appears when the instrument needs more information before performing an operation.

Disk space

The total amount of space available on the hard disk. Free disk space is the amount of disk space unused.

Directory

Computer files are stored on the computer's hard disk in directories. The directory name identifies the location where the files are stored. *See* Path.

Download

Importing a recipe from a remote host through the GEM/SECS Option.

DOS

Disk Operating System, also called MS-DOS. The central program used to control and manage the computer system.

Double-click

The mouse action performed when you press and release the mouse button twice in rapid succession. The first click selects the item and the second click performs the action associated with the item. When you double-click the left button on an application icon, the application starts. Left and right buttons have different functions when double-clicking. *Compare to* click.

DownBase

The bottom of the sloping side of a trough-like feature, or downward step.

DownEdge

The top of the sloping side of a trough-like feature, or downward step.

Drag

The mouse action performed when you hold down the mouse button and move the mouse. Dragging can be used to choose a menu item and to move a graphics cursor.

Drive (disk)

The disk drive identifier. A single character followed by a colon. For example, C: refers to drive C.

Edge

The distance to the first rising or falling edge of a step (or the apex of a peak) from the beginning of the profile. Also used (with prefix Up- or Down-) to identify the top of the sloping side of a step, to distinguish it from the bottom of the slope, called the *base*. See UpEdge, DownEdge.

Export

To save selected data, such as recipes, wafer summaries, and wafer maps, to diskette. Exported data can be imported into another Tencor P-20 system. *See* import.

Field

A rectangle in a dialog box used for entering data. The text cursor (a vertical bar) generally appears in the first field in a dialog box.

Finite Impulse Response (FIR)

The Tencor P-20 uses the Finite Impulse Response technique to calculate roughness and waviness from digitized data points.

Form Error

Form error is a deviation from a perfect realization of a nominally specified shape. For example, for a flat surface the form error would be the deviation from flatness. If the deviation is periodic (that is, has waves), the error is termed waviness. If there are many hundreds or thousands of randomly shaped undulations without a discernible pattern, the error is called roughness. The difference between form error, roughness, and waviness is not precisely defined; it is more a qualitative distinction. See Waviness and Roughness.

GEM

Acronym for *G*eneric *E*quipment *M*odel.

Graphics cursor

Graphics cursors appear as vertical bars in histogram windows and can be used to change defect bin splits.

HSC

See High Spot Count.

Height

The difference in height between two points on the sample surface defined by the positions of the measurement cursors.

High Spot Count (HSC)

The number of profile peaks per unit length projecting through a reference line parallel to and at a given height above a line drawn through the lowest point of the roughness trace, parallel to the mean line. See Peak Count.

Import

To load data previously saved in an export file. *See* export.

Keylock

The keylock limits operator access to Scan recipes and Sequence programs for operational security.

L_q

See Root-Mean-Square Wavelength.

Locator

The plate upon which a cassette rests when on the handler. The locator must be changed for different cassette sizes.

Log Off

Sign off from the Tencor P-20 by choosing the Log Off icon from the To Level menu.

Manual/Single Scan Mode

The user programs the parameters for a scan into a recipe using a menu. The scan can be specified to be continuous or segmented into sections of equal length.

Maximum Height (MaxHt)

The maximum height of a trace relative to the zero line within the sampling length.

Max R_a

See Maximum Average Roughness.

Maximum Average Roughness (Max R_a)

The trace within the cursors is divided into 19 overlapping sections. Each section is one-tenth of the sampling length. The average roughness (R_a) of each section is calculated and the maximum is displayed.

Maximum Stress

Maximum stress is the maximum of 13 overlapping sections of one-third the length and offset across the total profile.

Mean Peak Height (Rpm)

The mean value of the local peak heights of the roughness trace within the sampling length.

Mean Peak Spacing (S_m)

The mean value of the local peak spacing of the roughness trace within the sampling length, where the peaks are defined by the criteria of the Peak Count parameter. *See* Peak Count.

