

NanoSPD activity in Ufa and International Cooperation

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Abstract. This report presents main achievements of R&D activities of the Institute of Physics of Advanced Materials of Ufa State Aviation Technical University (IPAM USATU, Ufa, Russia) with a special attention to innovative potential of nanostructured metals and alloys produced by the severe plastic deformation (SPD) techniques. Several examples of the first promising applications of bulk nanostructured materials (BNM) as well as potential competing technologies are considered and discussed. The authors would like to focus special emphasis on international cooperation in view of numerous emerging projects as well as different conferences and seminars that pave the way to close and fruitful cooperation, working visits and exchange of young scientists. The possibilities of international cooperation through various foundations and programs are considered.

Introduction

Development and introduction of nanotechnologies and nanomaterials, training of highly-qualified personnel are the priority directions of science evolution in the Russian Federation. A system of innovative studies in the sphere of nanomaterials and nanotechnologies, including processing of nanostructured materials, application of nanocoatings, shaping of items made of nanomaterials, has been successfully developing at Ufa State Aviation Technical University (USATU, Ufa, Russia) for over 20 years.

One of the most topical directions in the sphere of nanotechnologies is nanostructuring of metals and alloys via severe plastic deformation (SPD) techniques.

Last year the world science celebrated a small anniversary – it's been twenty-five years since a classic description of the application of severe plastic deformation to bulk solids in order to achieve exceptional grain refinement to the submicrometer level appeared [1]. The start of these activities referred to the works of Ufa researchers demonstrated for the first time a possibility to form unique properties in metals and alloys due to their microstructure refinement up to nanosizes with the help of SPD methods. An important milestone was establishing on the basis of the Ufa State Aviation Technical University of the Research and Developing Institute of Physics of Advanced Materials (IPAM USATU) in 1995, headed by Prof. Ruslan Valiev.

Since then numerous research teams from all over the world got involved in this sphere of interests, however the pioneers of nanoSPD working at UUSATU are still the leader experts as in Russia and worldwide.



Presently more than 50 scientists, management and technical personnel perform research and development work at IPAM USATU. The spheres of their interests vary from development of approaches to formation of bulk nanostructured states in different metallic materials, establishing of regularities in microstructure evolution, analysis of the severe plastic deformation mechanisms, enhancement of mechanical and physical properties in metals, processing of bulk nanostructured ingots to innovative application and commercialization of bulk nanostructured materials. The results of the conducted investigations are presented in 13 books and in over 500 papers in international scientific journals and in numerous patents.



Figure 1. IPAM personnel (www.nanospd.ru)

Scientific activities in the sphere of bulk nanoSPD materials, including main conferences and key-note publications are successfully coordinated by the international steering committee (www.nanoSPD.org), represented by world-known scientists from different countries: M. Zehetbauer (Austria), R. Valiev (Russia), T. Langdon (USA), Y. Zhu (USA), Y. Estrin (Australia), Z. Horita (Japan).

Innovative studies in Ufa

Scientific basis of IPAM USATU, including the developed methods of analysis of nanoSPD materials, the unique equipment designed for processing of bulk nanostructured materials [2], etc. led to the emerging necessity to proceed from fundamental studies to real applications. Thus in 2005 first practical implementation of IPAM USATU developments started, when experts from the USA and Czech Republic expressed their interest in the samples, made of nanostructured titanium. A new design of dental implants was made by the Czech engineers considering enhanced strength properties of nanostructured titanium and its specific biological features. The new implant had a number of advantages as compared to conventional products. First, it was fully made of pure titanium. Earlier versions were made from the titanium alloy, containing toxic impurities. Second, having the same strength characteristics as in case of the conventional product (3.5 mm in diameter), the diameter of the new implant was only 2.5 mm, which opens up the way for application of this material in maxillofacial and children's implantology. In the course of the performed bio-medical studies there was revealed one more advantage of the nanostructured titanium: the number of the survived cells of the biological tissue when applying nanoTi is greater as compared to the case of the conventional metal. As a result the speed for the implant acceptance grows and the time for the post-surgery rehabilitation reduces [3, 4].

In 2006 IPAM started commercial application of the achieved scientific results. An innovative project aimed at transition from the laboratory samples to semi-products and further to the end product was launched. The innovative potential of this project was fully realized with the support of the International Scientific and Technological Centre (Moscow, Russia) and The Foundation for Assistance to Small Businesses after registration in 2007 of the Start-up companies NanoMeT Ltd., (Ufa, Russia) and Innovation technologies Ltd. (Sarov, Russia). In frames of the initial stage of the project there was launched the first in the world pilot-industrial production line for manufacturing of bulk nanostructured materials. This facility possessed the unique equipment, designed by the experts from IPAM USATU. The production capacity was over 2 tons per year. Regular commercial supplies to the Russian and international customers started in 2012.



