

# TOOLS FOR NANOTECHNOLOGIES

Interview with VICTOR BYKOV,  
Doctor of technical sciences,  
General Director of ZAO Nanotechnologia MTD

*The development of nanotechnological tools and methods became possible only thanks to the simultaneous evolution of computing technology. The quality strengthening of personal computers set prerequisites for intellectualizing the technology. Already today a software environment allows creating sophisticated complexes, which include a whole number of independently manageable elements. A further development of the software support will significantly simplify the use of nanotechnological hardware and make it possible to start its mass production*



**TECHNOPOLIS XXI: Mr. Bykov, why have You switched from the molecular electronics over developing tools for nanotechnologies or, to be more exact, for scanning probe microscope (SPM) and how did the formation of Your company happen?**

**V. BYKOV:** There is nothing surprising about it. Nanotechnologies are one of the most advanced and flourishingly developing spheres of research and developments covering the widest spectrum of disciplines: from the molecular biology and gene engineering to physics of surface of solid-state, electrochemistry, microelectronics, etc. Values commensurable with sizes of molecules and atoms are in use there. If the size of objects, which are being studied or being used as well as measurement accuracy do not exceed 100 nanometers (1 nanometer is equal to the one billionth of a meter), then, it is a matter of nanotechnologies already. In order to describe the complexity of operations being undertaken, imagine that the thickness of a human hair is about 30 microns or 30,000 nanometers. It is obvious that developing new direction of science and technologies needs new unique tools.

Such tools emerged only in 1981 and they have become known scanning probe microscopes (SPM). The principle of their operation is based not on *ЗexamingИИ* but on *ЗИtouchingИ* (scanning) of the

object's studied surface with a sharp probe eagle (its radius of curvature reaches 0,5 nanometers).

If one is to consider the origin of this scientific direction in our country, the nanotechnology, one should get back to the early 1970s, when the F. Lukin Scientific Research Institute of Physics Problems (currently, GNTS NIIPHP) started implementing the *Мolecular electronicsИ* program. Quite a lot of organizations got engaged in nanotechnologies, there was even a decision taken to establish a specialized institute, but there was not enough time for it. The main task of our Department at the Institute was to create molecular computing environment, computing machines with large density and enormous memory. In order to solve this problem, there was a need for scanning probe microscopes, however, in the second half of the 1980s their number in our country amounted to units. Foreign analogues, mainly, those made by the California's company Digital Instruments, were excessively expensive, while the financing of our subject was dramatically declining.

Then we with brothers Mikhail and Peter Lazarev decided to look for a way independently and in 1989 established the company MDT (Molecular Device Technology). In 1993 the company was transferred into *ТТ Nanotechnologia-MDT*, it became ZAO-MDT in 1995 and since 2003 it has been called Nanotechnologia

MDT.

*From the very first days of its existence the company has been directing itself on putting out the most advanced microscopes of different modifications. We have been basing ourselves not only on our own developments but also on scientific achievements of our many colleagues as well. In particular, a large contribution to the evolution of the subject made by A. Golubok (the Institute of analytical instrument-making of the Russian Academy of Science, Saint Petersburg), a number of scientists from the physics faculty of the Moscow State University (V. Panov, I. Yaminsky and others), talented electronics master V. Kharlamov from the Moscow region, town of Troitsk and others. As a result, already in 1990 first tools, tunneling microscopes, made by our company were put in operation. We were supported by the country's scientific community and, particularly, by academicians M. Prokhorov, K. Valiev and B. Vainshtein. But it became clear soon that there would be no chance to survive without commercial activity.*

The first steps in this direction were made in 1992, when Italian partners ordered two tunneling microscope and two Langmuir systems for applying molecular coverings. This order let us make \$100,000 and, at the same time, to master a new elemental base. By the way, the use of only the most advanced components in all further developments became one of the chief principles in operations of our company

There were a lot of difficulties in the beginning. First of all, it was necessary to overcome the whole complex of unbelief in the personnel's own abilities at our own company: there was a need to put out tools not only at acceptable level but at the level higher than the world standards. So there was a need for qualified personnel. By the way, Russian high schools' graduates are fine specialists, the only problem is to know how to work with them. If at once to put on their shoulders tasks beyond their strength, there is a chance that they could not bear it. But if they are being put in business gradually, seriously, then, there will be no better workers. We opened nanotechnology centers at the Moscow State University, MIET, MPHTI and others and equipped them with NanoEduKator, a specially developed teaching scanning probe microscope. This our know-how helps to teach our students to learn the main ways of working with objects of smaller sizes (less than 100 nanometers).

Let me repeat it again: from the very beginning we trying to produce not only good tools but the best ones. But in order to understand in what directions to move, it was necessary to learn better the world market with respect to the appropriate goods. And we started exactly with it. And then it was another task was to penetrate it.

The enormous help was provided by Russia's Ministry of Science and Technologies (it was called this way then) that made donations to scientific institutes for buying our tools.

