USER'S GUIDE

P4-SPM-MDT
MICROSCOPE CONTROL PROGRAM
DESCRIPTION

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NT-MDT

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1. Introduction

This program has been developed using a high level program language - Turbo-Pascal, Version 7.0 including object-oriented elements. Several modules have been developed in the Assembler language. The program (its full size is about 300 KB) can be located in any part of your hard disk. For its operation the following files are required in the same directory:

p7_spm.exe - executive program;

p7_spm.hlp - context-sensitive help file;

p7_spm.opt - configuration file;

The above mentioned software is intended for:

- ***Solver*** device control in the STM (Scanning Tunneling Microscope) and SFM(Scanning Force Microscope) modes;
- processing of data earlier obtained with ***Solver*** devices, as well as with some other devices.

In the STM mode:

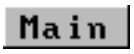
The Microscope operation control in the scanning, spectroscopy and lithography modes as well as presentation of measurement results in a convenient way for viewing and investigation.

In the SFM mode:

The Microscope operation control in the scanning, spectroscopy and lithography ("engraving") modes as well as presentation of measurement results in a convenient way for viewing and investigation.
The program (file **p7_spm.exe)** can open on the screen from one to four windows. Also, in the upper part of the screen a line-box is displayed showing the piezoscanner's absolute and relative coordinate along Z-axis. In addition to the four main windows whose location on the screen is defined by the user it is also possible to display the Tool Bar to ensure a quick access to some commands and operations (it is situated on the left side of the screen) and the status string containing the context-sensitive help string information about the free main and extended memory.

2. Main menu

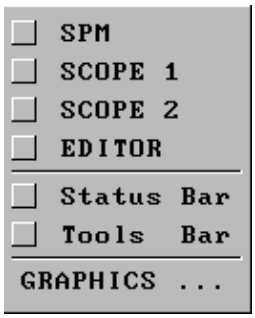
The large **“Main”** in the upper left corner of the screen is used to open the program’s main menu,



including the following items:

2.1 Opening program windows

“Window” is used to open the menu permitting to display on the screen the following windows:



2.1.1 SPM and Oscilloscope Window

“SPM” is used to open and close the main window for the Microscope operation control in the scanning, spectroscopy and lithography modes as well as to view and process the scanning and spectroscopy results

“SCOPE 1” is used to open and close the oscilloscope (internal oscillograph) window designed to observe various values time dependence, to measure and control signals in various points of the circuit board - processor as well as to view bidimensional data arrays: scanning sectional views and spectroscopy results. It is possible to open at the same time two such windows.

“SCOPE 2” similar to **“SCOPE 1”**.

“EDITOR” is used to open and close the Text Editor window. A text can be saved as a separate file or in the data file as a comment.

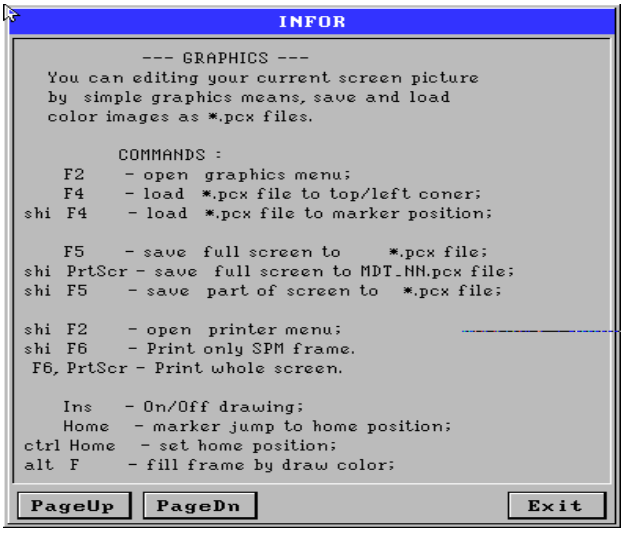
2.1.2 “Tool bar” and “Status bar” windows

“Status Bar” shows or hides in the screen bottom line the status string displaying on-line help about commands and buttons as well as the free main/extended memory

“Tools Bar” shows or hides on the left side of the screen the tool bar containing buttons permitting quick access to some commands and functions

2.1.3 The built-in graphics editor Information window

“GRAPHICS” displays the window containing information about using the graphics editor.



“PageUp” scrolls up the on-screen information.

“PageDn” scrolls down the on-screen information.

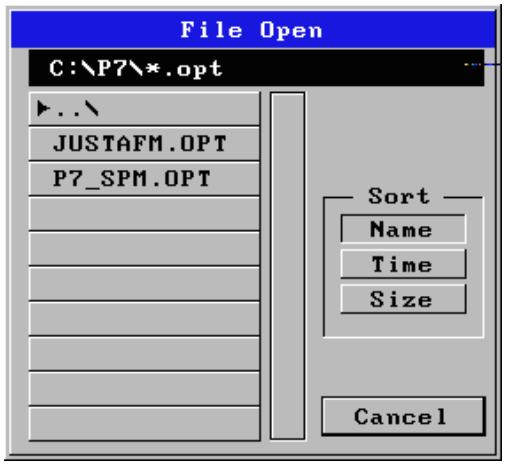
“Exit” closes the built-in graphics editor information window.

2.2 Saving and loading various program configurations

"Options" displays the Menu:

2.2.1 Reading and saving window

"Load" displays a list of configuration files "*.opt"



Upper string the upper string displays the path and pattern for the files contained in the files list

Files list in this window one configuration file can be selected in an open directory from a files list and loaded into the program

Scrolling bar permits scrolling through the files list.

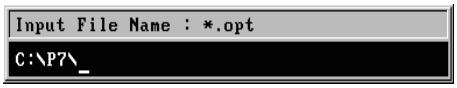
Additional commands:

"Sort" Menu permits to sort the files in the file list according to their Name, Time or Size.

"Cancel" cancels any selection and closes the Menu.

"Save" saves the configuration to the file "p7_spm.opt".

"Save as" displays the configuration saving box to save the configuration to any other "*.opt" file.



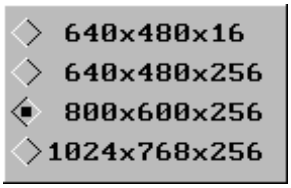
The configuration being saved includes:

- all parameters determining the device operation mode (excluding "Feedback=on" and "Laser=on") i.e. parameters for feedback, scanning, spectroscopy and lithography parameters as well as calibration;
- all parameters for the types, sizes and colors of the windows displayed on the screen;
- all the data presentation modes both in the SPMwindow and in the SCOPE 1, 2 windows

2.2.2 Resolution and colors selection window

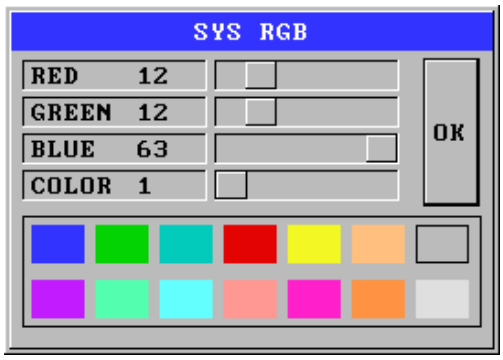
SVGA resolution mode setting window

"Resolution" displays the SVGA resolution mode setting window.



Main colors setting menu for the program windows

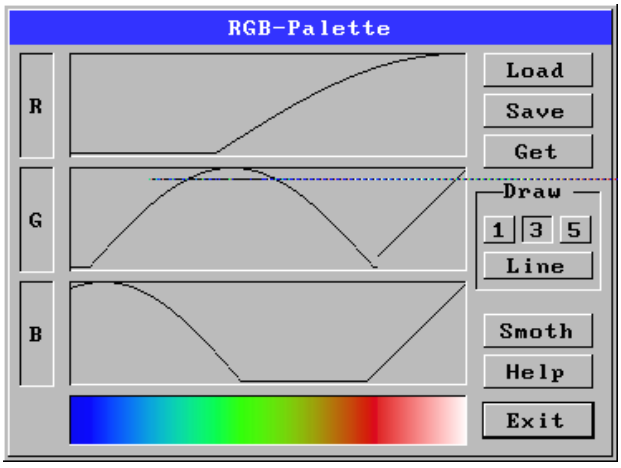
"Colors" displays the Main colors setting menu for the "SYS RGS" program.



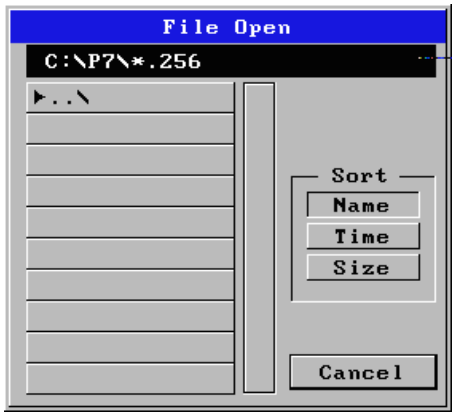
"OK" exit the menu and save all the user main colors parameters.

Menu for the Palette selection and editing

"Palette" displays the "RGB-Palette" - Palette selection and editing menu for SPM-pictures.
To edit click the left mouse button or press "ENTER" when in the graph window.



"Load" displays the Palette loading menu from a "*.256" file



Upper string the upper string displays the path and pattern for the files contained in the files list.

Files list in this window one palette file can be selected in an open directory from a files list and loaded into the program.

Scrolling bar permits scrolling through the files list.

Additional commands:

"Sort" Menu permits to sort the files in the file list according to their Name, Time or Size.

"Cancel" cancels any selection and closes the Menu.

"Save" displays box for saving the palette to a "*.256" file

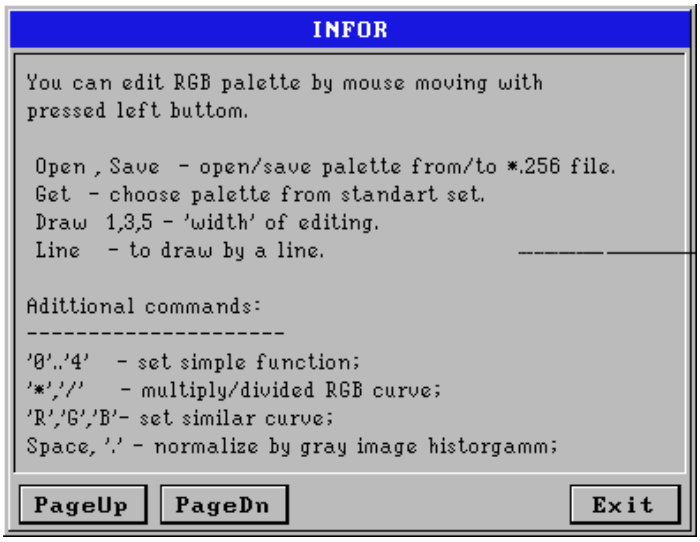
"Get" selection from the palette list.

"Draw" editing through changing one, three or five points.

"Line" not available.

"Smooth" graph smoothing.

"Help" displays the Help window for the **"RGB-Palette"** menu commands.



"PageUp" scrolls up the text in the Help window.

"PageDn" scrolls down the text in the Help window.

"Exit" Exits the Help window.

“Exit” Exits the **“RGB-Palette”** menu.

2.3 Context-sensitive HELP

“Help” in any point of the program you can position the cursor on any unknown object (window, button, menu) and press F1. It will display help information about this object.

F1+“Shift” moves the Help Window to the cursor position. It can be useful if the displayed Help Window obstructs the information you would like to view together with information in the Help window.

“ESC” exits and closes the Help window.

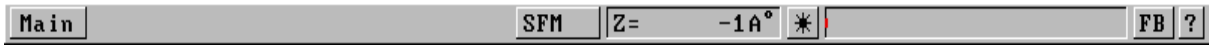
+“Shift” exits the Help window. This can be useful in case you want to save the on-screen picture together with the Help information.

2.4 Exit the program

“Exit” exits the program. To exit you can also press F10if there are no opened menus.

+“Shift” temporary exit from the program into the operating system (OS). In the case of temporary exit the feedback, laser and signal measurement by oscillographs stay on. To return to the program you must type **“Exit”** in the OS command string.

3. String window

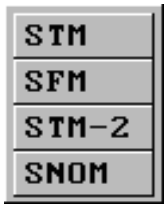


3.1 Main program menu

“Main” displays the main program menu (for details see item2).

3.2 Mode selection

“SFM” displays the mode selection menu.



“SFM” standard SFM head.

“STM” standard STM head or STM insert in the SFM head.

