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To the 20th year anniversary of the Department of Materials Science of the M V Lomonosov Moscow State University

The history of the Department of Materials Science (DMS) dates back to 1991 when the Higher College of Materials Science, which later acquired the status of a Department, was established based on the Departmenty of Chemistry. The Department of Materials Science was planned as an interdisciplinary division meant for training specialists in related fields of chemistry, physics and material mechanics that would be able to unite young members of the traditional faculties working in the field of materials science and to remove the gap between researchers of the Moscow State University (MSU) and research institutes of the RAS.

The DMS students acquire fundamental knowledge of higher mathematics, chemistry, physics and mechanics; they study a range of specially developed theoretical courses and learn modern experimental techniques. Considerable attention is paid to the learning of foreign languages.

The key feature of the students' training at the DMS is the existence of the most favourable conditions for scientific research. These include the specially designed curriculum that envisages at least one full day a week (two days for higher-year students) for the work at the laboratory and the encouragement of the participation in students' scientific conferences of the DMS, which are held twice a year. One more characteristic feature of the curriculum is a decreased number of compulsory courses for higher-year students and the presence of specialized elective courses, which may be important for the subsequent scientific career. Each of these courses (the range is very broad) is a complete science area that can be comprehended by a student without pre-training.

Since the foundation of the Higher College (now the Department) of Materials Science, *i.e.*, long before Russia joined the Bologna process and before this process started in Europe (1999), the system of two-stage (bachelor's and master's degrees) basic education was already implemented at the DMS. Perhaps, this was promoted by the experience the author had gained during his long stay abroad, especially in the USA, Australia and Japan. The interest in the two-stage education might also have been initiated by numerous discussions between the members of the Standing Conference on University Problems (CC – PU) of the Council of Europe in which the author had worked for a long period. Although the period of study at the DMS was initially 5.5 years (4 + 1.5 years), currently this period is six years (4 + 2).

The students' performance from the 1st to the 6th year is evaluated by the rating according to which the performance in each study course is scored and the scores are summed up thus forming the personal rating of the student during the whole study period.

Since the first days at the Department, every student has a personal curator, who supervises the students' research at laboratories of the Faculties of Chemistry, Physics, Mechanics and Mathematics (potentially also of the Faculties of Geology and Biology), laboratories of the institutes of the RAS and joint science and education centres. Each term ends with a student research and practice conference where students report the results of their research and special jury evaluates the reports. The conference is preceded by a two-week scientific session, which starts after the examination period.

In January, 1997, the first graduation thesis presentation took place at the Department. Relying on the experience of other faculties, 'Regulations for the presentation of graduation theses (for bachelor's and master's degrees) at the DMS' were developed taking into account the university traditions and specific features of the DMS. In addition to the reports and author's abstracts of the graduation theses (for bachelor's and master's degrees), the State Examination Commission considers the publications on the subject of the graduation thesis.

The State Examination Commission formed in 1997 included three Academicians of the RAS, nine Professors, 12 doctors of sciences in chemistry and physics/mathematics and other specialists of the MSU Faculties of Chemistry, Physics, Mechanics and Mathematics and the Department of Materials Science. For six years, Director of the N S Kurnakov Institute of the General and Inorganic Chemistry Academician N T Kuznetsov was the Chairman of the Commission, and then he was replaced by the Chairman of the Section of Materials Science of the RAS Academician E M Dianov. Currently, the Commission of bachelor's degree theses is headed by Corresponding Member of the RAS I G Tananaev, and the Commission of master's degree theses is headed by Director of the A N Frumkin Institute of Physical Chemistry and Electrochemistry Academician A Yu Tsivadze.

Since 1998, the DMS has provided full-time postgraduate courses for training high-grade specialists in fundamental materials science. Distinctive features of the postgraduate courses of the DMS are the presence of the personal rating, in-depth theoretical training, advanced pedagogical practice, work experience abroad, writing of scientific projects, obligatory social organization activity and also the fact that post-graduates supervise the research work of DMS students.

The Dissertation Council of the DMS accepts dissertations according to the specialties: condensed state physics (01.04.07), solid state chemistry (02.00.21) and inorganic

chemistry (02.00.01). The DMS alumni defended 2 doctor's and more than 80 candidate theses.

