15th International Conference on
Dental and Oral Health
June 27-28, 2024 | London, UK
Volume: 14

Mathematical Modelling for Construction of Optimized Biocompatible Coatings

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Statement of the Problem: Deposition of thin films and coatings on surfaces of dental implants and surgical tools can significantly change their physical and mechanical properties. Thus wear and erosion resistance, biocompatibility, durability, protection against abrasion and corrosion, thermal and chemical stability can be significantly increased. For practical researches of the mechanical characteristics of coatings both in laboratory conditions and for industrial needs, the nanoindentation technique is frequently used. This technique can be represented by a set of methods that use local precision force action on the material and simultaneously record the deformation responses with nanometer resolution. Most modern nanoindentation systems are equipped with software that allows operators to interpret experimental results. This software is built upon the methods based on the mathematical models that use solutions of classical contact problems for isotropic homogeneous materials. Such methods give the possibility to evaluate elastic moduli of bulk materials. In some cases, with their help the elastic properties of coatings can be determined. For this purpose, it is recommended to carry out indentation with depths not exceeding 10% of the coating thickness, and some specific ratios of the mechanical properties of the coating and the substrate must be fulfilled. However, these methods may radically underestimate or overestimate the unknown values of the characteristics in case of a sufficiently large difference between the elastic moduli of the coating and the substrate. It should also be taken into account that during the investigation of thin coatings, the recommended indentation depth may turn out to be comparable with the height of defects or roughness. This possibility entails high measurement errors or even an inability to conduct the experiment. To study the properties of inhomogeneous coatings required in modern dentistry one has to resort to the methods based on mathematical models using solutions of contact problems for solids with coatings.

Methodology & Theoretical Orientation: In the present study, an effective mathematical model, taking into account the layered or continuously inhomogeneous structure of the sample, is proposed for the description of nanoindentation experiment. The analytical solution was obtained using the bilateral asymptotic method. A comparison of the experimental results with the results, obtained using the mathematical model was performed for ZrN an ZnO coatings on various substrates.

Conclusion & Significance: A good agreement was demonstrated for the results of mathematical modelling and nanoindentation test data for various coatings.

Biography

Sergei Aizikovich, PhD, Head of Laboratory for Functionally Graded and Composite Materials of Don State Technical University. The main research interests of Dr. Aizikovich include biocompatible coatings, functionally-graded materials, composites, nanoindentation, mathematical modelling, contact problems, biomechanics of oral cavity. The team lead by Dr. Aizikovich is currently conducting research projects on biomechanics of the tissues of oral cavity and eyeball and optimized biocompatible materials for implantation.

Dentistry
ISSN: 2161-1122