Besides, the assistance from the Ministry of Economy of Russian Federation was very helpful. In 1995 there was a contest for innovation projects and our developments drew quite an attention. As a result, by the initiative of head of the Ministry's Departments A. Svinarenko and his deputy V.

Fridlyanov (now both are the deputy ministers of education and science) the company was provided with a privileged credit for development.

*A great interest in our company was shown by the Foundation of assistance to development of small enterprises in the scientific and engineering sphere, which is headed by I. Bortnik. He provided us with a credit under very low per cent and this was a strategically beneficial decision.*

**TECHNOPOLIS XXI: As far as one can understand, tools that you are telling about allow to operate at the nanolevel; objectives and practical results of such operations can be very different. But what else has had a significant influence on developing nanotechnologies and what are the prospect for these products' entry into the mass market?**

**V. BYKOV:** The advancement of nanotechnologies has generally become possible with inventing adequate control methods that it is provided by a proper development of its instrument and technological base. This base can be compared with a tree, the root of which is a number of base instruments and installations for main supplements. In their turn, they branch out becoming systems adapted to specific supplements. One of the most powerful classes of instruments, which happened to be required by nanotechnology, turned out to be precisely a scanning probe microscopes. At present, these instruments can be used to study surfaces of solid substances of any size and shape, in vacuum, in the air, in gas and liquid environments, within a wide range of temperatures and pressures and provide a high allowance, opportunities for studying topography, surface power fields of these surfaces.

Besides, the development of nanotechnologies requires creation of high-resolution systems of quality analysis that are capable of identifying molecular and atomic contents of nanoelements. And this is impossible to achieve without using different methods of spectrum analysis and creating combined tools blending an ability of high-accuracy positioning with measuring topographical parameters and methods of quality analysis.

Exceptionally important is the introduction of methods of influence on the systems, which, like a conductor, are able to manage conformation restructurings, complex-setting and initiate photochemical transformations. These methods of influence should be quicker than those existing during the intramolecular ones. Like developing methods to register these processes that will allow to study kinetics, they will let follow transformations in nanoelements, molecular complexes, clusters.

The development of nanotechnological tools and methods became possible only thanks to the simultaneous evolution of computing technology. The quality strengthening of personal computers set prerequisites for intellectualizing the technology. Already today a software environment allows creating sophisticated complexes, which include a whole number of independently manageable elements. A further development of the software support will significantly simplify

the use of nanotechnological hardware and make it possible to start its mass production.

It may seem fantastic right now. But some time ago both space flights and personal computers also seemed fantastic but now they are quite an ordinary element of our everyday life. With the stage-by-stage accomplishment the rise of nanotechnologies will become quite feasible.

As far as our company is concerned, one of its chief competitive advantages was the implementation of the idea to create a single technological platform.

A scanning probe microscope can be used in very different situations. However, so as to work with, say, polymers, we needed one tool, while for doing work of the biological nature we should have had another one and there was a need for a different instrument to accomplish a task in metallurgy. And so on, and so forth. But the matter is that each of them costs tens of thousands of dollars. Our idea was to collect different modifications of a scanning probe microscope from separate functional block modules, like in children's mecano. Through implementing this idea we received a possibility to easily satisfy practically any requirements of customers. It is much quicker and cheaper than producing a new tool.

**TECHNOLOGICAL XXI:** How could one describe the market niche, which Nanotechnology MTD is working in, as well as the strategy of your company's further development? To what extent does the range of your products meet the existing demand and are you going to form this demand? It is obvious that it is not enough to put out a nice good; it needs to be bought yet. So much so that this tool is of the innovation nature or, in other words, it is not too ordinary.

**V. BYKOV:** The first really worldwide success has been brought to us by the Solver-P4 SPM

produced by 1997. It has started the whole series of tools, which now includes six modifications: Solver ...', MFM, HV, LS, SNOM, BIO M and PRO. These models allow to get over 43 characteristics of the most different objects: from metals to DNA, which can be present practically in any environment: atmosphere that controls the given gas content, liquidity, vacuum, wide temperature range.

However, nanotechnologies are used not only for methods of scanning bonding microscopy, but for the whole number of others such as spectography, optics of near vision, etc. Several months ago a happy idea came to our mind to unite several methods of research in one tool and, as a result, we have got the probe NanoLaboratory 3Ntegra Scanning Bonding Laboratory. It has marked a real breakthrough in the world nanotechnological instrument-making: our PNL has at once become a base for highly informative experiments in biology, chemistry of polymers, studies of magnetic and semi-conducting materials as well as many other areas. At present, our company has been putting out already 8 modifications of 3Ntegra: spectra; vita; aura; solaris; prima; tomo, therma and maximus.

Figuratively speaking, if it is possible to make an analogy with the car-building industry, we have created the Lexus type car. Developing such a complex system and, as a result, winning the world's leadership in this direction have become possible only thanks to the innovation concept of MEGAPROJECTS, which were initiated and who became the chief ideologist, Russia's minister of education and science A. Fursenko. The natural economy has long gone in the past and there is one way left to succeed. That is a cooperation or, in other words, work openly. All world scientific community has been going this way for a long time already.

