Functional surfaces obtained by electroplating of nano – sized dispersed ceramic phases with metals for use in the nuclear industry to increase the corrosion and tribocorrosion resistance.

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Project motivation.

Conventional metals and alloys perform poorly in many applications where metal components are subjected to aggressive environments and mechanical friction conditions. In this project, it is proposed to fabricate nano structured metal matrix composite coatings using electrodeposition and co-deposition techniques of nanosized ceramic dispersed phases with metals. Significantly improved tribological and corrosion properties are desired from these nanostructured coatings.

Project objectives.

➢Making functional nano-structured surfaces by electrolytic deposition of nano-dispersed particles (mechanism and kinetic of co-deposition process of nanodispersed phases with metals).

➢Obtaining of nanocomposite coatings on support materials at optimum parameters for performing the specific characterization tests in working environment.

➢Characterisation of coating thicknesses, surface morphologies and composition by SEM-EDX, XRD, adhesion, roughness and micro hardness.

➢Characterisation of corrosion, wear – corrosion (tribocorrosion) properties of nanocomposite coatings in specific environments.

Results.

In Figure 1 there are presented as summary the results obtained in fabrication of functional surfaces by electro-codeposition process, kinetic and mechanism of nanoparticles codeposition with metallic matrix, changes in surface morphology by nanoparticles inclusion into nickel matrix, structural modification induced by nanoparticles as well as the increasing corrosion resistance by increasing the amount of nanoparticles into plating electrolyte.

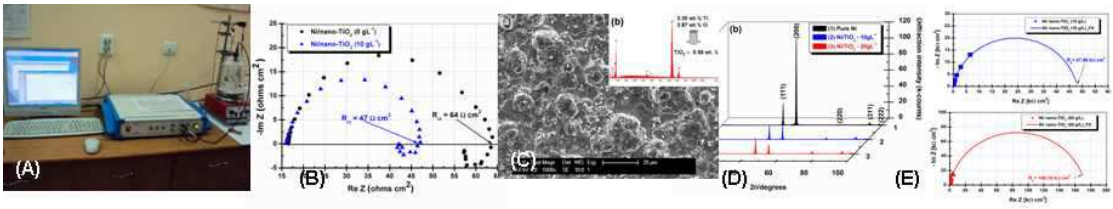

Fig.1. Electrochemical fabrication of nanostructured composite coatings: (A) – Electrochemical equipment for electrodeposition and corrosion studies; (B) – Comparative Electrochemical Impedance Spectroscopy Diagrams (EIS) obtained for the kinetic and mechanism of nanoparticles codeposition with metallic matrix during electroplatiung process; (C) SEM – EDX surface characterization of nanocomposite coatings; (D) – X-Ray Diffraction patterns showing structural modification by nanoparticles inclusion and (E) – EIS diagrams showing the effect of nanoparticles concentration into electrolyte on corrosion resistance of nanocomposite coatings obtained.

The nanocomposite coatings showed good adherence to stainless steel support, a coating thickness from 10 to 100 micrometers and about 12 wt % of nano dispersed phase included into metal matrix with enhanced properties (nanohardness, corrosion and wear resistance in dry and wet conditions. In the tribocorrosion experiments it was used a solution that simulates at room temperature the corrosion environment from the

primary circuit of PWRs in order to consider the real impact of the coatings obtained. Figure 2 shows a summary of special characterization of nanocomposite coatings in tribocorrosion system.

