

## Russian Federation State Prize in Science and Technology for 2009

The Russian Federation State Prize in the field of Science and Technology for 2009 for "A Set of Scientific Works on the Development of Laser and Information Technologies in Medicine" (Presidential Decree № 678, dated June 6th, 2010) was awarded jointly to Doctor of Physical and Mathematical Sciences, Academician of the Russian Academy of Sciences, Director of the Institute of Laser and Information Technologies, Russian Academy of Sciences, V. Ya. Panchenko; to Doctor of Medical Sciences, Academician of the Russian Academy of Medical Sciences, Deputy Director of the Burdenko Neurosurgery Research Institute, Russian Academy of Medical Science, A.A. Potapov; and to Doctor of Medical Sciences, Russian Academy of Medical Sciences, Academician of the Russian Academy of Sciences, Director of Herzen Cancer Research Institute V.I. Chissov.

**In** an interview with *Acta Naturae*, the winners talk about the developments that were honored as fundamental and of great importance to modern applied medicine.

State Prize Winner, Doctor of Physical and Mathematical Sciences, Academician, Director of the Institute of Laser and Information Technologies Vladislav Panchenko.

**Vladislav Yakovlevich, please tell us about the work for which you received the State Prize?**

– The Institute of Laser and Information Technologies is the first institute to build a system that helps remotely produce individual implants and biomodels based on the tomographic data of patients' pre-surgery examinations.

It was an interdisciplinary achievement which involved the participation of many of the Russian Academy of Sciences' institutes, as well as Lomonosov Moscow State University, and leading medical centers such as the Vladimirsky Moscow Regional Research Clinical Institute (MRRCI), the Burdenko Institute of Neurosurgery, the Herzen Moscow Can-

cer Research Institute (MCRI), the Central Research Institute of Dental and Maxillofacial Surgery of the Federal Agency of High-Tech Medical Care (CRIDMS), and the Blohin Russian Cancer Research Center (RCRC). At the Institute of Laser and Information Technologies of the Russian Academy of Sciences (ILIT RAS), the main work was done at laboratories run by V.V. Vasil'tsov, A.V. Evseev, and A.V. Ulyanov.

We began developing laser-information technologies of remote biomodeling more than 15 years ago. It is gratifying today to know that this technology has been included in the Health Ministry's approved list of high-tech procedures in oncology and neurosurgery.

The algorithm of this technology is as follows: a three-dimensional patient diagnostic is done (usually via tomography), then modern imaging is employed to diagnose both bone fragments and soft tissue with a resolution of about 1 millimeter. The obtained tomographic data is transmitted via the Internet to the center of rapid prototyping located in Shatura, in the greater Moscow area.

The tomographic data is then verified with a computer, and a working program is generated to reconstruct the model. This information is transmitted to a laser stereolithograph computer. A working chamber of a stereolithograph is filled with a complex composite polymer (developed in conjunction with the Institute of Chemical Physics and the Center of Photochemistry, Russian Academy of Science). Then, using programming, a laser beam with a preset wavelength, power, and frequency scans the surface of the liquid for any assigned program. Following that, a trace of the laser beam is hardened at a certain depth. All major equipment in the center (laser stereolithography machine, selective laser sintering of micro- and nano-powders) was designed and engineered at the Institute's laboratories.

**How long did the selection of those conditions take?**

Our institute conducted several experiments in photochemistry using different lasers. The results of these experiments led us to the synthesis of a new oligomer. Dozens of iterations were performed



Vladislav Panchenko

before we started to get hard, not easily breakable biomodels that exactly reproduce the data of the patient's tomographic examination.

For more than 5 years, several laboratories worked on developing the photo polymerization selection conditions. This is a very interesting, delicate, and time-consuming technology, which automatically forms biomodels layer after layer; for example, of a skull or bone fragment lost as a result of trauma.

Now ILIT RAS is investigating the possibility of multiphoton laser polymerization. Preliminary studies indicate the possibility of topologically complex structures

with a spatial resolution of up to 10 nm. Such a high resolution is required for the development of future technologies in neurological cancer surgery and cognitive studies.

Laser-Information biomodeling technology allows for very precise planning of future surgery. For example, its use in spinal surgery allows us to produce and "fit" the implant for biomodels without disturbing the patient. Summing up the experience, we can say that the use of rapid prototyping allows us to create individual biomodels based on tomographic data, and a script can be written for surgeries in almost every field of medicine.

As a result of this technology, the surgery itself is accelerated 2-3 times, while at the same time the rehabilitation time is reduced by the same rate. The number of surgeries planned and performed using this technology is approaching 4,000 now, and the technology is being used in more than 30 clinics throughout the country. The technology is mostly applied in neurosurgery, where almost everything is done under a microscope. Using this method in maxillofacial surgery has allowed to save dozens of children suffering from congenital diseases. This method has generated some interest on the part of many surgeons, including

oncological surgeons, and heart surgeons are also starting to show interest. But here I am intruding into someone else's territory. This is medicine. This would be better discussed by my colleagues, Academician A.A. Potapov and Academician V.I. Chissov, who are more knowledgeable on the subject.

