New developments in NT-MDT microscope line

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Fig. 1 The design of SPL

The new line of NT-MDT microscopes is based on the Scanning Probe Laboratory complex (SPL) (Fig. 1). SPL is a versatile complex, a benchtop nanolaboratory which opens a new era of scanning probe microscopy. Being a high level modern scanning probe microscope (SPM) it permits the sample surface investigations with highest resolution available nowadays. The system is able to run any of the 43 SPM techniques, has low intrinsic noises and due to integrated capacitive sensors the scanner non-linearity is also very low. User-friendly developed design solution allows customer easily modify configuration currently used by changing active parts and external devices.

The self-recognition option is included so the autoadjustment is possible. SPL lays on the crossroad of scanning probe microscopy, optical microscopy, spectroscopy, and electron microscopy techniques. The high quality surface information about the object is greatly supplemented by spectral properties characterization, 3D physical properties reconstruction and automated high throughput screening that can be performed using SPL based systems. Full range of nanolithographic techniques provides a broad spectrum possibility to modify the object surface deliberately. Thus unlike conventional SPM, the SPL based systems provide high score tools for large scale optical observations, chemical analysis, and spatial structure investigations.

As to new developments on the scanning probe microscopy field the AFAM (Atomic Force Acoustic Microscopy) mode should be especially mentioned. It provides the unique possibility to perform contrast imaging of the local hardness distribution on soft as well as on hard samples that is hardly possible using other techniques, such as Phase Imaging or Force Modulation. What is even more valuable, AFAM allows Young’s modulus to be quantitatively determined at each point of the scan.

The scientific market tendencies direct creation of a new generation of scientific instrumentation aimed to deal with specific applications on rather narrow science fields. For example biologists have rarely exploited the SPM so far. The cause was that they work with relatively large objects that could not be properly fastened. On the other way conventional light microscopes that provide large scale observations are very limited in spatial resolution. The NT-NDT solves the problem combining the high quality light optical system with the SPM facilities. Now it is allowed to observe the object with the resolution up to 0,4 µm then select the region of interest and scrutinize it with all the power of modern scanning probe microscopy. Optical and SPM images are electronically overlapped so one can easily change the scale from hundreds of microns to several nanometers.

Substantially more complex information about the same object can be obtained by addition to the system the laser confocal and the Raman's spectroscopy facilities. The femptoseconds lasers and time-resolved photon counting techniques not only provide wide-range spectral information concerning specimen chemical composition but also make possible to carry out the fluorescence measurements and lifetime analysis. Such laser spectrometry equipped system will be very helpful in biological sciences (molecular and structural biology, nanosurgery), material sciences (detection of contaminants, defects, and stresses in semiconductors, liquid crystal investigations etc), physics and anywhere the detailed information of specimen subsurface chemical properties is desirable.

A very promising way of the SPM development lays on the joint of SPM and electron microscopy techniques. The SPM investigation of freeze-fractured surface let to obtain images based on physical properties non-heterogeneity inside biological objects as cells or tissues. That is very like to conventional image processing in transmission electron microscope based on non-heterogeneous transparency for electron beam. The SPM image has the same or even better spatial resolution as conventional technique and often is more informative because of multiple modes available in SPM. Sequential removing of ultra thin slices using the ultratome permits analysis of serial surfaces followed by 3D reconstruction of the whole object spatial structure. 3D reconstruction of biological object takes only a day using SPL comparing to weeks in conventional techniques.

High resolution SPM is usually obstructed when the experiment must be run in changing temperature conditions. Our new temperature controller maintains temperature with the stability of 0,005^{o}C and provides temperature stabilization almost at room temperature up to 300^{o}C. Lateral as well as normal thermal creep is less than 20 nm/^{o}.

The possibility to run the experiment with thoroughly controlled external magnet field applied can be very helpful in a broad range of material science and industrial applications. The SPL new utility is designed to control external magnet field as much as 0,2 T to be exploited in magnetic film investigations, studies of magnetic materials domain structure and data storage devices testing.

Speed up of modern polymer synthesis technologies raises the problem of high throughput screening of new materials for desirable properties. That is the main factor limiting the creation process. As soon as micro quantities are usually available for analysis and a lot of information is necessary to predict macro level material properties a new approaches of SPM should greatly support the progress in this area. NT-MDT has developed the SPL based system adopted to automatically scan the specimen with known synthesis parameters, analyze the information obtained performing data base search, and optimize parameters for new synthesis. This automatic high throughput screening system can accelerate a new polymer materials creation cycle for thousands times.

Full-featured user-friendly software designed for SPL based models provides a flexible control of many working parts and microscope utilities. Moreover it permits a wide-spread net formation utilizing computing power of supercomputer and Internet information resources. So it is possible to carry out calculations of incredible complexity and results obtained can be used immediately to correct the new investigation cycle. With distant coordination of several working nanolaboratories one can organize a sophisticated scientific hyperstructure for very fast and fundamental investigation of submolecular properties of his/her object.