“STM 2” precision STM head.

“SNOM” SNOM head.

3.3 Digital indicator

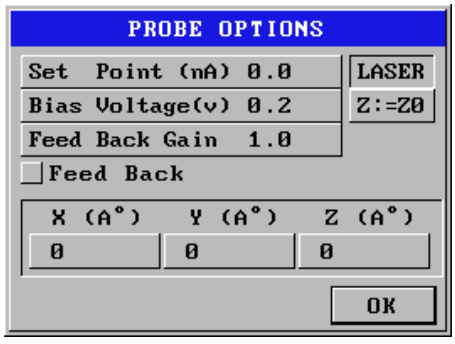
digital indicator for absolute/relative scanner extension Z coordinate. If you point to this indicator with the mouse cursor and press “ENTER” or the left mouse button, the “Z=Z0” operation is carried out (Z-coordinate starts to be measured relative to its last absolute value). This operation can be repeated if necessary.

3.4 Laser control

turns the laser on and off (when the laser is switched on the symbol turns red).

3.5 Analog indicator

analog indicator (“red line”) for scanner extension Z coordinate. If you point the mouse to this window and press “ENTER” or the left mouse button the **“Probe Options”** menu is displayed.



"SetPoint (nA)" sets the current value to be maintained constant by feedback (tunnelling current for the STM mode and photodiode differential current for the SFM mode).

"Bias Voltage (V)" sets the value of voltage applied between probe and sample.

"Feedback Gain" factor inversely proportional to the feedback integrator constant.

"Feedback" turns the feedback ON and OFF.

"Laser" button turning the laser ON and OFF. When the laser is ON the symbol on the laser switch button in the line-box turns red.[1]

"Z:=Z0" setting new reference value for relative Z axis coordinate. This operation is also possible if you point the mouse to the digital indicator's window located in the upper central part of the screen. This operation can be repeated if necessary.

"X(A), Y(A), Z(A)" placing the sample into the required position relative to the probe along the X, Y and Z axis. The placing is done immediately (at the same time various signals can be viewed in the SCOPE window).

3.6 Feedback control

turning the feedback on and off.

3.7 Help

displays the Help information for this window.

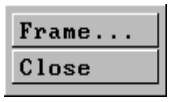
[1] SFM mode: the turned on laser serves as a light source in the optical system for registration of the cantilever probe deviations. STM mode: normally the laser is off, but it can be used as a lighting when positioning the sample.

4. “SPM-(SFM/STM)” WINDOW

The main window for the SPM control

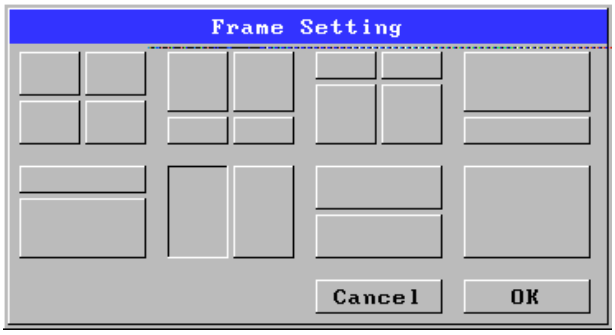
4.1 Main window position selection menu

displays the main window position selection menu:



“Close” closes the main window.

“Frame” displays the main window position selection menu -**“Frame Setting”**, permitting to select from the given examples the required size and position of the main window.



“Cancel” cancels the size selection (closes the menu without changing the size of the main window).

“OK” confirms the main window size and position selection and closes the menu.

4.2 The SPM window menu

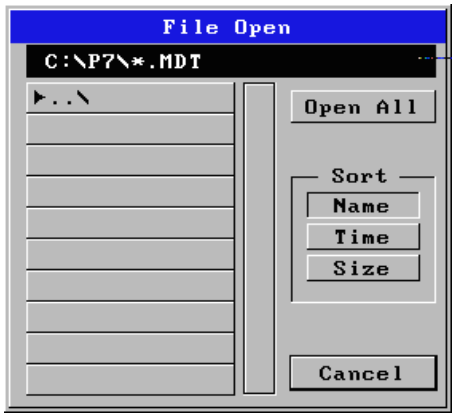
4.2.1 File operations menu

“File” displays the data files operation menu

4.2.1.1 File operations window

"Open" opens the **"File Open"** window (for loading files).

+Ctrl opens the working directory selected in**"File Options"**.



Upper string the upper string displays the path and pattern for the files contained in the files list.

Files list in this window one configuration file can be selected in an open directory from a files list and loaded into the program.

Scrolling bar permits scrolling through the files list.

"Open All" displays the first pictures of all files in the list for subsequent loading one of them.

The following hot keys are enabled in this mode:

F1 getting information about a file.

F5 file copy.

F8 delete a file from the disk.

Additional commands:

"Sort" Menu permits to sort the files in the file list according to their Name, Time or Size.

"Cancel" cancels any selection and closes the Menu.

"Merge" opens the **"File Open"** window (to merge the loaded file with another file from the disk).

"Save" opens the file save box for a file with the "*.mdt" extension (file name and directory must be entered if the directory is different from the default one).

The following data are saved in a "*.mdt" file:

- data regarding all scanning operations carried out after the program start;
- spectroscopy data marked using the **"Put"** item in the menu;
- text entered in the text editor and marked using the **"Put"** command;
- scanning parameters information.

"Make Dir" opens the box for creating new directory (the path and directory name must be entered).

4.2.1.2 Page operations window

"Tile" displays all pages for subsequent loading of one page.

The following hot keys are enabled in this mode:

F1 getting information about a page.

F5 saves a page as separate file.

F8 deletes a page from the main memory.

"Duplicate" copies the active page to the position following it pushing the list contents apart, if required.

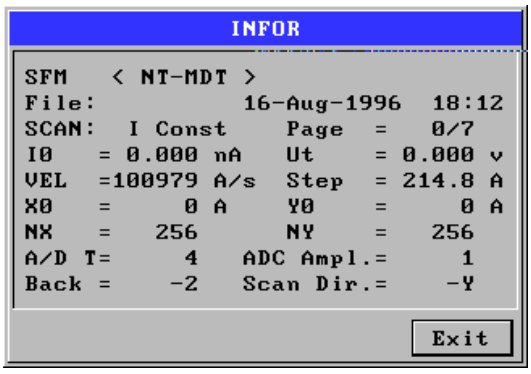
"Delete" deletes the active page.

"Delete All" deletes all pages.

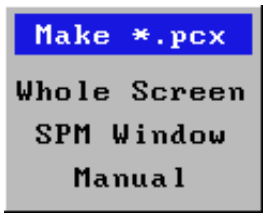
"Infor" displays the information about the scanning parameters the data of which are currently displayed in the window: file name, saving date and time, scanning mode, scanning parameters, scanning speed, scanning step, number of points in the scan along each axis, availability of spectroscopy data. After closing the parameters information window the text entered in the Editor window and merged with the file is displayed in a similar window.

+"Shift" manual selection of scale factors along the X, Y and Z for a loaded picture.

+"Ctrl" the following table is moved into the Editor window.



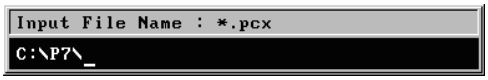
"Export" displays the menu for the picture saving in a PCX file.



"Whole Screen" copy all the screen display.

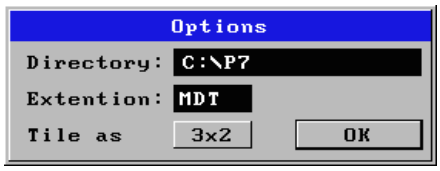
"SPM Window" copy the contents of the SPM window.

"Manual" copy an arbitrarily selected area (when this menu item is selected a cross-like mouse pointer appears). Place the pointer in any corner of an imaginary rectangle (representing the area to be copied) click the left mouse button and drag the pointer to the opposite corner of the imaginary rectangle. When all of the area to be copied is enclosed inside the frame click the left mouse button once again and the menu for the picture saving in a PCX file is displayed.



4.2.1.3 File operation options window

"Options" displays the file operation options window.



"Directory" Default directory for file operation.

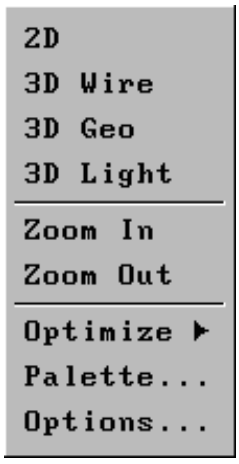
"Extension" Extension of the file to be loaded.

"Tile as" Inputs the number of files (pages) whose pictures are displayed simultaneously when loaded in the **"Open All"** (**"Tile"**) mode.

"OK" Exit and close the Options window.

4.2.2 Scanning data presentation menu.

"View" opens the scanning data presentation menu.



4.2.2.1 Data presentation window

"2D" data presentation in top view - X and Y coordinates are expressed in angstroms (A), nanometers (nm) or micrometers (μm); height or current, depending on the scanning mode, are presented in the form of a color palette.

+"Shift" selection of the viewing scale.

"3D Wire" data presentation as a three-dimensional surface. The picture is drawn as a net based on points where measurements of the height or tunnelling current have been done,

that becomes apparent with a small number of points or when viewed at high magnification.

+"Shift" viewing scale (if the Shift key is continuously pressed) and point of view selection.

+"Ctrl" after the picture is drawn as a net, the picture filling is carried out.

"3D Geo" three-dimensional picture display in a geographic palette.

+"Shift" viewing scale (if the Shift key is continuously pressed) and view point selection.

"3D Light" three-dimensional picture display in the simulated illumination mode.

+"Shift" viewing scale (if the Shift key is continuously pressed) and point of view selection.

+"Ctrl" selection of the light source position.

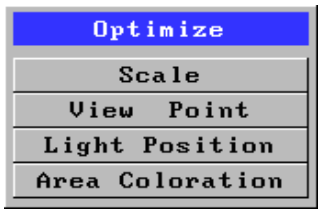
4.2.2.2 Zoom control window

"Zoom In" picture area selection and magnification.

"Zoom Out" decreasing magnification by one half.

4.2.2.3 Picture display optimization

"Optimize" opens the "**Optimize"** menu.



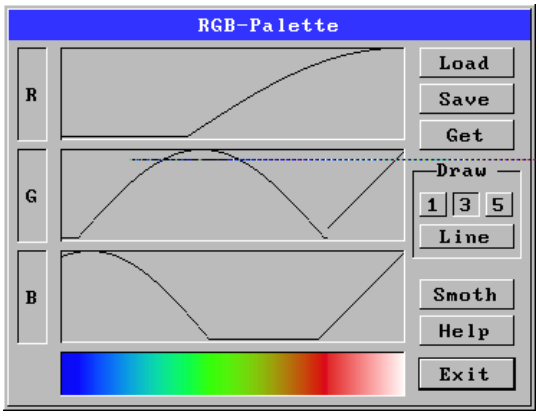
"Scale" scale selection.

"View Point" view point selection (for "3D" viewing mode).

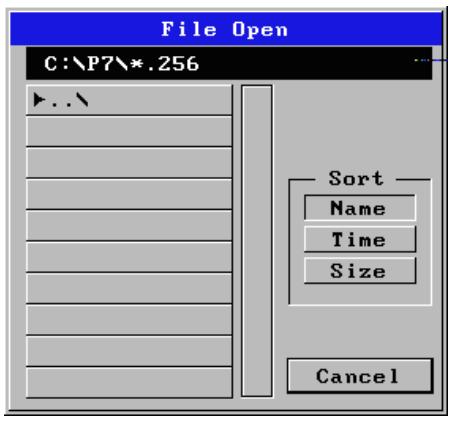
"Light Position" light source position selection (for "3D Light").

"Area Coloration" picture area selection to determine the height range corresponding to the palette; some parts of the image outside the chosen area can go beyond the new coloration range, but their true heights remain saved in memory. To return to the previous coloration you should proceed with this operation over the whole picture.

"Palette" opens the **RGB-Palette** editing menu.



"Load" displays the palette loading menu from a "*.256" file.



“Save” displays the window for saving the palette to a “*.256” file.