**Are the authors of this method Russian scientists?**

– Yes. Based on currently available published data, our teams were among the first to create individual biomodels based on a patient's tomographic data, which have been found to be widely used in clinical practice. We were behind the concept of making individual "spare parts" for the human body in preliminary tomographic surveys, which are carried out anywhere in the world. In principle, you can scan the human skeleton, record the results, and, if necessary, refer to this information to reconstruct fragments, such as bones, in case of a fracture. Such surgery has already been successfully performed on animals.

**Vladislav Yakovlevich, is government support necessary for the development of this technology?**

Government support is always important, especially in large projects of international importance. The first problem is that such operations need to be standardized. When we speak of modern medical technology, we set specific actions that can be replicated by an accurate description in another location by another professional.

Development of a new technology is fundamental research and, to some extent, art. However, its application is routine. Russia often amazes the world by the unique surgeries performed here, but repeating it, making it serial, to help all those who are in need, is nearly impossible due to the lack of technology. It's 'high', but not 'tech', but if we're talking about high-

tech mass medical care, that is exactly what it should be - technical.

**Did the successful establishment of biomodels inspire you and your staff to create implants from biocompatible materials?**

– To some degree, yes. It is the next phase associated with tissue engineering. In conjunction with the Institute of Transplantation and Artificial Organs, we are looking for new biocompatible materials to use with laser stereolithography technology and for cleaning materials using supercritical fluids. This will create a complex configuration of implants and scaffolds – the vessels of a given shape for the directional growth of cells, which are used for tissue growth, eventually growing organs as well.

**An intelligent laser surgical diagnostics system was included in the award. What is this system?**

I will say a few words about one of these systems. As we know, laser is a good scalpel, and we thought - why not arm the surgeon with such a scalpel? That way it would be instantly clear what biological tissue is being cut. The fact is that during surgery various tissue particles can fly in various directions. Moreover, different particles fly with different distributions of velocity in space. A laser can adopt a scattered light and is much faster than human reaction; so it can help a surgeon identify the type of particles that evaporated at the moment. This information is transmitted to the surgeon in the form of certain signals. Thus, the surgeon knows exactly that he is removing a meningioma and not a healthy brain tissue.

So this system allows the surgeon to clearly define the boundaries of the unhealthy tissue, which is especially important in oncology. This idea has been discussed by Academician V.I. Chissov and corresponding member of the Academy, I.V. Reshetov. Intelligent laser

systems of this type were designed, built, and used in dozens of successful operations.

**Corresponding member of Russian Academy of Medical Sciences, Medical doctor, Professor Igor Vladimirovich Reshetov:**

– Research in the use of laser information technology began almost 10 years ago. In speaking to different audiences in academia, Vladislav Yakovlevich Panchenko awakened some interest in the medical applications of these developments. A research group was started focusing on the use of laser information technology in medicine. The group was headed by the following leaders: V.Ya. Panchenko from the Institute of Laser and Information Technologies, A.H. Konovalov and A.A. Potapov from the Research Institute of Neurosurgery, and V.I. Chissov from the Moscow Research Institute of Oncology.

Prototyping of biological objects was recently put into clinical application. Models are created at the stage of diagnosis clarification, evaluation of treatment, or follow-up corrective rehabilitation. The easiest prototypes to fabricate are those of body parts that have a support structure. So, there is no part of a human skeleton that was not considered. Naturally, we have sought not only to accumulate the observations, but also wanted to find new solutions that qualitatively improve the patient's life; for example, to produce an individual prosthetic bone, called an implant. The technology is already here: however, now we are working on making these implants not by making a cast of a symmetric part (i.e. through the mirror transport of the missing pieces), but in a way such that during the prototype model growth a biocompatible fragment is produced.

**Why is the technology of rapid prototyping important to the surgeon and his patient?**

- Thanks to this technology we now have an opportunity to predict the operation, optimally fit all “parts” and to assess the impact. Currently, the requirements for functional rehabilitation have increased considerably: people don’t want to feel impaired in any way, which requires technology to ensure very precise custom fitting. A surgeon has to be very aware of his actions. Procedures that previously had to be estimated are now performed accurately. This technology is not computer 3D animation, but a real, tangible thing.

As a general conclusion, laser technology in medicine is a reservoir of knowledge and technology that still requires lots of work. We are in the process of applying so-called intelligent laser devices that allow the surgeon to dissect tissue and to change the power mode, as well as the depth of dissection, that will contribute to the simplification of robotic surgery.

I have to note that the introduction of these technologies will require an increase in technical staff at hospitals, especially “medical physicists,” who are now in high demand. ●

**Interview by  
Svetlana Sinyavskaya**



Igor Reshetov