After the post graduate courses and presenting the thesis, post-doc training is available at the Department.

Although the Department does not include purely scientific staff or divisions, it still does a large body of research by efforts of the pedagogical staff and students.

The Department of Materials Science of the MSU performs interdisciplinary research directed at the production of new classes of functional materials. Particular attention is devoted to nanotechnologies. According to forecasts, in the 21st century, nanotechnologies will make a revolution in the manipulation of matter similar to that made by computers in the 20th century in the operation of information. Only the active involvement of Russian scientists in these design works can ensure a competitive position of Russian science in the world.

Biomaterials, electroceramics, functional composites, thin films and heterostructures are the priority research objects at the Department. During the last years, promising results were achieved, their scientific level being comparable with the best world achievements in various advanced high-tech researches.

Methods of chemical design of magnetic nanocomposites in solid-phase nanoreactors (mesoporous oxides, layered double hydroxides, *etc.*) were proposed and implemented for the manufacture of super-high density data recording devices (up to 10^3 Gb cm^{-2}) based on iron, cobalt, nickel and platinum nanoparticles (less than 50 nm). The thermodynamic and chemical features of fullerenes, unusual globular allotropes of carbon, were studied.

Preparation methods of high-density ceramics based on barium cerate and zirconate have been developed; they are used as barrier materials chemically resistant to the action of various melts. A procedure for the manufacture of heat protective coatings made of stabilized zirconia for turbine blades was developed based on chemical vapour deposition processes.

A versatile graphotexturing procedure was developed to be used for the preparation of flexible long length conductors from biaxially textured high-temperature superconductors, which can be advantageously used in various devices operating at liquid nitrogen temperature.

Materials with record high magnetoresistance for magnetic sensors and spintronics based on manganites (ceramics, thin films and tunnel heterostructures) were obtained and composition – structure – property correlations were elucidated for them.

Various ion-conducting oxide materials (cobaltites, $BiMeVO_x$, one-dimensional superionic conductor whiskers) and polymers for secondary lithium current sources were synthesized and electron and ion transport in nanocrystalline oxides was studied. These materials are finding wide use, for example, in high-capacity cell phone batteries.

Approaches to the formation of electron-ion conducting membranes based on cobalt oxides were developed for the design of new generation fuel cells. In the field of photonics materials, methods for the preparation of photonic crystals with direct and reverse opal structures and precursors of organic light emitting diodes were devised.

Calcium phosphate and silicate cement mixtures to produce compact materials that acquire unique strength after treatment in a solution of artificial tissue fluid were proposed. These biologically active materials can be effectively used in dentistry for filling inner cavities of tooth tissue of any shape. New-generation composite materials for replacement of bone tissue were developed.

Sodium titanium bronzes in the form of nanotubes meant for photodegradation of industrial wastes and for the production of aerogels, versatile heat insulation materials, were obtained by hydrothermal synthesis, fast expansion of supercritical solutions or supercritical drying. The design of these promising materials lays the foundation for the subsequent development of science-intensive technology in the power engineering, information science, health care and medicine in Russia.

A priority task of the Department is to purchase modern equipment needed for high-level scientific research. This is where DMS spends most of finances gained from grants and executed projects.

The equipment purchased by the Department provides the development of the MSU Shared Use Centre 'New Nanostructured Materials Technologies and Integrated Research', which supports the modern interdisciplinary research and allows the MSU to equally compete with the best foreign universities and scientific centres. During the master's programme each student has a chance to do practical training on several modern instruments at the Shared Use Centre and to get the operator researcher certificate.

Primary attention is paid at the DMS to the integration of science and education. Since the foundation, the Department has been cooperating with institutes of the RAS, which resulted in the establishing of six science and education centres involving chemistry-oriented institutes of the RAS.

The Department of Materials Science maintains broad scientific relations and has cooperation agreements with foreign universities and many research organizations of the USA, Germany, France, Sweden, Japan, South Korea, China and Taiwan.

According to the curriculum, students have the opportunity of work practice abroad in the 10th half-year (the first master's year).

The post-graduates of the DMS may do joint courses of the DMS with universities of France. After completion of the joint courses and presentation of the thesis, the young researchers are awarded not only the Russian Candidate degree but also the French Ph.D. degree.