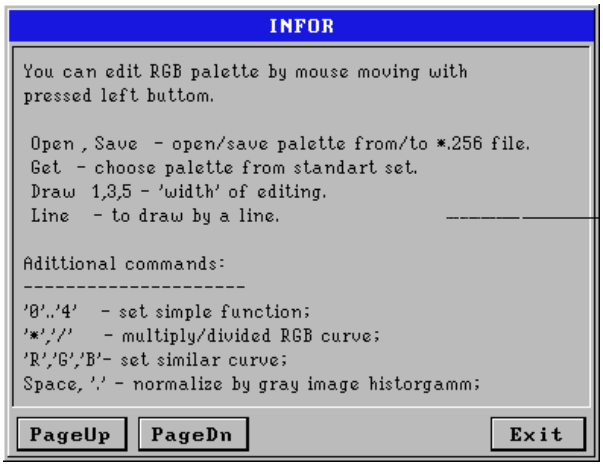
“Get” palette list selection.

“Draw” window editing through changing one, three or five points.

“Line” not available.

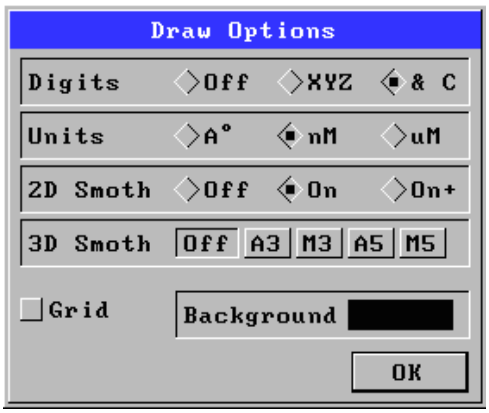
“Smooth” smoothing the graphics.

“Help” displays the help window for the RGB-Palettemenu commands.



“Exit” exit the **“RGB-Palette”** menu.

“Options” opens the “**Draw Options”** menu to set the picture display options.



"Digits" coordinate axis type selection:

"XYZ"- digital values are displayed for the scan coordinate axis;

"XYZ&C"- digital values are displayed for the scan coordinate axis and a color altitude scale for Z-coordinates;

"Off"- digital values for the scan coordinate axis and a color altitude scale are not displayed.

"Units" sets the measurement units for the coordinate axis:

"Å"-angstroms;

"nm"-nanometers;

"um"-micrometers.

"2D Smooth" picture smoothing in top view.

"3D Smooth" after a three-dimensional picture has been plotted the selected picture filtration is done automatically.

"Grid" when turned on a coordinate grid net is displayed (in top view -**"2D"**).

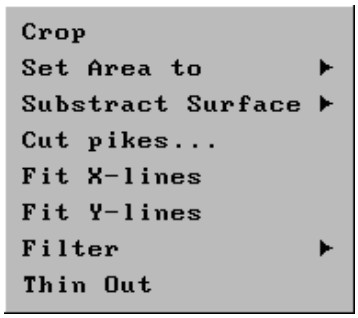
"Background" the background color selection.

"OK" exit the "**Draw Options"** menu.

To set the selected parameters and exit the menu for the window re-drawing click the left mouse button in the main window area.

4.2.3 Edit menu

"Edit" displays the edit menu.



"Crop" cuts the selected data.

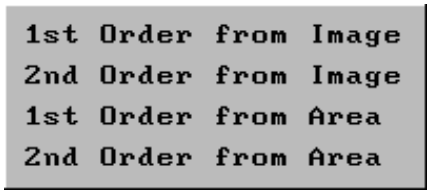
WARNING:
An unrecoverable loss for a part of data since only the selected area remains in the main memory!

"Set Area to" displays the associated menu.

"Zero" assign to the selected data the zero value for Z-coordinates.

"Minimum" assign to the selected data a minimum area value from the selected part Z-coordinates array.

"Subtract Surface" displays the Surface Subtract menu.



"1st Order from Image" fitted plane subtraction. This operation eliminates the inclination effect appearing as a result of nonparallelity of the scanning plane and surface plane.

"2nd Order from Image" subtraction of the 2nd order surface.

"1st Order from Area" surface subtraction from the whole data array, but the surface formula is calculated from the selected area. (This is necessary to save the real surface configuration, for instance, the step shape on HOPG - Highly Orientated Pyrolithic Graphite).

"2nd Order from Area" second order surface subtraction from the whole data array, but the surface formula is calculated from the selected area.

"Cut pikes" cuts sharp pikes from the picture.

+"Ctrl" cuts sharp cavities from the picture.

+"Shift" the width of a pike or a cavity is determined and all that is less than or equal to is equalized.

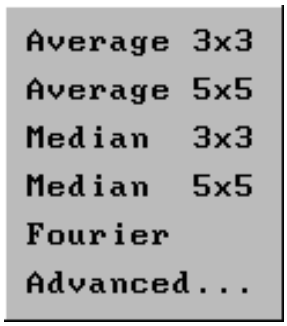
"Fit X-lines" equalizes the average X-lines heights.

This function is designed to eliminate the defects due to errors in the course of scanning along the X axis.

"Fit Y-lines" equalizes the mean Y-lines values.

This function is designed to eliminate the defects due to errors in the course of scanning along the Y axis.

"Filter" displays the Data filter menu.



"Average 3X3" filtration by the average value of a 3X3 square.

+"Shift" filtration by the pattern. Weights are specified by the user.

+"Ctrl" filtration of the picture only, i.e. only the graphic image is filtrated but not the data for its plotting. In this way it is possible to filtrate a "*.pcx" file loaded in the program.

"Average 5X5" filtration by the average value of a 5X5 square.

+"Shift" filtration by the pattern. Weights are specified by the user.

+"Ctrl" filtration of the picture only, i.e. only the graphic image is filtrated but not the data for its plotting. In this way it is possible to filtrate a "*.pcx" file loaded in the program.

"Median 3X3" median filtration by the 3X3 square.

+"Ctrl" filtration of the picture only.

"Median 5X5" median filtration by the 5X5 square.

+"Ctrl" filtration of the picture only.

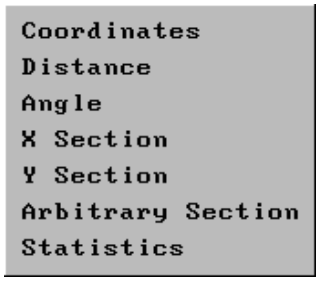
"Fourier" direct or inverse Fourier transformation. In case the scan dmensions in points located along the X and Y axis do not match with numbers of the 2**n type, it will be proposed to cut a part of maximum size data suitable for treatment by means of Fourier transformations.

"Advanced" not available.

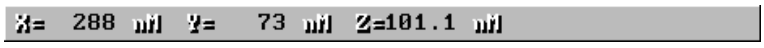
"Thin Out" erases all the odd points on the X, Y plane. This operation may be useful for large files. File size becomes one-fourth as the original one.

4.2.4 Tools menu

"Tools" displays the tools menu.



"Coordinates" displays in the upper line of the main window the status string showing the coordinates for the selected point.



"Distance" displays in the upper line of the main window the status string showing the distance between two selected points in the XY plane.

+"Shift" displays the distance between two selected points in the XYZ space.

"Angle" displays in the upper line of the main window the status string showing the angle between two selected directions in the XY plane.

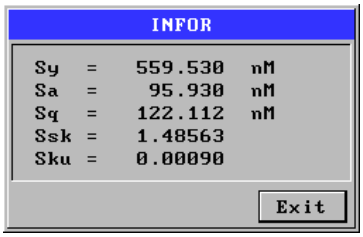
+"Shift" displays the angle between two selected directions in the XYZ space.

"X Section" displays a section along the X axis in the selected location. Sections are moved to the **SCOPE** window after the "ENTER" key or the left mouse button have been pressed.

"Y Section" displays a section along the Y axis in the selected location. Sections are moved to the **SCOPE** window after the "ENTER" key or the left mouse button have been pressed.

"Arbitrary Section" displays an arbitrary stretch section. Sections are moved to the **SCOPE** window after the "ENTER" key or the left mouse button have been pressed.

"Statistics" the followings coefficients are calculated for the selected area:



“Sy” peak to peak value (ISO 4287/1):

$$S_y = z_{\max} - z_{\min}$$

“Sa” average surface roughness (DIN 4768):

$$S_a = \frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|z(i,j)\right|$$

“Sq” surface root-mean-square (ISO 4287/1):

$$S_q = \sqrt{\frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N} z^2(i,j)}$$

“Ssk” surface skewness (ISO 4287/1):

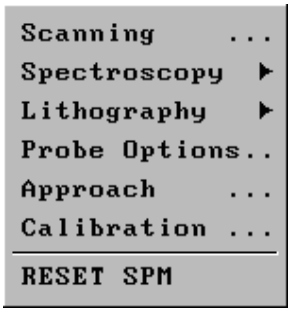
$$S_{Sk} = \frac{1}{N^2 S_q^3}\sum_{i=1}^{N}\sum_{j=1}^{N} z^3(i,j)$$

“Sku” surface kurtosts (AN between points):

$$S_{ku} = \frac{1}{N^2 S_q^4}\sum_{i=1}^{N}\sum_{j=1}^{N} z^4(i,j)$$

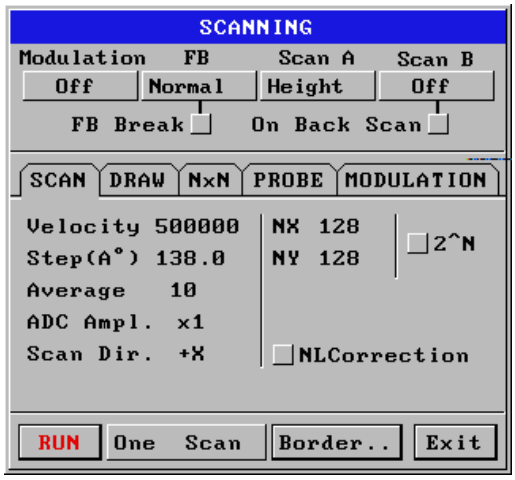
4.2.5 The microscope control menu

“Operation” displays the microscope control menu.



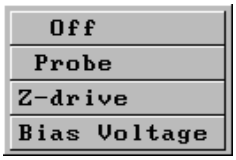
4.2.5.1 The microscope control in scanning mode.

“Scanning” opens the menu for the microscope control in scanning mode.



The window for the microscope control in scanning mode contains:

"Modulation" modulation modes (when the button located under the item is pressed a pull-down menu is displayed).



"Off" modulation is off.

"Probe" driving signal is applied to the piezo in the cantilever holder.

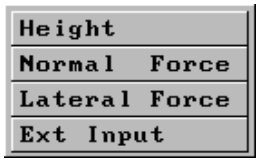
"Z-drive" driving signal is applied to Z-electrodes of piezotube.

"Bias Voltage" bias voltage between STM tip and sample is modulated

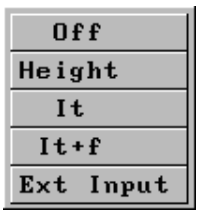
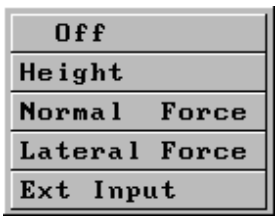
"FB" feedback modes (modulation modes (when the button located under the item is pressed a pull-down menu is displayed whose contents are different in various modes).

STM	SFM
	
"It" for the tunneling current.	**"Normal Force"** for the probe-sample interaction force.

"Scan A" signal to be registered in Window A (when the button located under the item is pressed a pull-down menu is displayed).

STM	SFM
	
"Height" height (topography). **"It"** the value of tunneling current between the probe and the sample. **"It+f"** filtered value of tunneling current. **"Ext Input"** signal recorded from external input.	**"Height"** height (topography). **"Normal Force"** interaction force between the probe and the sample. **"Lateral Force"** friction force appearing in the process of the probe movement along the sample. **"Ext Input"** signal recorded from external input

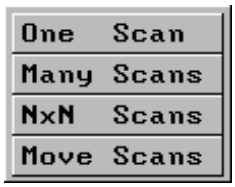
"Scan B" signal to be registered in Window B (when the button located under the item is pressed a pull-down menu is displayed).

STM	SFM
	
"Off" no other signal registration when scanning **"Height"** height (topography). **"It"** the value of tunneling current between the probe and the sample. **"It+f"** filtered value of tunneling current **"Ext Input"** signal recorded from external input	**"Off"** no other signal registration when scanning **"Height"** height (topography). **"Normal Force"** interaction force between the probe and the sample. **"Lateral Force"** friction force appearing in the process of the probe movement along the sample. **"Ext Input"** signal recorded from external input

"Fb Break" feedback is maintained up to the moment of scanning start, then scanning is executed with constant length of piezotube; after scanning feedback turns on again.

