INNOVATIVE OF TIN/ZNO COATINGS OBTAINED BY A HYBRID PVD/ALD METHOD

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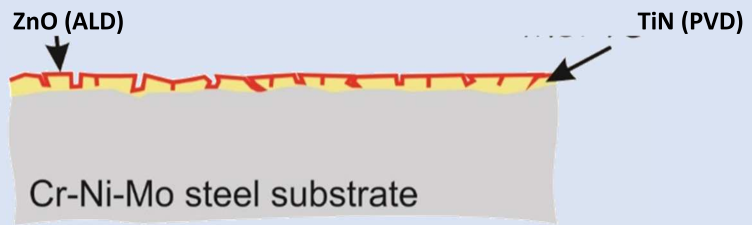
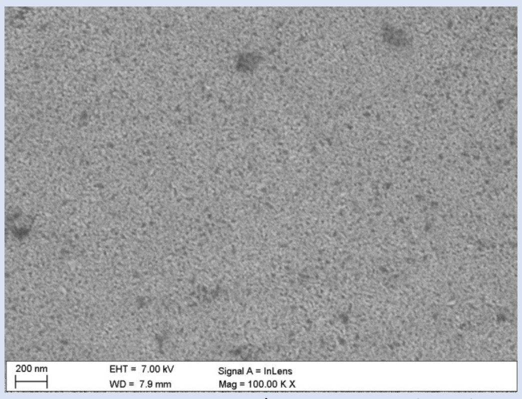
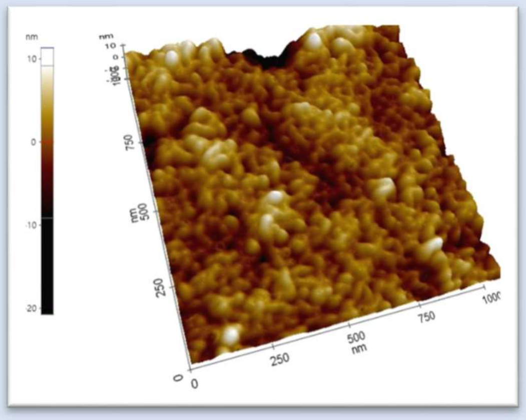


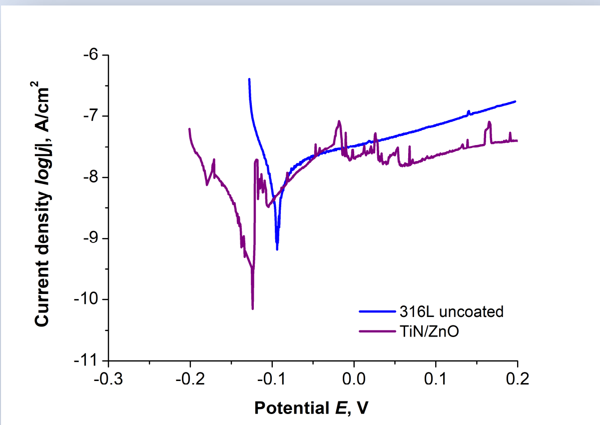
The idea of TiN/ZnO coatings obtained by the PVD/ALD hybrid process



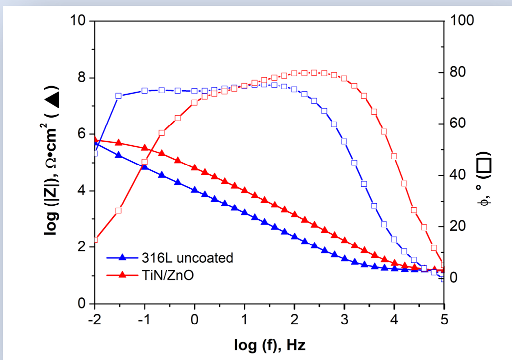
Morphology of PVD/ALD coatings (SEM)



Morphology of PVD/ALD coatings (AFM)

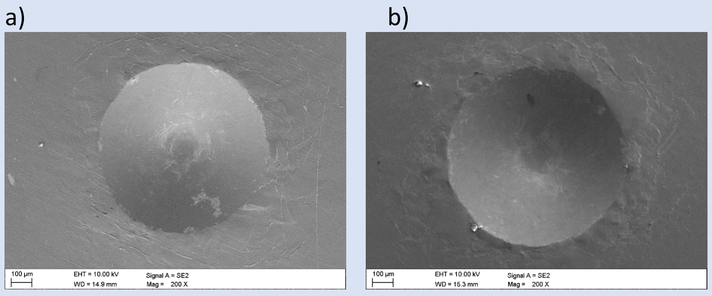


Potentiodynamic polarization curves for the investigated samples.