Now we will consider the most important activities that can provide bringing up of scientific elite of Russia in materials science, particularly, in the engineering of functional and structural nano- and biomaterials, which is the key goal of the DMS staff.

Ten years ago, when celebrating the ten-year anniversary of the DMS, we emphasized that like any complex structure, the Department of Materials Science evolves with time. Two issues, one from the past and one from the future, appear to be the key stages of this evolution. The first one dates back to the period where the DMS was established, which included epic political and environmental events (breakup of the Soviet Union, Chernobyl disaster) and simultaneously great scientific achievements (discovery of HTSC), which stimulated previously unprecedented rate of the development of new technologies and materials. The second stage of evolution, equally important for the DMS, refers to the time that is still to come where the fate of DMS will be in the hands of its most talented alumni for whom

the existence and development of the Department will be a mission in life. Only then, will it possible to state that all of us, who were at the origin of the DMS, did not work in vain and made our, although modest, contribution to the future of our long-suffering motherland.

From the very beginning, the most important goal of the DMS was to collect the most gifted young people from any, including most remote, areas of Russia, to provide them with the opportunity to develop as fully as possible their talents at the University and to finally become a part of the scientific elite of the society.

The combination of the interdisciplinary nature and high professional skills is a necessary condition of elite education, especially in the field of development of new materials and technologies. However, this combination may arise only with exceptionally hard-working students. It is pertinent to recall D I Mendeleev words that 'Russia has grown to the demand of freedom but only that connected with labour and performing duties'.

Certainly, not every student is able to reach success. The author shares the idea expressed by B Akunin in his first and perhaps the best novel Azazel: 'Every human is inimitably talented, every has a God's gift. The tragedy of the mankind is that we do not know how to discover and nurture this gift in a child'.

The problem of bringing up the scientific elite as a whole and, in particular, in the modern materials science is closely connected with the in-depth psychological investigations according to which motivation is more important than an innate ability, and mastering in any field of knowledge requires about ten years of hard work. It is not the training itself that is important but rather the activity that requires continuous effort where a person constantly tries to solve problems somewhat exceeding the person's capacity.

In this respect, note the annual Internet Olympiad 'Nanotechnologies as a breakthrough to the future' the success of which is mainly determined by the devoted work of students, post-graduates and teachers of the DMS headed by the Head of the Chair of Nanomaterials Corresponding Member of the RAS E A Goodilin and his co-workers. There is no age restriction for participation in the Olympiad, and often very young participants come to the top. It is sufficient to say that the average age of the winners and awardees of the latest fifth Internet Olympiad was 16.5 and 17 years, respectively.

The training level of the students and graduates of the DMS is reflected by very high scores in the number of scientific grants obtained annually by the research associates, post-graduates and students of the Department; the number of scientific publications and reports (8 times higher than the average value for the MSU); the number of named scholarships got by students and post-graduates; the number of medals of the RAS awarded to DMS students; the number of post-graduates who defended the candidate theses in due time, and so on.

Unfortunately, the limited size of this issue of Russian Chemical Reviews dedicated to the 20th-year anniversary of the DMS MSU precludes the possibility to publish all reviews written by the alumni of DMS together with their supervisors. When choosing papers for the anniversary issue, we attempted to reflect various areas of scientific research performed at the Department hopefully that the rest of the reviews will be published in the subsequent issues of the journal.

Academician **Y D Tretyakov**,
Dean of the Department of Materials Science
of the M V Lomonosov Moscow State University

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On the occasion of this issue dedicated to 20th year anniversary of the Department of Materials Science, which was founded by the initiative of Academician Yury Dmitrievich Tretyakov, the dean of the Department since the foundation, the Editorial Board and the editorial staff of the Russian Chemical Reviews journal take the opportunity to congratulate Yury Dmitrievich on his 80th birthday. Yury Dmitrievich Tretyakov is a world-renowned scientist. He actively works in science organization, education and in the public sphere. For many years, Yury Dmitrievich has been a member of the Editorial Board and a frequent referee of the Russian Chemical Reviews who shows active interest in the journal's life. Yury Dmitrievich often acts as the guest editor preparing thematic issues, which always arouse interest of the scientific community.

Dear Yury Dmitrievich! We wish you many happy returns of this day, good health, a lot of creative activity and unfailing success.