"On Back Scan" registration of the second signal - **"Scan B"** - on the way back for each scan line - "on" position or during repeated scanning in the same direction for each scan line - "off" position.

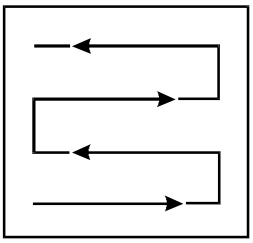
"One Scan" scanning mode (when the button located under the item is pressed a pull-down menu is displayed).



"One Scan" a single scanning will be done at the area selected using the **"Border"** menu.

"Many Scans" scanning will be done at the area selected using the **"Border"** menu until interrupted by pressing the **"ESC"** button.

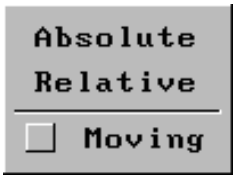
"NxN Scans" displacement will be done according to the following scheme. The overlap degree is specified in **"Options"** - **"NxN"** menu.



"Move Scans" displacement direction is specified using the cursor control keys in the course of scanning. The actual displacement is done after scanning.

Warning:
In all multiple scanning mode only the last scan may be processed and saved to the disk.

"Border" selection of the scanning area dimensions and the start point (when the button located under the item is pressed a pull-down menu is displayed).



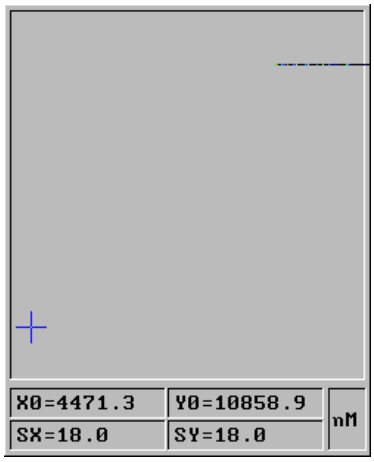
"Absolute" setting the scan dimensions (by changing the scanning step) and the scanning start point with respect to maximum possible scan.

"Relative" setting the scan dimensions (by changing the scanning step) and the scanning start point with respect to the last scan made or the loaded file that has been created earlier.

"Moving" if this option is activated any movement of the scanning area marker in real time results in the probe movement with respect to the sample.

Changing is done:

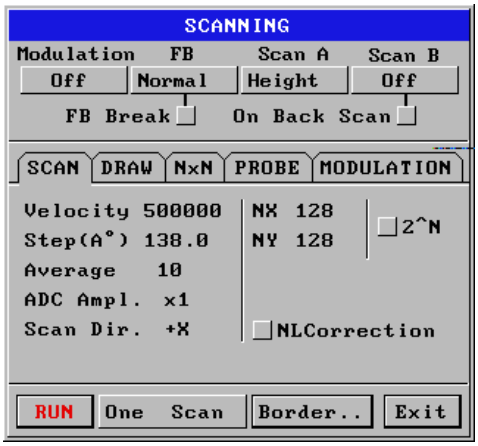
- position of center - arrow keys and mouse;
- scan dimensions - arrow keys or mouse + Shift.



"RUN" starts the selected scanning mode.

"Exit" exit and close the menu for the microscope control in scanning mode.

"SCAN" label - general scanning parameters.



"Velocity" the sample-vs-probe movement speed along the surface when scanning between points, in Angstroms/s.

"Step (A) distance between scan points, scan step.

"Average" number of measurements in each point (averaged value is recorded for each point).

"ADC Ampl." the value of gain coefficient for relative changing value. This gain is necessary to increase resolution along the Z axis. The maximum gain is set in case of a low drift along the Z axis in time and insignificant heights difference on the surface that is being measured. The gain coefficient Kz in this item must satisfy the condition Kz<20000A/dZ, where dZ - heights difference on the surface with allowance made for drift along the Z axis.

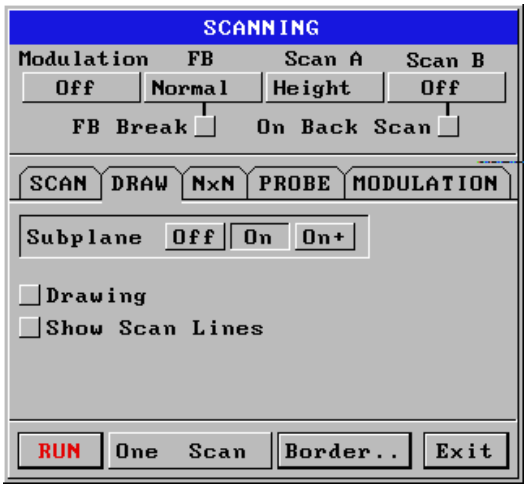
"Scan Dir." scanning direction.

"NX","NY" scan dimensions (number of points in each direction).

"2^N" if the ON setting is selected the scan sides dimensions in points are automatically reduced to the nearest number of the 2**n type, where n is a natural number; only scans of this size can be processed using Fourrier transformations.

"NLCorrection" in the ON position the scanning is done with correction of the piezoscanner movement nonlinearity.

"DRAW" label - parameters for data display when scanning.

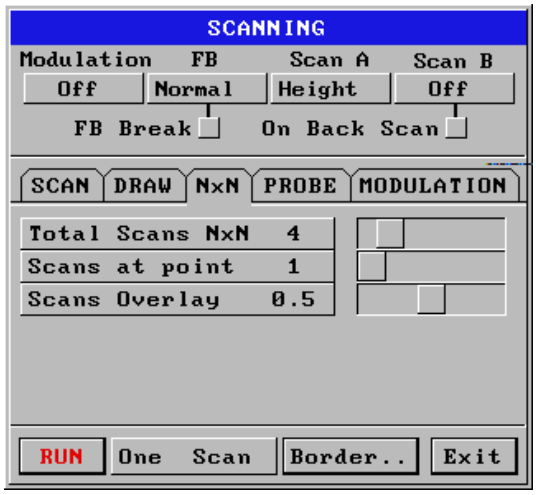


"Subplane" when set in the ON position, fitted surface subtraction operation is carried on immediately after scanning . When set in the (ON+) position the surface subtraction operation is carried on after the first 20 scan lines have been scanned.

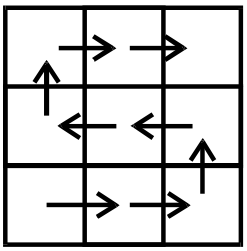
"Drawing" when set in the ON position the measurement results are displayed during scanning, in the OFF position - after scanning.

"Show Scan Lines" each scan line profile is displayed in the SCOPEwindow.

"NxN" label - parameters of successive scanning with displacement.



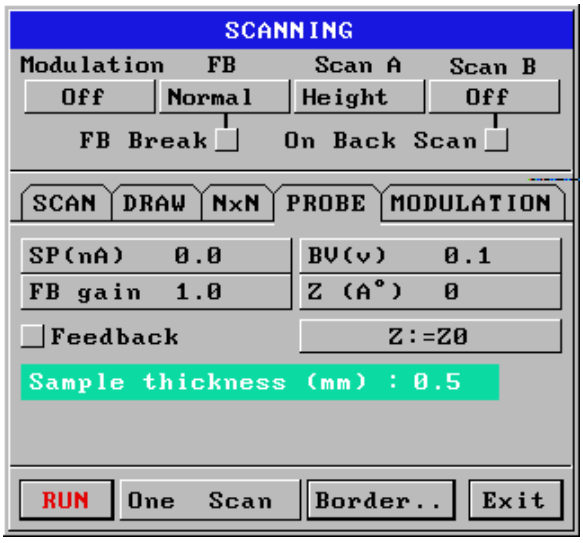
"Total Scans NxN" for multiple scanning - number of scans in each direction of the scanned area. For instance, with N=3 we shall have 9 areas where scanning will be done consequently.



"Scans at point" for multiple scanning - number of scans in each area between displacements.

"Scans Overlay" for multiple scanning - scans overlapping degree (0 - no overlapping, 1 - complete overlapping).

"PROBE" label - feedback parameters etc.



"SP (nA)" the value of current to be maintained constant by feedback (tunnelling current for the STM mode and photodiode differential current for the SFM mode).

"BV (V)" the value of voltage between probe and sample.

"FB gain" factor inversely proportional to the feedback integrator constant.

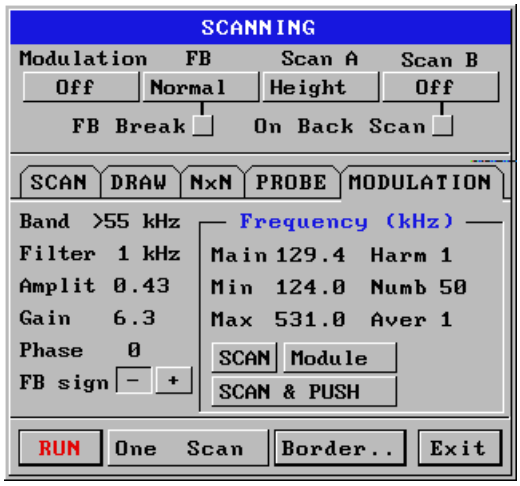
"Z (A)" changes the Z coordinates - manual scanner extension (the feedback is automatically turned off).

"Z:=Z0" determines new reference value of Z0 and sets relative Z coordinate to zero.

"Feedback" turns the feedback ON and OFF.[2]

"Sample thickness (mm)" thickness of the sample measured from the mounting plate (substrate), that should be set for correct calibrating the lateral dimension of the image.

"MODULATION" label - parameters of modulation driving signal etc.



"Band" selection of low-pass (<65kHz) or high-pass (>55kHz) input

"Filter" filter bandwidth of the detected signal (1 or 30kHz)

"Amplit" amplitude of the driving signal.

"Gain" amplifier gain in Resonant Mode unit.

"Phase" additional phase shift between driving signal and response signal added before synchronous detector.

"FB sign" selection of the sign of feedback (+/-).

"Frequency (kHz)" parameters of modulation frequency scanning and setting.

"Main" permanently maintained frequency.

"Min" lower limit of frequency scanning range for getting some frequency dependence.

"Max" upper limit of frequency scanning range for getting some frequency dependence.

"Harm" the harmonic (1...10) of the main frequency chosen to be measured in response signal.

"Numb" number of intervals into which Min...Max range is divided during frequency scanning for getting some frequency dependence.

"Aver" number of measurements of a value in each point of scanned frequency range (only one averaged value is recorded for each frequency point).

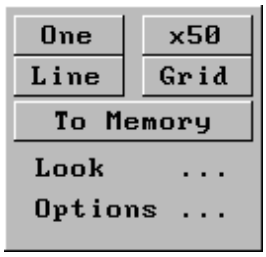
"SCAN" button that starts frequency scanning from Min to Max to get frequency dependence of some value.

[2]The Feedback can be also turned on and off in the line-box using the FB button.

“SCAN & PUSH” button that starts multiple frequency scanning from Min to Max, with sample being slightly displaced towards the probe after each successive scan. “Scan&Push” permits to get a set of dependences for different sample-probe separations. Sample is moved towards the probe from its initial position to the position specified by setting slider that appears after clicking “Scan&Push” button.

4.2.5.2 The microscope control in the spectroscopy mode

“Spectroscopy” opens the menu for the microscope control in the spectroscopy mode. Spectroscopy can be done in two microscope operation modes (I(U), I(Z) for STMand I(Z), F(Z) for SFM), but the most application finds operation in the STM mode.



“One” spectroscopy in one selected point. Spectroscopyis done one time in the specified point. Data are available for viewing and saving only in the**“SCOPE”** window.

+“Shift” spectroscopy is repeated in a specified point until interrupted by pressing the “ESC” key. The results of each measurement are displayed in the**SCOPE** window.

“x50” making a run of 50 measurements in one point. The results of all measurements are displayed upon completion in the form of a three-dimensional picture, where along the X axis - U or Z, along the Y axis - the measurement’s number, the color gamut - current.

+“Shift” repeating the runs of measurements until interrupted by pressing the “ESC” key.

“Line” making a run of measurements along a selected line. The results of all measurements are displayed upon completion in the form of a three-dimensional diagram, where along the X axis - U or Z, along the Y axis - the measurement’s number, the color gamut - current. I(U)[I(Z)] is read in every point where measurement was done when scanning, along the selected line with step equal to the scanning step.

+“Shift” repeating the runs of measurements until interrupted by pressing the “ESC” key.

“Grid” runs of measurements at points of a selected grid. Number of points in the grid is set using the ‘left’, ‘right’ arrow keys or appropriate mouse movements. The results of all measurements are displayed upon completion in the form of a three-dimensional diagram, where along the X axis - U or Z, along the Y axis - the measurement’s number, the color gamut - current.