Figure 2. Production line at NanoMeT Ltd., Ufa, Russia

The areas of application of nanotitanium are not limited by medicine. There are several promising economic sectors, where it can be used in the near future – like machine building, aviation, sports and energy.

Titanium is not the only metal, on which the IPAM USATU research team is focused. Jointly with scientific and industrial colleagues from Magnitogorsk (Russia) there was developed a pilot-industrial technology for manufacturing of fasteners from nanostructured steel. The specific feature of this development is that the end products are made from low-carbon steel instead of the alloyed one. Strength characteristics of the new items preserve at the same level as in case of the alloyed items. The main advantage of this technology is that it is less energy and labour consuming. The products become approximately 10% less expensive.

Other developments of IPAM USATU, including nanostructuring of copper and aluminium alloys also present great innovative interest for future application in energy, transport industry and construction works. Presently alongside with scientific investigations IPAM USATU personnel perform applied studies, aimed at processing of items made from ultra-fine-grained (UFG) aluminium alloys, such as aviation fasteners and other items for aviation and power industry. Also there has been started some research activity aimed at innovative application of UFG metals and alloys at cryogen temperatures.

Studies, focused on processing and application of nanostructured materials for aviation engines of the new generation, as well as for manufacturing of items of irregular shape under the conditions of superplasticity have been actively performed recently.

International certification

The success of the commercial application and sales of nanomaterials is largely attributed to the choice of strategy performed via international cooperation and certification in accordance with the ISO 9000 standard. ISO 9000 or 9001 standard certification guarantees the company has the right to produce the quality product. The sense of certification consists in organization of quality management in the company. ISO 9000 or 9001 secures optimal control of production and prompt response, ensures the provision with services of high quality and constant further improvement of the latter.

Certification of the production is in demand to make the clients, partners, potential investors, supervisory authorities and other interested parties confident in the company's possibility to steadily make its goods and services satisfy the corresponding international standard requirements. It produces positive effect on the company image, increases chances of its triumph in the calls and tenders and what is more important, is a powerful instrument in providing of stable high quality of goods (services). The certification system by itself can not a hundred percent guarantee the quality of an end product. But it enables to detect and eliminate problems.

Thus, the USATU start-up company NanoMeT Ltd. Applied for and successfully achieved in 2012 the International Certification ISO 9001:2008.

International cooperation

Works of the Ufa scientists have received broad international recognition. Numerous scientific relations are being maintained with the leading experts from different countries from all over the world, namely: the USA (the University of California, Davis, the University of Southern California, Los Angeles, Los Alamos National Laboratory, the University of North Carolina, etc.), Germany (The Institute of Nanotechnologies, Karlsruhe, University of Munster, etc.), France (the University of Rouen, the Université de Lorraine, Metz, etc.), Austria (the University of Vienna), Japan (Kyushu University), the Czech Republic (the University of Ostrava), Poland (Warsaw University of Technology), The Republic of China (Nanjing University of Science and Technology, Peking University) and others.

The support of research and developing activities in the sphere of nanomaterials and nanotechnologies at IPAM USATU is fulfilled via international and Russian grants, programs and direct contracts with industrial customers.

Active international cooperation contributes to the exchange of lecturers, training of the personnel in world-known scientific centres in the USA Germany, France, Austria, et al., scholarships for PhD students.

Besides the IPAM USATU team on regular basis holds once in two years the International Symposium «Bulk Nanostructured Materials: from fundamentals to innovations», attracting over 250 participants from more than 26 countries.



The 3rd International conference «Bulk nanostructured materials: from fundamentals to innovations», Ufa, Russia, 2011

The scientific success, achieved by the Ufa scientists was the basis for realization of the innovative educational program on training of the research personnel in the field of nanomaterials and nanotechnologies. One of the demands of this program was development of the unique lectures, laboratory and practical exercises with the use of results achieved in the course of recent topical investigations. Modern research equipment is available now in the Centre of collective use «Development and investigation of bulk nanostructured materials» at USATU.

Conclusions

The transition from the R&D product to the commercial one should be performed step-by step via adjustment of laboratory technologies to commercial application under the conditions of pilot-experimental production with direct participation in the innovative process of trained scientific and management personnel.

The principal aspect of the strategy at the initial stages of realization of the commercialization mechanism is certification of the production according to international standards ISO 9000 or 9001, determining the image and success of BNM, as well as of manufacturers of these nanomaterials.

International cooperation plays a pivotal role in the innovative activities connected with BNM. This is the key to world-wide recognition.

References

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