Menu

A list of commands. Two types of menus are supported — icon-based menus and drop-down menus. Full-screen menus such as the Top Level Menu display application icons. You can start an application by double-clicking the left button on its icon. A menu in the menu bar opens when clicked. *See* menu bar.

Menu Bar

Menu bars are displayed at the top of application windows and list menu titles. You can open a menu listed in the menu bar by clicking on its title. You can choose from the menu by clicking on an item.

Microsoft Windows

A graphical user environment developed by Microsoft Corporation that uses windows to present information and a pointing device, usually a mouse, for user interaction.

Minimum Height (Min Ht)

The minimum height of a trace relative to the zero line within the sampling length.

Multiscan Average Mode

A scan is repeated up to ten times and the average is calculated automatically.

PC

See Peak Count.

Parameters

Measurement attributes such as length, speed, and direction are the parameters used in the Tencor P-20 software.

Path (to file)

The location of a file or directory. A complete path consists of a drive identifier (A:, for example) followed by the directory and subdirectory names. The directory and subdirectory names are separated with the backslash character (\). In C:\DATA\TEMP\TEST.DAT, the path to the TEST.DAT file is C:\DATA\TEMP.

Peak

The distance between the mean line and the highest peak of the roughness trace or waviness trace within the sampling length.

Peak Count (PC)

The number of peak/valley pairs in the roughness trace per unit length, projecting through a band of width b, and centered about the mean line. Projecting through means that the profile curve climbs above and then falls below the band. Thus, if the profile rises above the band more than once without falling below the band, multiple peaks are not identified. *See* High Spot Count.

Peak/Valley

The vertical distance between the highest peak and the lowest valley of the roughness or waviness trace, leveled on the mean line. Also known as R_{max} or W_{max}, Maximum Peak-to-Valley Roughness or Waviness.

Profile Length (ProfL)

The length that would be obtained from drawing out the profile in a straight line within the sampling length.

ProfL

See Profile Length.

R_{3z}

See Six-point Height.

R_a

See Roughness Average.

R_h

See Roughness Height.

R_p

See Peak.

R_q

See Root-Mean-Square Roughness.

R_t (P/V)

See Peak/Valley.

R_v
See Valley.

R_z
See Ten-Point Height.

RMS
See Root-Mean-Square.

Rpm
See Mean Peak Height.

RRWG
Acronym for raw scan, roughness, waviness, and grid. The RRWG colors represent the individual color options for the graph and grid lines.

Radius
The distance from the center of curvature of the profile arc (assuming a circular profile within the sampling length) to the profile. The measurement cursors define two points of a circular arc. A least squares fit is performed on the points between the cursors.

Recipe
A recipe is a list of scan parameters.

Recipe ID
The Recipe ID is the name of the generating recipe.

Restore
To return data previously saved by a backup operation.

Root-Mean-Square Roughness (R_q)
The root-mean-square or geometric average deviation of the roughness profile from the mean line measured in the sampling length.

Root-Mean-Square (RMS)
The square *root* of the arithmetic *mean* of the *squares* of a set of numbers.

Root-Mean-Square Slope (D_q)
The root-mean-square or geometric average deviation of the slope of the roughness trace.

Root-Mean-Square Wavelength (L_q)

2π times the ratio of the root-mean-square deviation of the profile (R_q) to the root-mean-square slope of the profile (D_q). L_q is a measure of the spacing of local peaks and local valleys, taking into account their relative amplitudes and individual spatial frequencies.

Root-Mean-Square Waviness (W_q)

The root-mean-square or geometric average deviation of the waviness profile from the mean line measured in the sampling length.

Roughness

A surface is said to be rough when the surface's deviation from flatness has many hundreds or thousands of randomly shaped undulations. *See* Form Error and Waviness.

Roughness Average (R_a)

The arithmetic average deviation of the absolute values of the roughness profile from the mean line or centerline. Also known as Centerline Average Roughness. *See* Centerline.