+“Shift” repeating the runs of measurements until interrupted by pressing the “ESC” key.

The results of measurements in the last three items can be represented in a three-dimensional form, to do this exit the menu and select 3-D item in the Viewmenu (see item 4.2.2).

“To Memory” stores the spectroscopy results in the main memory (except for those read in the **“One”** mode) to save them afterwards together with the data file.

“Look” opens the menu for viewing all spectroscopy data stored in the main memory. The last measured array is also available for viewing.

“View” viewing the three-dimensional spectroscopy data by specifying the points or the measurements numbers. The markers automatically goes through appropriate scan points, the spectroscopy results are displayed in the SCOPEwindow in the form of two-dimensional diagrams.

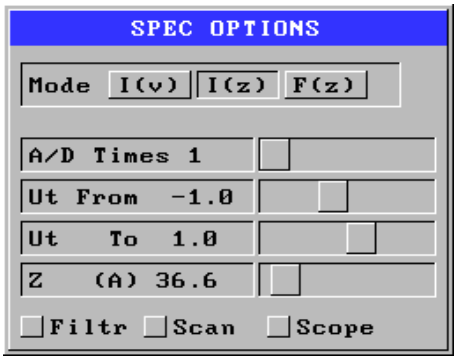
+“Shift” manual control of the through-points movement.

“<<” (“>>”) viewing the previous (next) spectroscopy data array if available.

“Scan” displays the scanning results.

“Spec” displays the spectroscopy results.

“Options” opens the menu for the spectroscopy mode parameters.



“Mode” selecting one of the three spectroscopy modes: (U), I(Z) or F(z).

	I(U)	**I(Z)**	**F(Z)**
ÑÒ Ì	At a fixed Z value, the U values in the range specified in the **“Options”** menu are changed with a1/64 interval increment. In the process the I(U) dependence is measured. Such voltage-current characteristics show the quantum properties of the sample.	At a fixed current quantity, Z values are measured in the direction from the surface within the range specified in the **“Options”** menu with a 1/64 interval increment. In the process the I(Z) dependence is measured. The I(Z) dependence obtained on pure unoxidizable metal surfaces Au, Pt or on HOPG surface makes it possible to determine the tip’s quality, see ‘The User’s Guide’ Appendix.	
ÑÑ Ì	Measurement of the I(U) dependence is possible with the use of conductive cantilevers.	The I(Z) dependence makes it possible to determine the cantilever’s functionality and the proportionality factor between the registered current and the interacting force between the probe and the sample.	Changing Z from this point to the scanner range limit in the direction from the surface, in the process the I dependence is measured, I meaning in this case photodiode misalignment current, proportional to the force acting between the probe and the sample. The I(Z) dependence makes it possible to determine the cantilever’s functionality and some of the surface properties

“A/D Times” sets the number of measurements at each voltage quantity (Z coordinates) for averaging. (Only for the STM mode).

“Ut From” sets the initial value for tunnel voltage measurement in the I(U) mode. (Only for the STM mode).

“Ut To” sets the final value for tunnel voltage measurement in the I(U) mode. (Only for the STM mode).

“Z (A) sets the measurement range for the Z coordinate in the I(Z) mode. In this mode the tip when measuring moves in direction from the surface to the distance specified in this item.

"Scan" in case "Yes" is set the scanning is done in accordance with parameters specified in the Options menu, and spectroscopy is carried out in the specified point (points) (only for I(V) and I(Z)); if "No" is set scanning is not done, the tip is initially set at the specified point (points) and spectroscopy is carried out.

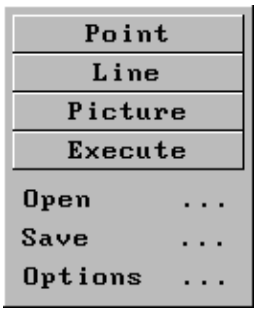
Be careful! In case scanning parameters are changed after scanning but prior to spectroscoping and NO setting is selected for a particular picture zone spectroscopy points positions on the scan may not represent the actual ones.

"Scîpe" if the YES setting is selected the results of each measurement in the spectroscopy mode are moved to the SCOPE window immediately after measuring.

"Filtr" if the ON setting is selected data analog filtration is carried out, in the OFF position filtration is not done.

4.2.5.3 Lithography mode control

"Lithography" opens the menu for the microscope control in lithography mode i.e. surface influence by means of voltage impulses (menu items are listed from left to right).



"Point" Lithography in one selected point.

Lithographic influence is effected in a specified point.

"Line" Lithography along a selected line segment. Lithographic influence is effected along a selected line segment.

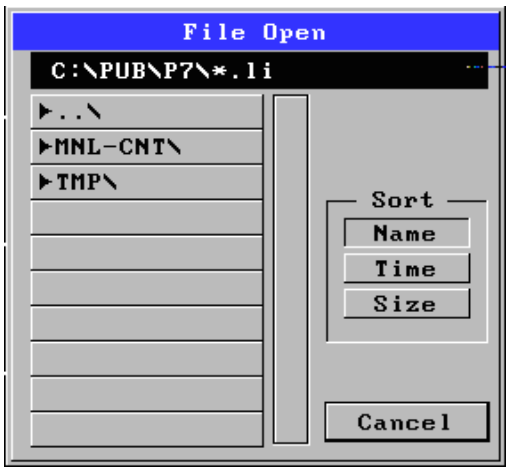
"Picture" Lithography over a selected picture. The picture is defined by lines the ends of which are marked by pressing the "ENTER" key. Lithography is done over the selected picture.

"Shift+ENTER" over the whole selected picture including the line the end of which has not been marked by pressing the "ENTER" key. In case such unfinished line is not available you should press the "ENTER" key and then Shift + ENTER or use another option.

"Shift+ESC" over the whole picture including the line the end of which has not been marked by pressing the "ENTER" key if such line is available.

"Load" opens the files loading window.

loading the template files for lithography having the extension "*.li". To carry out lithography to the loaded template press Shift + any of the first three lithography start commands.



Upper string the path where the templates having the extension "*.li" are located is displayed is displayed in the upper string.

Files list in this window one template can be selected in the open directory from a templates list and loaded into the program

Scrolling bar permits scrolling through the files list.

Additional commands:

"Sort"Menu permits to sort the files in the file list by their Name, Time or Size.

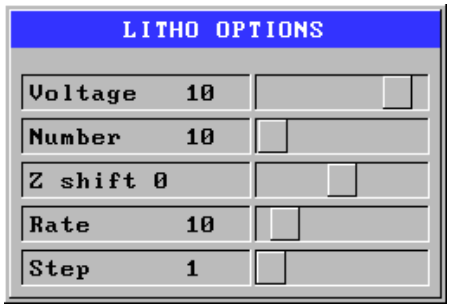
"Cancel" cancels any selection and closes the Menu.

+"Shift" loading the lithography template files having the extension "*.li" to a specified location.

"Save" opens the window for lithography template saving.

saving a lithography template in a file having the extension "*.li" (the path and the name of the template to be saved must be specified).

"Options" opens the lithography parameters menu.



"Voltage" sets the voltage to be applied to the sample with reference to the tip.

"Number" sets the number of impulses in every point. With the 0 setting lithography is not effected (to create a template).

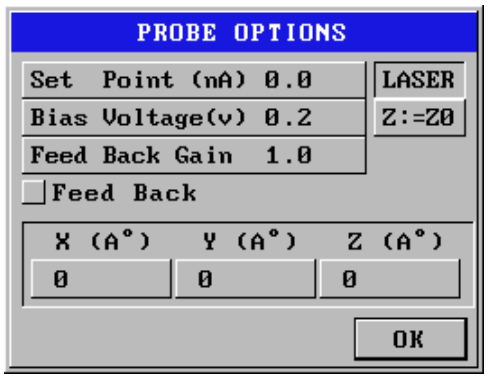
"Z shift" setting the tip displacement along the Z axis from the surface before lithography start. With Z<0 voltage impulses are not applied and the tip just "scratches" the surface.

"Rate" setting the impulse application rate in one point (if N>1).

"Step" setting the step between lithographic influences, relative units. (1 - in all points of the picture, 2 - in every second point etc.).

In the SFM mode lithography is done by the surface "scratching" in case of the Z-Shift setting as <0 in the Opt menu.

"Probe Options" displays the parameters control menu.



"Set Point (nA)" sets the current quantity to be maintained constant by means of feedback (tunnelling current for the STM mode and misalignment current for the SFM mode).

"Bias Voltage (V)" sets the voltage quantity between the probe and the sample.

"Feed Back Gain" factor inversely proportional to the feedback integrator constant.

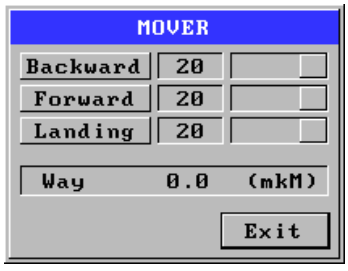
"Feed Back" turns the feedback ON and OFF.

"Laser" button turning the laser on and off. When the laser is on the symbol on the laser switch button in the line-box turns red.[3]

"Z:=Z0" relative Z axis coordinate reset-to-zero Δ. This operation is also possible if you point the mouse to the digital indicator's window located in the upper central part of the screen. This operation can be repeated if necessary several times.

"X(A), Y(A), Z(A)" placing the sample into the required position in relation to the fixed probe along the X, Y and Z axis. The placing is done in real time (at the same time various signals can be viewed in the SCOPE window).

"Approach" opens the "**Mover"** menu for approaching the sample fixed at the piezoscanner.



"Backward" moves the step motor one step back.

+"Shift" backward movement until interrupted by pressing the "ESC" key.

[3] SFM mode: the turned on laser serves as a light source in the optical system for registration of the cantilever probe deviations. STM mode: normally the laser is off, but it can be used as a lighting when positioning the sample.

+"Shift+Ctrl" backward movement until interrupted by pressing the "ESC" key at the maximum Rate=20.

"Forward" moves the step motor one step forward.

+"Shift" forward movement until interrupted by pressing the "ESC" key.

+"Shift+Ctrl" forward movement until interrupted by pressing the "ESC" key at the maximum Rate=20.

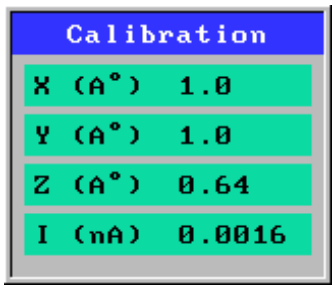
"Landing" automatic sample's approach until feedback is established.

It is possible to set for each type of movement a rate of its own from 1 to 20 conventional nonlinear units.

"Way" counter for the relative position of the step motor in µum.[4] When pressed the counter is reset to zero.

"Exit" exits the **"Mover"** menu.

"Calibration" displays the Calibration menu where you can set the low order unit for the DAC along the X and Y axis and for the ADC along the Z axis and for tunnelling current.



"X(A)" the piezoscanner's DAC step along the X axis (in Angstroms).

"Y(A)" the piezoscanner's DAC step along the Y axis (in Angstroms).

"Z(A)" the piezoscanner's ADC step along the Z axis (in Angstroms).

"I(nA)" the tunelling current channel's ADC step.

WARNING:
The device calibration has been done by experts, therefore it is not recommended to change it if you are not absolutely sure about what you are doing.

"Reset SPM" reset and initial installation of the electronic circuit parameters. This operation must be carried out in case the power supply unit is turned on during the program operation. When the program is loaded this operation is done automatically.

WARNING:
This operation involves the probe's displacement along the surface. In order to avoid damage to the probe prior to this operation the probe must be removed from the sample.

[4] as the step motor has some free travel its reading can take several seconds, in this time values in the **"Way"** menu can change up to 300 µm though the real movement of the sample in relation to the probe is only starting which can be seen by the graphic representation of the piezoscanner advance in the analog indicator's window and by Z representing this movement digitally.

4.3 Full-screen mode

changes the window to a full-screen size, if you press this button again the screen returns to its original view.

4.4 Help

displays the help window.

4.5 The bottom line of the “SPM-(SFM/STM)” window.

It is located in the bottom part of the main window.

splits the main window into two windows (The same status line appears in the bottom of each window). If this button is pressed again in any of the two windows this window is enlarged to the size of the main window.

“A”/”B” activates one of the windows.

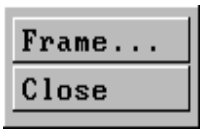
scrolls up the pages of the loaded file.

scrolls up the pages of the loaded file.