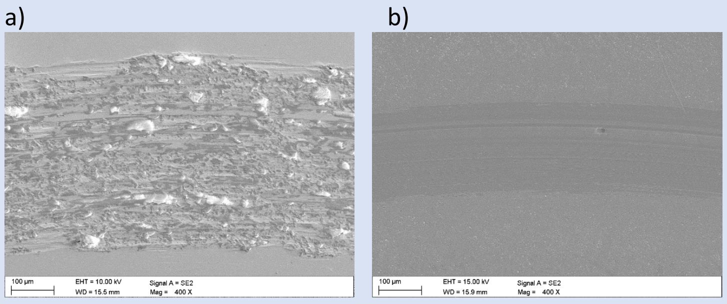
Impedance spectra for uncoated 316L steel and TiN/ZnO hybrid coated samples (Bode diagram).

a) b)



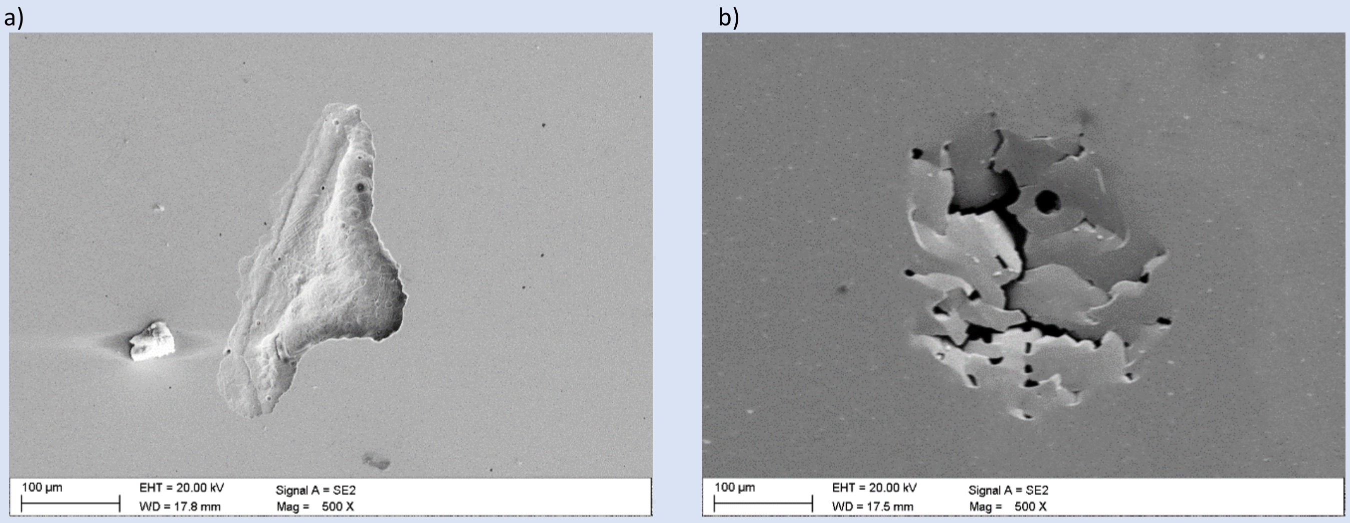
Coatings impressions after the Rockwell C adhesion test: a) TiN, b) TiN/ZnO

a) b)



Frictions trace formed in the tested coatings and substrates after tribological tests (SEM): a) uncoated 316L steel, b) TiN/ZnO

a) b)



The appearance of samples obtained by scanning electron microscopy after corrosion resistance tests of a) uncoated 316L steel, b) TiN/ZnO

Introduction

In the current era of civilization development, health protection, and quality of life, the materials used for implants are gaining importance. These elements should be characterized by high quality and reliability. Metal biomaterials currently used for implants include stainless steel, cobalt-chromium alloys, technically pure titanium, and its alloys. The most common austenitic stainless steel Cr-Ni-Mo is widely used in biomedicine because of its high mechanical properties, corrosion resistance, sufficient biocompatibility, and very low cost compared to the other biomaterials of metals mentioned above. The most popular representative of this group of austenitic steels in medicine is 316L steel, which is widely used for bone screws and plates or joint endoprosthesis, among others

Problem

Nickel contained in austenitic stainless steel (11.2%) as a result of corrosion in the tissue environment can be released into the patient's body, causing allergic reactions. This is one of the main drawbacks of stainless steel as a biomaterial.

Solving the problem

This unfavorable phenomenon can be counteracted by applying an appropriate surface treatment, which increases corrosion resistance and biocompatibility, and provides osteointegration and antibacterial properties, without worsening the mechanical properties of the material. The authors of this project have developed the PVD/ALD TiN/ZnO hybrid coating. The following coatings were applied to the prepared steel substrates: the Arc-PVD method for the TiN layer and the ALD method for the ZnO layer. The Arc-PVD coatings were applied in an optimized technological process. The ZnO layers were applied using the ALD method at 150 °C, using DEZ and H_2O precursors.

Results

As a result of the research, the following conclusions have been drawn:

- TiN/ZnO hybrid coating influence a significant improvement of the operational properties of AISI 316L steels coated with them, in particular the electrochemical properties in Ringer's solution and abrasion resistance.
- The electrochemical properties of hybrid coatings according to EIS studies increase with increasing thickness of the ZnO sealing layer obtained by the ALD method on a TiN coating deposited by the PVD method.
- The adhesion of the ZnO layer to TiN in TiN/ZnO hybrid coatings on AISI 316L steel has a strong influence on the tribological properties of these materials. In the case of poor adhesion, the detached brittle ZnO layer forms a nano-abrasive that enhances the abrasion process of the tested surface.
- The optimal thickness of the ZnO ALD sealing layer on the TiN PVD coating is about 90 nm, which corresponds to 500 ALD cycles.

Based on the studies performed, it can be concluded that the use of hybrid TiN/ZnO coating on 316L steel contributes to obtaining much better functional properties of the material compared to uncoated steel or in the case of a single TiN coating. The application of a TiN/ZnO coating, provides good tribological properties and very high corrosion resistance.

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