Roughness Height (R_h)

The difference in height in the roughness profile between the values at the left and right cursor positions of the profile.

SD

See Std Dev Heights.

SECS Interface

The Semiconductor Equipment Controller Standard (SECS) Interface provided on the Tencor P-20 defines a computer-to-computer communications interface between the Tencor P-20 and a host computer.

S_m

See Mean Peak Spacing.

Sampling Length

The length of trace between the cursors.

SECS

Acronym for *S*emiconductor *E*quipment *C*ommunication *S*tandard.

Segmented Scan

The scan is divided into segments of equal length and no data is taken between the segments. Using this method, roughness can be measured over several short lengths spaced equally along a straight line.

Select

To highlight an item by clicking it with the mouse or by using the keypad.

Selection bar

The highlighted bar or dotted rectangle appearing in a dialog box that indicates the option or command button that is selected if you press the ENTER key. The selection bar can be moved by using the keypad.

Sequence

A program of sequential scans to be performed on a single substrate.

Sequence Identifier

The Sequence ID is the name of the generating sequence program.

Six-Point Height (R_{3z})

The average height difference between the three highest peaks and the three deepest valleys within the cursors measured from a line parallel to the mean line and not crossing the profile.

Slope

The ratio of the difference in vertical positions to the difference in horizontal positions of the measurement cursors. The slope is reported as an angle in degrees.

Spatial resolution

Spatial resolution is a measure of a profiler's capability to resolve the smallest vertical or horizontal feature on a surface. Four primary factors determine spatial resolution: stylus radius, short wave filtering, vertical resolution, and horizontal resolution. In practice, stylus radius and short wave filtering are the two factors that limit spatial resolution.

Std Dev Heights (SD)

The standard deviation of the local peak heights of the roughness trace about the mean peak height within the sampling length.

StpWt

See Width of Step.

Stylus Force

The force of the stylus tip when the stylus is in contact with the substrate.

t_p

See Bearing Ratio.

TIR

See Total Indicator Runout.

Ten-Point Height (R_z)

The average height difference between the five highest peaks and the five deepest valleys within the cursors measured from a line parallel to the mean line.

Text cursor

The vertical straight line appearing in fields. The text cursor marks the location where characters appear when typed.

Title bar

Each application displays a title bar at the top of the application window. The title bar shows the application name, current recipe in parentheses, communication mode—Local or Remote—and window control buttons.

Top Level Menu

The Tencor P-20 Top Level menu displays icons of the applications available to the user.

Total Indicator Runout (TIR)

The difference in height between the highest and the lowest points within the surface bracketed by the cursors.

Type

Type identifies the type of data that can be saved, recalled, restored, or deleted in a sequence. The following six preset values are available: raw trace data, point data, sequence results, 3-D data, and any data. Statistics data is supplied within sequence results.

UpBase

The bottom of the sloping side of a step-like feature, or upward step.

UpEdge

The top of the sloping side of a step-like feature, or upward step.

Upload

Exporting a recipe or data set to a remote host through the GEM/SECS Option.

Valley

The distance between the mean line and the lowest valley of the roughness or waviness trace within the sampling length.

W_a

See Waviness Average.

W_h

See Waviness Height.

W_p

See Peak.

W_q

See Root-Mean-Square Waviness.

W_t

See Peak/Valley.

W_v

See Valley.

Waviness

Waviness of a surface is a periodic deviation from flatness, where the wavelengths generally range from 30 to more than 100 times the average wavelength of the roughness. *See* Form Error and Roughness.

Waviness Average (W_a)

The arithmetic average deviation of the absolute values of the waviness profile from the mean line or centerline. Also known as Centerline Average Waviness. *See* Centerline.

Waviness Height (W_h)

The difference in height in the waviness profile between the values at the left and right cursor positions of the profile.

Width of Step (StpWt)

The distance between the first rising edge and the next falling edge of a step height plateau.

Window

Rectangular area for displaying and running an application program. The Scan application displays the Scan window.

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