5. The Oscilloscope window

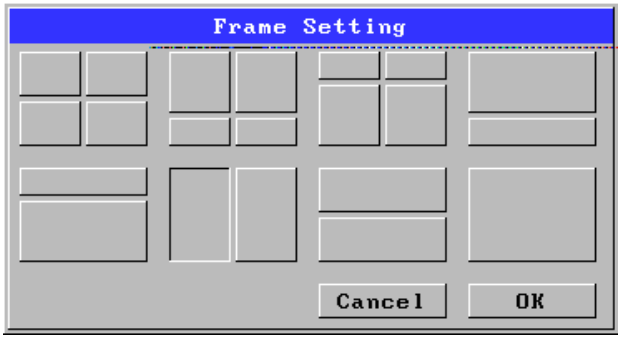
5.1 Window parameters

displays the menu for the oscilloscope window positioning:



“Close” closes the oscilloscope window.

“Frame” displays the menu for the oscilloscope window positioning **“Frame Setting”**, where you can select from the given examples the required size and position for the window.



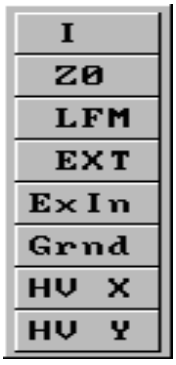
“Cancel” cancels the size selection (closes the menu without changing the size of the oscilloscope window).

“OK” confirms the oscilloscope window size and position selection and closes the menu.

5.2 Oscilloscope control menu

5.2.1 Oscilloscope connection port setting

“EXT” displays a list for the oscilloscope connection port setting.



“I” relationship between the tunnelling current/misalignment current in the working direction and the time.

“Z0” relationship between the scanner extension and the time.

“LFM” relationship between the photodiode misalignment current in the non-working direction and the time.

“EXT” external port for viewing scan sections, spectroscopy data.

“ExIn” signal from the external port.

“Grnd” signal from the “ground”.

“HV X” voltage at the piezoscanner along the X axis.

“HV Y” voltage at the piezoscanner along the Y axis.

5.2.2 Measurements start/stop

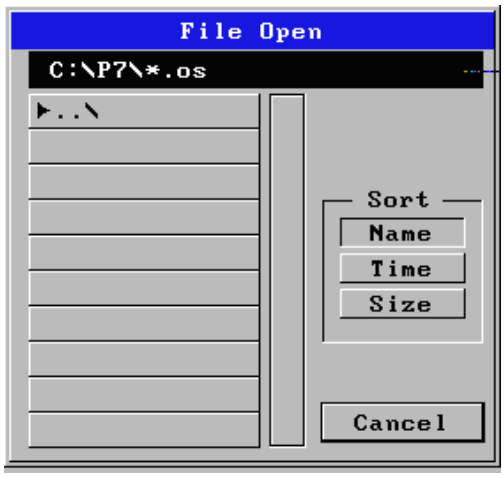
“GO” measurements start/stop.

+“Shift” clears the data buffer before starting / after stopping the measurement.

5.2.3 File operations

“File” opens the file operations menu.

“Open” loads external or earlier saved two-dimensional arrays data into the window.



Upper string the upper string displays the path where the two-dimensional arrays data files with “*.os” or “*.dat” extensions and corresponding to the set parameter are located.

Files list in this window one two-dimensional arrays data file can be selected in an open directory from the list of two-dimensional arrays data files and loaded into the program.

Scrolling bar permits scrolling through the files list.

Additional commands:

“Sort” Menu permits to sort the two-dimensional arrays data files in the file list according to their Name, Time or Size.

“Cancel” cancels any selection and closes the Menu.

“Save” saves two-dimensional array data in a separate file (the path and the array name must be specified).

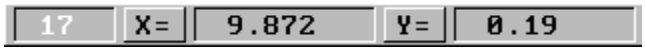
5.2.4 Scaling the displayed data

"Scale" displays the menu for scaling the displayed measurements.

"X&Y"	scaling along the X or Y axis.
+ "Ctrl"	the signal sent along the X axis takes 10% of the scale.
+ "Shift"	manual change (if the Shift key is pressed) and positioning of the scale. When the required scale is selected press "ESC" or the right mouse button.
"X"	scaling along the X axis only.
+ "Shift"	manual change (if the Shift key is pressed) and positioning of the scale. When the required scale is selected press "ESC" or the right mouse button.
"Y"	scaling along the Y axis only.
+ "Ctrl"	the signal sent along the Y axis takes 10% of the scale.
+ "Shift"	manual change (if the Shift key is pressed) and positioning of the scale. When the required scale is selected press "ESC" or the right mouse button.

5.2.5 Viewing the digital values of the measurements for various points

"View" displays the menu for viewing the digital values of the measurements forvarious points.



"17"	point's number.
"X"	viewing the digital values of the measurements for points along the X axis.
"Y"	viewing the digital values of the measurements for points along the Y axis.

5.2.6 Two-dimensional arrays processing

"Edit" displays the menu for two-dimensional arrays processing.

"XY"	viewing the digital values of the measurements for points.
"/2"	deletes every second point from the array (to reduce over-sized arrays).
"<1"	deleting points with equal pairs of values.
"À3"	averaging data for three points.
"À5"	averaging data for five points.
" Ì 3"	median filtration of data for three points.
" Ì 5"	median filtration of data for five points.

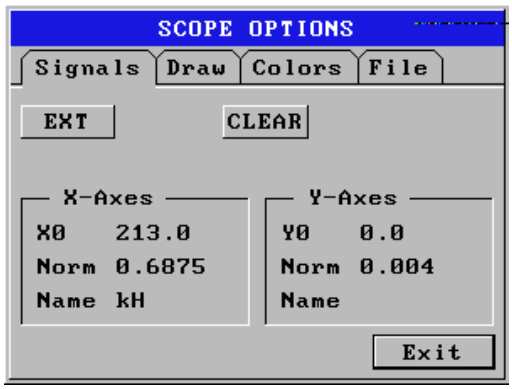
All operation (except for the first one) result in an unrecoverable loss for a part of data in the two-dimensional array.

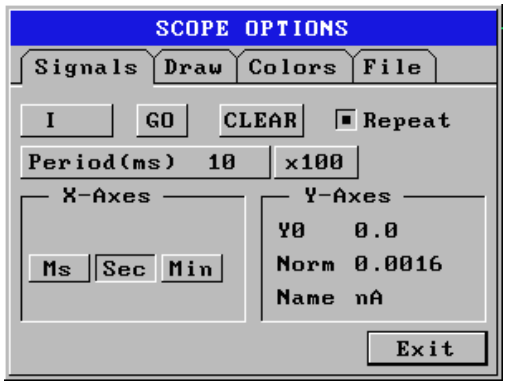
5.2.7 Diagrams in-window display parameters.

"Options" displays the menu for the diagrams in-window display parameters.

5.2.7.1 "SIGNALS" label

Various parameters are represented in the label if different settings are selected for the oscilloscope input port.





"CLEAR" clearing the data buffer.

"X(Y)-Axes" specifies the initial points **"X0(Y0)"** and the norming coefficients **"X(Y) norm"** and names **"X(Y) name"** for the axis.

"GO" measurement start.

"CLEAR" clears the data buffer.

"Repeat" sets repeated measurement screen by screen

"Period (ms)" time interval between measurements

"x100" multiplier for Period.

"X-Axes" specifies either units of measurement or the parameters similar to those for "Y-Axes" (see below).

"Y-Axes" specifies the initial points **"Y0"** and the normalizing coefficients **"Y norm"** and names **"Y name"** for the axis.

"EXT" displays a pull-down menu for the oscilloscope incoming port selection.

"I" relationship between the tunnelling current/misalignment current in the working direction and the time.

"Z0" relationship between the scanner extension andthe time.

“LFM” relationship between the photodiode misalignment current in the non-working direction and the time.

“EXT” external port for viewing scan sections, spectroscopy data.

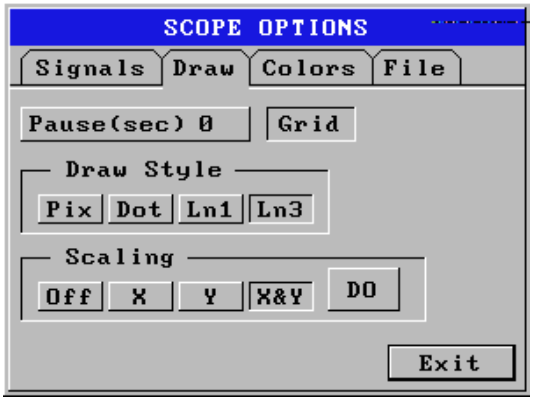
“ExIn” signal from the external port.

“Grnd” signal from the “ground”.

“HV X” voltage at the piezoscanner along the X axis.

“HV Y” voltage at the piezoscanner along the Y axis.

5.2.7.2 “DRAW” label



“Pause (sec)” pause between the data buffer’s filling and its clearing (in case the Repeat parameter in the Signal menu under the gray button is set in the ON position).

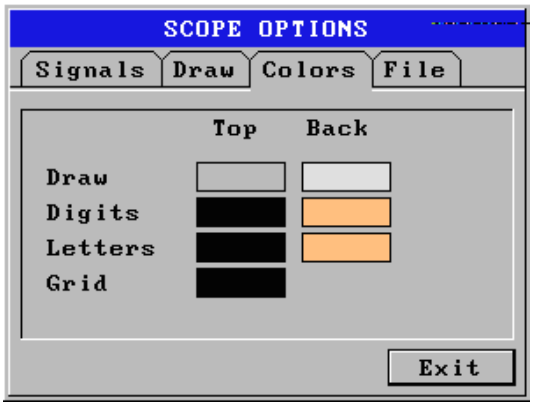
“Grid” when in the ON position the scaling grid is displayed.

“Draw Style” diagrams drawing using points of different styles. Press the **“Pix”** button to use points, the **“Dot”** button to use large points, the **“Ln1”** button switches to a thin line, the **“Ln3”** button to a thick line.

“Scaling” when pressed automatic scaling is done only along the X axis - **“X”** button, only along the Y axis - **“Y”** button or along the both axis - **“X&Y”** button, scaling is not done - **“Off”** button.

“DO” do the selected scaling.

5.2.7.3 “COLORS” display label



“Top”:

“Draw” drawing color.

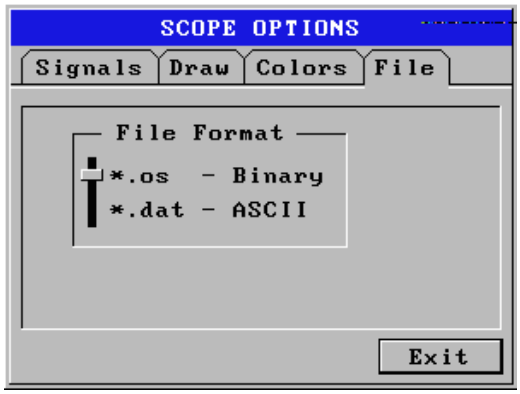
“Digits” digits’ color.

“Letters” letters’ color.

“Grid” grid’s color.

“Back” the background color.

5.2.7.4 Data format label - “File”



“File Format” sets the data format to be saved to the disk:

“*.os” the system’s own format saving the initial points and the axis scale;

“*.dat” ASCII file for X, Y values.

“Exit” closes the menu for diagrams in-window display parameters setting.

5.3 Full-screen mode

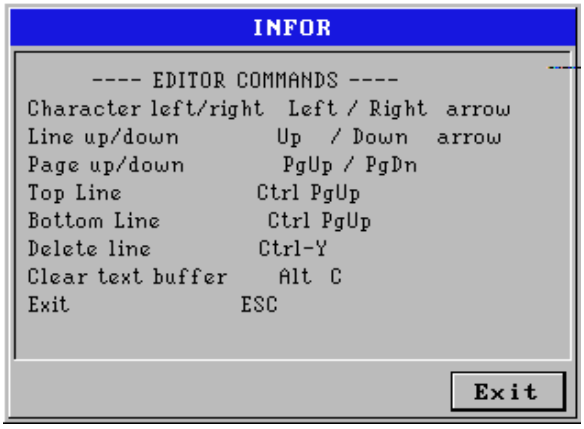
changes the window to a full-screen size, if you press this button again the screen returns to its original view.

5.4 Help information

displays the help information text for the oscilloscope window.