There are recognized leaders in producing different chips, LSI-circuits and other electronic as well as mechanical components. These enterprises operate under the Sigma six scheme (3 or 4 defected items per 1 million of the produced ones), and their products meet the highest requirements of any customers. They supply their products not only to those desiring them the most but only to those desiring them the most. Thus, the quality is guaranteed either in big or in small quantities. The BigM is provided by designers and developers of the science complexes, whose brands are well known to all the world. The MDT is among them.

Not long ago our company has started to implement one more breakthrough project: producing research-and-creation nanoplants, i.e. such commercial complexes, which make it possible to purposefully change properties of objects with sizes less than one tenth of a micron. NANOFAB can be considered the

Doctor of technical sciences Victor A. Bykov graduated from the Physical Technical Institute (1973). Worked at the F. Lukin Scientific Research Institute of physical problems (currently, GNTS NIPFP, Zelengrad). Authored and coauthored 146 scientific works, including 52 applications for inventions and patents. The Russian Government Awards Laureate in Science and Engineering (2004). Holder of honorary titles Manager-2002 and Manager of Small Business - 2002. Chairman of the Russian Society of Scanning Probe Microscopy and Nanotechnology, Chairman of High-Tech and Innovation Enterprises Guild of the Moscow Chamber of Trade and Industry.

pro-type being developed in the company. NANOFAB is a unique scientific and technological complex to implement various kinds of operation. Such as methods of focused ion beams, atomic power and electronic microscopy as well as the system of molecular beam epitaxy (group processing), methods of chemical vacuum drawing, plasma sputtering, etc. This platform can be used the semi-conducting industry, in production of biosensors, in local chemistry.

We are working now on a new project generally called 3NanoelectronicAI. Its implementation will allow to not simply building up our positions of the world's leader in producing tools for nanotechnologies but also make us 3fashion settersAI in this direction.

There is a serious struggle on the world market of nanotools but we got real professionals working at our marketing and sales department and we should win the struggle. At present, our products are being bought in 38 countries, including the US, Germany, Japan, China, etc. And with 3INtegraAI we are already winning up to 70 of all competitive deals.

It should be taken into account that the attitude to Russian companies that put out hi-tech products is rather cautious. That is because tools themselves as everything that is connected with them (teaching, accompaniment, provision with components and service parts) should be of high level. And, of course, a big role belongs to advertising.

**TECHNOPOLIS XXI:** Who should be the object of such an advertising? A specialist knows understands even without it the importance of nanotechnology. That is why there is a need not so much for the product itself as for its producer's brand; it seems

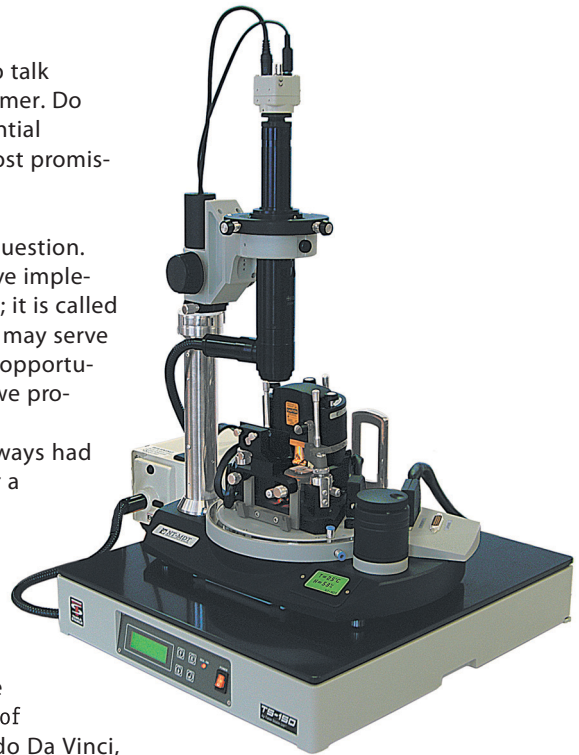
that it is too early to talk about a mass consumer. Do you think that potential investors are the most promising group today?

**V. BYKOV:** Good question. Just recently we have implemented one project; it is called Microcosmos and it may serve as an illustration of opportunities of tools that we produce.

Symbols have always had special meaning for a human being: time, unity of micro- and macro-cosm, continuity of culture, etc. And we tried to use all these. By the 500-th anniversary of Jokonda by Leonardo Da Vinci, Russian artist Georgy Puzenkov did it computer version Single Mona Lisa (1:1). We decided made our contribution to this project and with the help of Ntegra created a nanolithography on a titanium-silicon plate (8x8 um), sealed it in a transparent crystal and on April 15, 2005, to the International Space Station with the help of spaceman Sergey Krikalev sent it there.

I hope that this is an obvious and convincing example of opportunities of both our company as of nanotechnologies as they are. □

Arkady MALTSEV,  
special for TECHNOPSIS XXI



2. "Ntegra" prima

1. 3NtegraAI vita