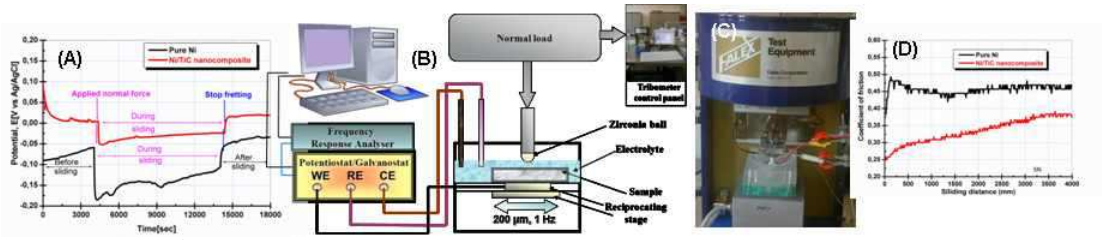

Fig. 2. Characterization of nanocomposite coatings in tribocorrosion conditions: (A) – In –situ Electrochemical measurements showing the open circuit potential before, during fretting and after stopping the sliding with the better behaviour of nanocomposite coatings; (B) – Schematic set-up of tribocorrosion tests for simultaneously measures of electrochemical and mechanical parameters; (c) Tribometer to impose normal forces and measure the friction coefficients with electrolytic cell containing the tested sample (coating) and (D) – Specific friction coefficients diagrams.

Dissemination of the results.

In summary the results were disseminated by ISI and BDI publications, thesis, and presentation to international symposiums and conferences as follow:

Authors / Paper title / Journal
A. I. Pavlov, L. Benea, J.-P. Celis, L. Vazquez, *Influence of nano-TiO2 co-deposition on the morphology, microtopography and crystallinity of Ni/nano-TiO2 electrosynthesized nanocomposite coatings.* **Digest Journal of Nanomaterials and Biostructures**, Vol. 8, No. 3, July – Sept. **2013**, p. 1043 – 1050. **ISI / I.F.=1.092.**
L. Benea, A. I. Pavlov, *Ni-TiO2 nanocomposite coatings as cathode material for hydrogen evolution reaction*. **Optoelectronics and Advanced Materials – Rapid Comunications**, Vol. 7, No. 11 - 12, P 895-899, Noiembrie - Decembrie 2013, p. 895-899.**ISI / I.F.=0.402**
Lidia Benea, Eliza Danaila, Jean-Pierre Celis, *Influence of electro-co-deposition parameters on nano-TiO2 inclusion into nickel matrix and properties characterization of nanocomposite coatings obtained*. **Materials Science & Engineering A.** Vol 610, 29 July **2014**, p 106-115. **ISI / I.F.=2.108.** http://dx.doi.org/10.1016/j.msea.2014.05.028
Lidia BENEA, Sorin – Bogdan BAŞA, Eliza Dănăilă, Nadège CARON, Olivier RAQUET, Pierre PONTHIAUX, Jean-Pierre CELIS. *Fretting and wear behaviors of Ni/nano-WC composite coatings in dry and wet conditions*. In publication. Manuscript Number JMAD-D-14-02367 in **Materials and Design**. ISI / **I.F=2.913.**
Eliza Mardare, Lidia Benea, Iulian Bounegru, Electrochemical Modifications of Titanium And Titanium Alloys Surface For Biomedical Applications – A Review. The Annals of "Dunarea De Jos" University Of Galati, Fascicle IX. Metallurgy and Materials Science, N0. 1 – 2013, p. 68 – 78, ISSN 1453 – 083X. BDI.

12 paper presented oral / poster at international / national conferences.

1 PhD Thesis (Dr. ing. Adina Ionica PAVLOV), **1 Master Thesis** (Student – Roman Ortanţa), **2 Bachelor Thesis (**Students Başa Bogdan – Sorin, and Chiriac Andrei Mihai) coordinated by prof univ dr Lidia Benea.

Cooperation perspectives.

Taking into account the promising results both partners decided to propose another project in the next call in order to continue the collaboration. By continue collaboration it will be create the poll of excellence in the field of nanostructured functional surfaces obtained by electro-codeposition of nanosized ceramic dispersed phases with metals, corrosion – tribocorrosion by UDJG-CC - ITES (RO) and CEA Saclay – Ecole Centrale Paris (F). The international visibility of research teams from both countries will increase through publications and international conferences. The training of Human resources will improve the research qualities of young researchers and PhD students.

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