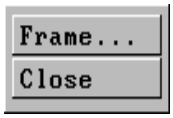
6. “EDITOR” window

In this window it is possible to create or edit a text file up to 100 lines long. To enter the editor press the **“Edit”** button, to get information about the editor press F1or “?”.



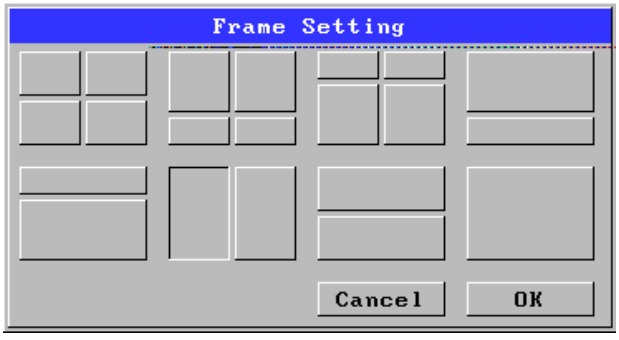
6.1 The text editor window positioning menu

displays the text editor window positioning menu:



“Close” closes the text editor window.

“Frame” displays the menu for the text editor window positioning**“Frame Setting”**, where you can select from the given examples the required size and position for the window.

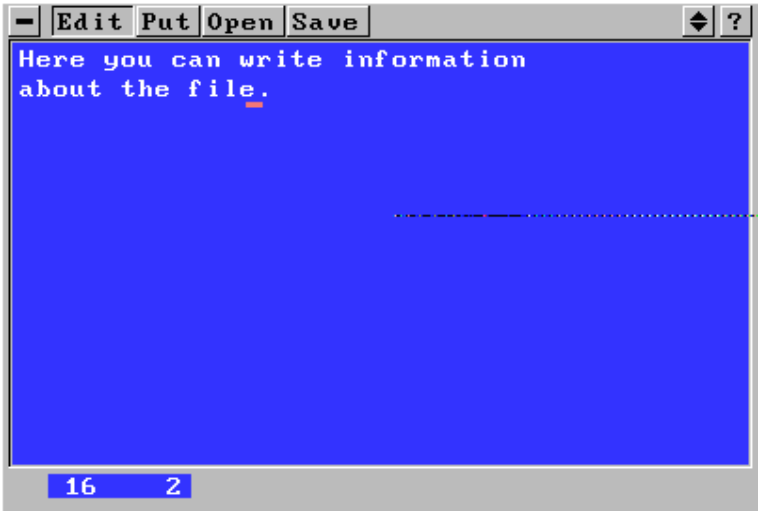


“Cancel” cancels the size selection (closes the menu without changing the size of the text editor window).

“OK” confirms the text editor window size and position selection and closes the menu.

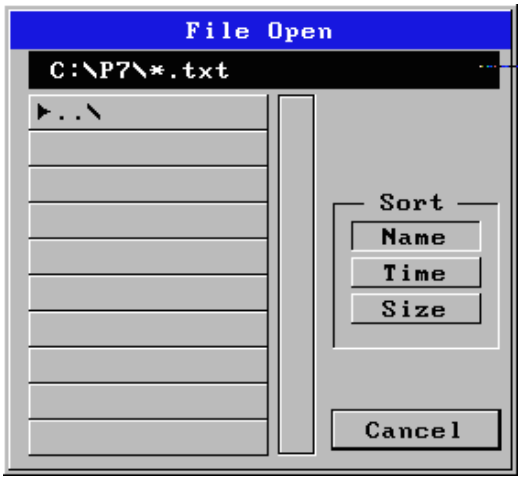
6.2 Editor control menu

“Edit” activates the cursor in the editor’s window to enter information, notes etc. about the loaded file.



“Put” puts the text to a page in RAM memory that can be saved together with the images

“Open” opens the **“File Open”** window (for a text file loading).



“Save” opens the file save box for a file with the “*.txt” extension (file name and directory must be entered in case the directory is different from the default one).

6.3 Full-screen mode

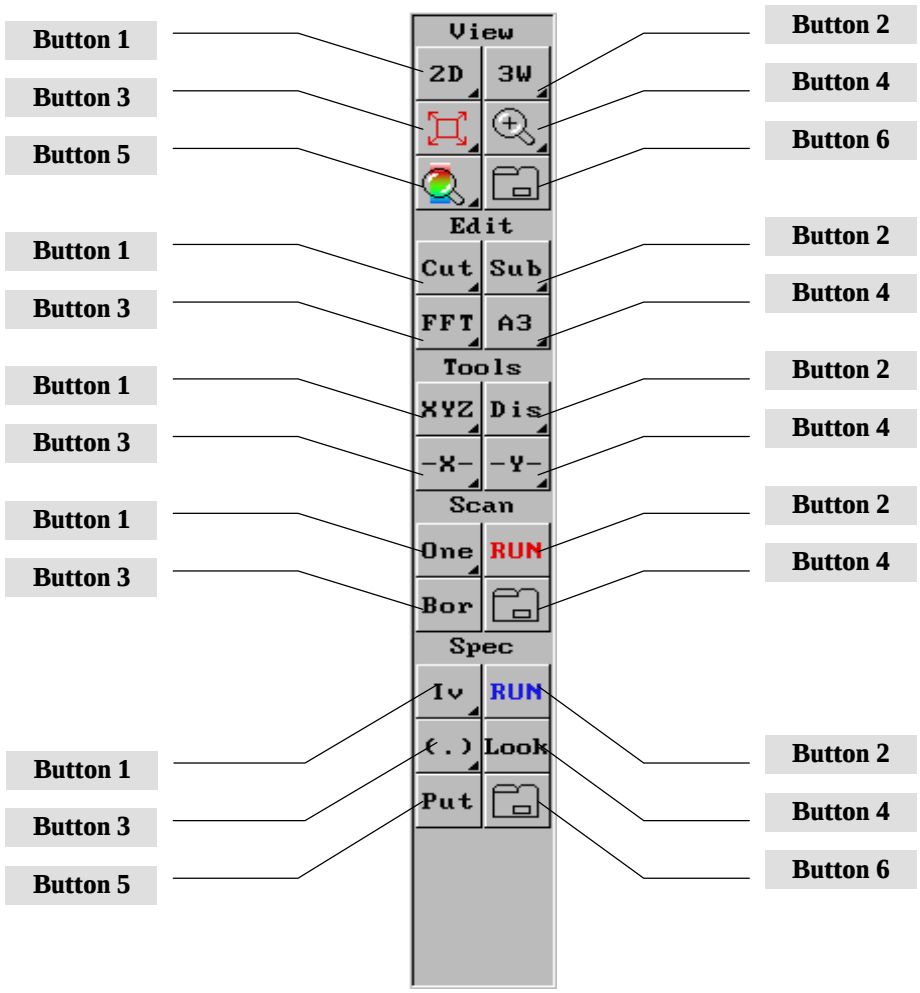
changes the window to a full-screen size, if you press this button again the screen returns to its original view.

6.4 Help

displays the help information on the text editor.

7. Quick Access Tools Bar

See item 2.1.2 **“Tools Bar”**.



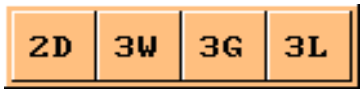
Buttons overview (from left to right, from top to bottom)

For all buttons providing access to tools:

- quick pressing triggers the action of the device shown on the button;
- when a button is kept pressed for several seconds the tools selection menu is displayed. The selected tool remains on the Quick access tools bar.

7.1 Viewing window

Button 1 opens the menu:



“2D” data presentation in top view - X and Y coordinates are expressed in angstroms (A), nanometers (nm) or micrometers (µm), height or current, depending on the scanning mode, are presented in the form of a color palette. (similar to **“2D”** see item 4.2.2.1).

+“Shift” selection of the viewing scale.

“3 W” data presentation in a three-dimensional surface form. The picture is drawn in the form of a net based on points where measurement of the tunnelling current have been done, which become apparent with a small quantity of points or in case of magnification. (similar to **“3D Wire”** see item 4.2.2.1).

+“Shift” viewing scale (if the Shift key is continuously pressed) and point of view selection

+“Ctrl” after the picture is drawn in the form a net the picture filling is carried out

“3 G” three-dimensional picture display in a geographic palette. (similar to **“3D Geo”** see item 4.2.2.1).

+“Shift” viewing scale (if the Shift key is continuously pressed) and view point selection.

“3 L” three-dimensional picture display in the lighting mode (similar to **“3D Light”** see item 4.2.2.1).

+“Shift” viewing scale (if the Shift key is continuously pressed) and point of view selection

+“Ctrl” the lightning source position selection.

Button 2 similar to 1.

Button 3 opens the menu:

 scale selection (similar to **“Scale”** see item 4.2.2.3).

 view point selection for “3D” (similar to **“View Point”** see item 4.2.2.3).

 light source position selection for **“3D Light”** (similar to **“Light Position”** see item 4.2.2.3).

Button 4 opens the menu:

 selection and magnification of a picture area (similar to **“Zoom In”** see item 4.2.2.1).

 demagnification of the picture by twice (similar to **“Zoom Out”** see item 4.2.2.1).

 all data in full-screen.

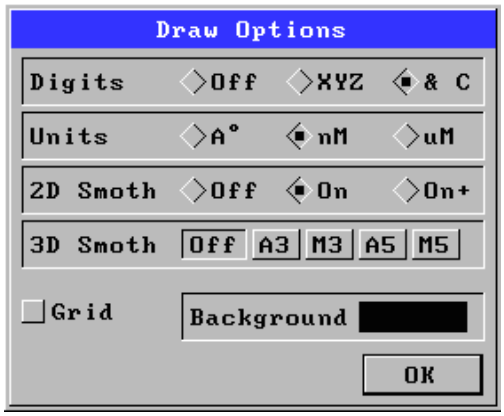
Button 5 opens the menu:

 Picture zone selection the coloration of which will employ all of the color palette, in the process the highest and the deepest zones may not be displayed remaining in the memory. To return to the previous coloration you should proceed with this operation over the whole picture. (similar to **“Area Coloration”** see item 4.2.2.3).

 Palette selection (similar to **“Get”** see item 4.2.2.3).

 displays the palette editing menu (similar to **“RGB-Palette”** see item 4.2.2.3).

Button 6 opens the menu (similar to **“Draw Options”** see item 4.2.2.3).



"Digits" coordinate axis type selection.

"XYZ"- digital values are displayed for the scan coordnate axis;

"XYZ&C"- digital values are displayed for the scan coordinate axis and a color altitude scale for Z-coordinates;

"Off"- digital values for the scan coordinate axis and a color altitude scale are not displayed.

"Units" sets the measurement units for the coordinate axis:

"**À"**-angstrom;

"**nM"**-nanometers;

"**uM"**-micrometers.

"2D Smooth" picture smoothing in top view.

"3D Smooth" after a three-dimensional picture has been plotted the selected picture filtration is done automatically.

"Grid" when turned on a coordinate grid net is displayed (in top view - '**2D"**)

"Background" the background color selection.

"OK" exit the "**Draw Options"** menu.

7.2 "Edit" window

Button 1 opens the menu:

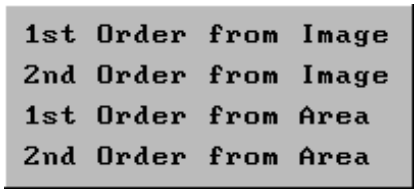
"Cut" cuts the selected part of data (similar to **"Crop"** see item 4.2.3).

"Zer" displays the associated menu (similar to **"Set Area to"** see item 4.2.3).

"Zero" assign to the selected data the zero value for Z-coordinates.

"Minimum" assign to the selected data a minimum area value from the selected part Z-coordinates array.

"Sub" displays the Surface Subtract menu (similar to **"Subtract Surface"** see item 4.2.3).



"1st Order from Image" surface substruction. This operation eliminates the inclination effect appearing as a result of drifts and absence of perpendicularity between the probe and the surface.

"2nt Order from Image" 2nd surface subscription.

"1st Order from Area" surface substruction from the whole data array, but the surface formula is calculated from the selected area. (This is necessary to save the real surface configuration, for instance, the step form on HOPG - Highly Orientated Pyrolytic Graphite).

"2nt Order from Area" second order surface substruction from the whole data array, but the surface formula is calculated from the selected area.

"Pik" cuts sharp pikes from the picture (similar to **"Cut pikes"** see item 4.2.3).

+"Ctrl" cuts sharp cavings from the picture.

+"Shift" the width of a pike or a caving is determined and all that is less than or equal to is equalized.

"F-X" equalizes the mean lines values along the X axis.

