

## Analytical Review of the Reports Presented at the 13th International Conference on Films and Coatings (ICFC13)

V G Kuznetsov<sup>1</sup> and D K Kostrin<sup>2</sup>

<sup>1</sup> Institute of Problems of Mechanical Engineering, Russian Academy of Sciences, 199178, Saint Petersburg, Russia

<sup>2</sup> Saint Petersburg Electrotechnical University "LETI", 197376, Saint Petersburg, Russia

E-mail: kvgipme@gmail.com

**Abstract.** In this preface main trends in the development of films and coatings technology presented at the 13th International Conference on Films and Coatings (ICFC13) that was held on 18–20 April 2017 in Saint Petersburg, Russia are discussed.

During the Conference (figure 1) were presented the results of theoretical and experimental research in the physics and mechanics of condensed matter, physics of low temperature plasma, formation of films and coatings using plasma and related methods that were obtained over the past two years that have passed since the previous meeting.



**Figure 1.** Introduction to the 13th International Conference on Films and Coatings (ICFC13).



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Special attention was paid to the study of properties of surfaces and coatings, methods of their research, new coating materials, including nanomaterials, new areas of their application, development of modern equipment and technological processes, surface preparation and many other issues.

During the Conference were presented more than 150 reports that were distributed in 8 sections:

- vacuum ion-plasma methods;
- thermal spray coating methods;
- physical processes at all stages of coatings formation;
- equipment for application of films and coatings;
- materials for sputtering and deposition;
- nanomaterials and nanotechnologies;
- properties of coatings and films and methods of their evaluation;
- preparation of surfaces before application and methods of post-processing of coatings and films.

For the first time the Conference had a special section for young scientists, where presentations were made by students, postgraduates, candidates and doctors of science aged up to 35 years (figure 2). Among the participants were representatives of Russia, Germany, Czech Republic, Poland, Belarus, Ukraine, China, Vietnam, Myanmar and Kazakhstan.



**Figure 2.** Participants of the 13th International Conference on Films and Coatings (ICFC13).

In their reports the authors reflected the issues of thin films growth, their compositions and structures, including nanostructures. Were presented original researches in the field of thermodynamics and kinetics of phase transitions of the first kind in multicomponent systems. Particular attention was paid to the kinetic theory of initial stages of brittle destruction of solids. Great attention was paid to the mechanical properties of films and coatings. Was presented a two-dimensional experimental-theoretical approach to determining the integral stiffness tensile for non-planar film or membrane compositions of complex structure. Was proposed a variant of the asymptotic expansion of the differential equations of plane problem of elasticity theory, describing the joint deformation of isotropic beams and applied on it layer of the elastic coating. Algorithm for calculating the stresses during bending of the connection was created.

In a number of reports were presented the issues of optimization of the growth processes of thin films during vacuum ion-plasma and gas-thermal spraying using computer methods. Further development have acquired the theoretical and experimental researches in the field of physics and mechanics of formation of hollow powders for thermal spray methods of coatings deposition. On the example of

thermal spray coating process of a hollow microsphere  $\text{Al}_2\text{O}_3$  powder was experimentally confirmed a significant advantage of this class of powders to enhance the performance properties of coatings.

Special attention was paid to the reports on the implementation of the arc discharge in vacuum and possibilities of its use for coating deposition and for the solution of special technological problems. Further development has received the direction of research associated with the processing of materials surface with a cathode spot of a vacuum-arc discharge. For the first time this process was used to clean the surface of metals from radionuclides. The coefficient of purification at the level of 20 000 is the maximum compared to all existing methods.

One of the new trends in the development of science and technology, reflected in the reports is the formation of pyrocarbon coatings in plasma of a vacuum arc discharge. For the first time such coating has been researched and applied to the electrodes of powerful generator tubes as antiemission coatings. Theoretically and experimentally were investigated the thermal processes during treatment of the inner surface of the cylindrical cavity by the cathode spots of a vacuum arc discharge.

In a number of reports were reflected the characteristics of magnetron sputtering systems and principles of coatings deposition on their basis. The characteristics, technological aspects of production and results of testing of gradient coatings for aerospace optics were discussed. Promising technology of pulsed magnetron sputtering was noted. Possibilities of application of multilayer composite coatings in the systems of radiation protection of spacecraft were reviewed. Were shown the advantages of composite coatings before traditionally used in space technology aluminum alloys.

At this Conference many reports were devoted to the formation of oxide coatings by different methods and for different fields of application. For example, the results of comparative studies of the original and processed in the plasma flow oxide microcomposites, consisting of  $\text{TiO}_2$ ,  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ , and also plasma coatings from them – materials with amorphous-crystalline structure and a reinforced ultrafine phases of stishovite.

It was shown that a reliable method of forming a specified surface nanorelief is a direct resistless lithography by a focused ion beam. The use of ions of different masses and energies significantly expands its abilities for nanoconstruction and nanoengineering of thin-layer structures. Examples of the use of different ions for the nano-processing of coatings and surfaces of solids were shown.

In the series of reports were presented the results of studies on the effect of layout schemes of technological installation on the structure parameters and mechanical properties of wear-resistant coatings. The physical aspects of the developed by the authors low temperature process of plasma hardening of the surface layer of geometrically-complex products, characterized by the low-energy plasma particles that interact with surface atoms according to the scheme of heterogeneous recombination were discussed.

The possibility of application of film coatings rich with hydrogen for storage and desorption of hydrogen were analyzed. Was proposed a film hydrogen accumulator for use in the mobile objects on hydrogen fuel cells. Were discussed the method of its production and its application prospects.

Possibilities of acquisition of the graphene materials during the decomposition of acetylene with the plasma torch with DC power up to 35 kW were shown. The influence of the coating material and the geometric shape of the reactor on the morphology of graphene were determined.

Results were presented at the modeling and study of the processes of reactive ion-plasma etching. The results of stochastic modeling of the formation of the layered structure and the characteristics (microstructure, porosity, roughness) of the ceramic coatings from powders of corundum ( $\alpha\text{-Al}_2\text{O}_3$  phase) under conditions typical for the atmospheric plasma spraying and also detonation and supersonic flame spraying were shown. Fundamentals of physico-chemical model of reactive sputtering of the hot metal target in nitrogen environment were stated. The system of equations describing the model was solved for spraying of titanium in nitrogen environment. The features of the numerical method in modeling of processes of thin films formation were discussed. Was demonstrated the procedure of application of numerical methods to improve the accuracy and efficiency of computational processes.

Many of the results and designs of the authors were at the world level. Many developments are protected by patents for inventions. The design and main parameters of vacuum ion-plasma systems for applying functional coatings were presented. Examples of the application of superhard nanostructured coatings on materials and products were shown. Prospects for the use of the developed equipment in the industry were discussed. Also during the Conference were discussed issues of preparation of young specialists and scientific personnel.

Thus, the 13th International Conference on Films and Coatings contributed to the further development of this scientific and applied direction of research and professional development of the participating scientists.