This function is designed to eliminate the defects due to errors in the course of scanning along the X axis. (similar to **"Fit X-lines"** see item 4.2.3).

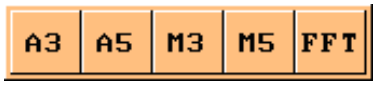
"F-Y" equalizes the mean lines values along the Y axis.

This function is designed to eliminate the defects due to errors in the course of scanning along the Y axis. (similar to **"Fit Y-lines"** see item 4.2.3).

"Flt" displays the data filtration menu (similar to **"Filtr"** see item 4.2.3).

Button 2 similar to **Button 1**.

Button 3 opens the menu:



"A3" filtration by the average value of a 3X3 square. (similar to **"Average 3x3"** see item 4.2.3).

+"Shift" filtration by the pattern. Weights are specified by the user.

+"Ctrl" filtration of the picture only, i . e. only the graphic image is filtrated but not the data for its plotting. In this way it is possible to filtrate a *.pcx file loaded in the program.

"A5" filtration by the average value of a 5X5 square. (similar to **"Average 5x5"** see item 4.2.3).

+"Shift" filtration by the pattern. Weights are specified by the user.

+"Ctrl" filtration of the picture only, i.e. only the graphic image is filtrated but not the data for its plotting. In this way it is possible to filtrate a "*.pcx" file loaded in the program.

"M3" median filtration by the 3X3 square. (similar to **"Median 3x3"** see item 4.2.3).

+"Ctrl" filtration of the picture only.

"M5" median filtration by the 5X5 square. (similar to **"Median 5x5"** see item 4.2.3).

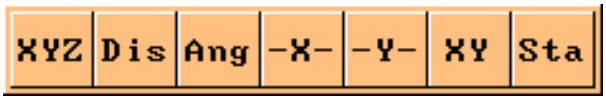
+"Ctrl" filtration of the picture only.

"FFT" Fourier direct or inverse transformation. In case the scan dimensions in points located along the X and Y axis do not match with numbers of the 2**n type, it will be proposed to cut a part of maximum size data suitable for treatment by means of Fourier transformations. (similar to **"Fourier"** see item 4.2.3).

Button 4 similar to **Button 3**.

7.3 Tools window

Button 1 opens the menu:



"XYZ" displays in the upper line of the main window the status string showing the coordinates for the selected point (similar to **"Coordinates"** see item 4.2.4).

"Dis" displays in the upper line of the main window the status string showing the distance between two selected points in the XY plane. (similar to **"Distance"** see item 4.2.4).

+"Shift" displays the distance between two selected points in the XYZ space.

"Ang" displays in the upper line of the main window the status string showing the angle between two selected directions in the XY plane. (similar to **"Angle"** see item 4.2.4).

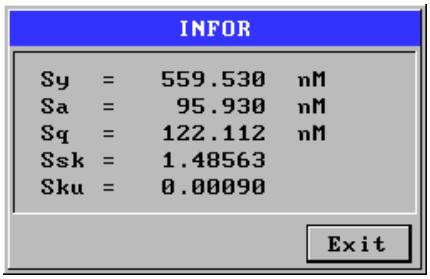
+"Shift" displays the angle betwæn two selected directions in the XYZ space.

"X" displays a section along the X axis in the selected location. (similar to **"X Section"** see item 4.2.4).

"Y" displays a section along the Y axis in the selected location. (similar to **"Y Section"** see item 4.2.4).

"XY" displays an arbitrary stretch section. (similar to **"Arbitrary Section"** see item 4.2.4).

"Sta" the followings coefficients are calculated for the selected area (similar to **"Statistics"** see item 4.2.4:



"Sy" peak to paek value (ISO 4287/1):

$$S_y = z_{\max} - z_{\min}$$

"Sa" average surface roughness (DIN 4768):

$$S_a = \frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|z(i,j)\right|$$

"Sq" surface root-mean-square (ISO 4287/1):

$$S_q = \sqrt{\frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N} z^2(i,j)}$$

"Ssk" surface skewness (ISO 4287/1):

$$S_{Sk} = \frac{1}{N^2 S_q^3}\sum_{i=1}^{N}\sum_{j=1}^{N} z^3(i,j)$$

"Sku" surface kurtosts (AN between points):

$$S_{ku} = \frac{1}{N^2 S_q^4} \sum_{i=1}^{N} \sum_{j=1}^{N} z^4(i,j)$$

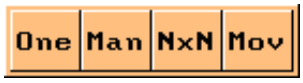
Button 2 similar to **Button 1**.

Button 3 similar to **Button 1**.

Button 4 similar to **Button 1**.

7.4 Scanning parameters window

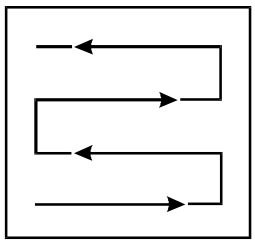
Button 1 opens the menu:



"One" a single scanning will be done at the area selected using the **"Border"** menu. (similar to **"One Scan"** see item 4.2.5).

"Man" scanning will be done at the area selected using the **"Border"** menu until interrupted by pressing the **"ESC"** button. (similar to **"Many Scans"** see item 4.2.5).

"NxN" displacement will be done according to the following scheme. The overlap degree is specified in **"Options"** - **"NxN"** menu (similar to **"NxN Scans"** see item 4.2.5).

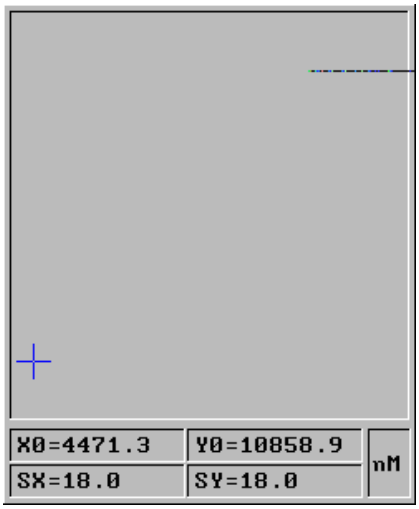


"Mov" displacement direction is specified using the cursor control keys in the course of scanning. The actual displacement is done after scanning. (similar to **"Move Scans"** see item 4.2.5).

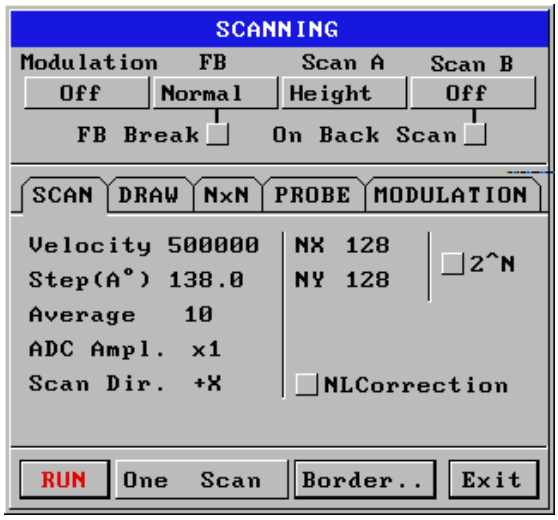
Warning:
In all multiple scanning mode only the last scan can be processed and saved to the disk.

Button 2 **"RUN"** starts the scanning mode.

Button 3 **"Bor"** selection of the scanning area dimensions and the start point (similar to **"Border"** see item 4.2.5.1).

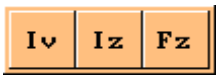


Button 4 opens the menu for the microscope operation in the scanning mode (similar to "**Scanning Options"** see item 4.2.5.1).



7.5 Spectroscopy window

Button 1 opens the menu for spectroscopy modes selection:

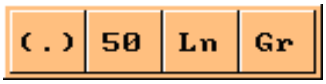


	I(U)	I(Z)	F(Z)
STM	At a fixed Z value, the U values in the range specified in the **"Options"** menu are changed with a1/64 interval increment. In the process the I(U) dependence is measured. Such voltage-current characteristics show the quantum properties of the sample.	At a fixed current quantity, Z values are measured in the direction from the surface within the range specified in the **"Options"** menu with a 1/64 interval increment. In the process the I(Z) dependence is measured. The I(Z) dependence obtained on pure unoxidizable metal surfaces Au, Pt or on HOPG surface makes it possible to determine the tip's quality, see 'The User's Guide' Appendix.	
SFM	Measurement of the I(U) dependence is possible with the use of conductive cantilevers.	The I(Z) dependence makes it possible to determine the cantilever's functionality and the proportionality factor between the registered current and the interacting force between the probe and the sample.	Changing Z from this point to the scanner range limit in the direction from the surface, in the process the I dependence is measured, I meaning in this case photodiode misalignment current, proportional to the force acting between the probe and the sample. The I(Z) dependence makes it possible to determine the cantilever's functionality and some of the surface properties

Button 2 **"RUN"** spectroscopy is done

+ "Shift" runs of measurements until interrupted by pressing the "ESC" key.

Button 3 opens the menu:



"(.)" spectroscopy in one selected point. Spectroscopy is done one time in the specified point. (similar to **"One"** see item 4.2.5.2).

"50" making a run of 50 measurements in one point. The results of all measurements are displayed upon completion in the form of a three-dimensional picture, where along the X axis - U or Z, along the Y axis - the measurement's number, the color gamut - current. (similar to **"x50"** see item 4.2.5.2).

"Ln" making a run of measurements along a selected line. The results of all measurements are displayed upon completion in the form of a three-dimensional diagram, where along the X axis - U or Z, along the Y axis - the measurement's number, the color gamut - current. I(U)[I(Z)] is read in every point where measurement was done when scanning, along the selected line with step equal to the scanning step.(similar to **"Line"** see item 4.2.5.2).

"Gr" runs of measurements at points of a selected grid. Number of points in the grid is set using the 'left', 'right' arrow keys or appropriate mouse movements. The results of all measurements are displayed upon completion in the form of a three-dimensional diagram, where along the X axis - U or Z, along the Y axis - the measurement's number, the color gamut - current. (similar to **"Grid"** see item 4.2.5.2).

Button 4 opens the menu for viewing all spectroscopy data stored in the main memory. The last measured array is also available for viewing. (similar to **"Look"** see item 4.2.5.2).

"View" viewing the three-dimensional spectroscopy data by specifying the points or the measurements numbers. The marker automatically goes through appropriate scan points, the spectroscopy results are displayed in the SCOPE window in the form of two-dimensional diagrams.

+"Shift" manual control of the through-points movement

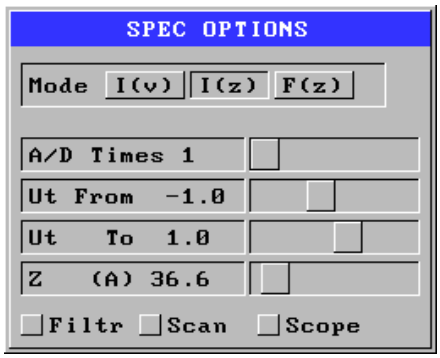
"<<" (">>") viewing the previous (next) spectroscopy data array if available.

"Scan" displays the scanning results

"Spec" displays the spectroscopy results

Button 5 **"Put"** puts the set of curves to a page in RAM memory that can be saved together with the images

Button 6 opens the menu **"Spec Options"** (see item 4.2.5.2).



"Mode" selection of one of the three spectroscopy modes: I(U), I(Z) or F(z).

"A/D Times" sets the number of measurements at each voltage quantity (Z coordinates) for averaging. (Only for the STM mode).

"Ut From" sets the initial value for tunnel voltage measurement in the I(U) mode. (Only for the STM mode).

"Ut To" sets the final value for tunnel voltage measurement in the I(U) mode. (Only for the STM mode).

"Z (A) sets the measurement range for the Z coordinate in the I(Z) mode. In this mode the tip when measuring moves in direction from the surface to the distance specified in this item.

"Scan" in case "Yes" is set the scanning is done in accordance with parameters specified in the Options menu, and spectroscopy is carried out in the specified point (points) (only for I(V) and I(Z)); if "No" is set scanning is not done, the tip is initially set at the specified point (points) and spectroscopy is carried out.

Be careful! If scanning parameters are changed after scanning but prior to spectroscopy and NO setting is selected for a particular picture area, spectroscopy points positions on the scan don't represent the actual ones.

"Scope" if the YES setting is selected the results of each measurement in the spectroscopy mode are moved to the SCOPE window immediately after measuring.

"Filtr" if the ON setting is selected data analog filtration is carried out, in the OFF position filtration is not done.

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