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UNIVERSITAS GALATIENSIS

Project number: C2-02 / 01 march 2012 (2012-2015)

Project title:

Functional surfaces obtained by electroplating of nano – sized dispersed ceramic phases with metals (Co, Ni, Zn, Cu) for use in the nuclear industry to increase the corrosion and tribocorrosion resistance

Project acronym: NanoSurfCorr

Joint Research and Development Projects between:

1. Competences Centre Interfaces – Tribocorrosion – Electrochemical Systems (CC-ITES), Dunărea de Jos University of Galati, 47 Domneasca Street, 800008, Romania
   Project Director: Prof. Univ. Dr. Lidia BENEA

2. DPC/SEARS/Laboratoire Ingénierie des Surfaces et Lasers (Lasers and Surfaces Engineering), CEA Saclay - Bâtiment 467, F91191 Gif sur Yvette Cedex, France
   Project Director: Dr. Nadège CARON

Project general objective are elaboration, making and experimentation of new nano-functional materials used as functional surfaces highly resistant to corrosion and wear which make them fit for use in nuclear industry, human body implants, industrial tribo-corrosion systems through synergy and convergence of competences in various scientific fields: chemistry, physics, materials science, engineering, biology, medicine.

The present project shall bring an important contribution to the development of knowledge in the field of advanced materials and processes by:

► making functional nano-structured surfaces by electrolytical deposition of nano-dispersed particles (mechanism and kinetic of co-deposition process of nanodispersed phases with metals);

► investigation of the mechanism of functional surfaces repassivation kinetic by in situ electrochemical investigations (free potential during intermittent friction potential-dynamic curves with and without friction, impedance diagrams of surfaces in passive and active state, potential jumps from active to passive recording the current by monitoring the development and growth of the passive film);

► the corrosion and tribocorrosion tests on functional surfaces as nano-structured composite coatings;

► elaboration of the repassivation mathematical model depending on time and layer thickness based on in situ and ex situ electrochemical measurements, the surface structure and composition.

Objectives of each partners

- In- situ and ex- situ testing techniques for the kinetic mechanism of obtaining the functional surfaces (by different procedures) compatible with the scope of applications (**CC – ITES**);
- Correlation of their characteristics with the nano/micro structure, chemical composition, surface defects, type of disperse phase (**CC - ITES**).
- Processes taking place at the interface of functional surfaces (nano and microcomposite layers, hard layers, protection layers) / working environments (**all partners**);
- Mechanism and kinetics of dispersed phase's (*ceramics and polymers*) electro – co - deposition with metallic matrices (*Co, Ni, Cu, Zn*) (**CC – ITES**);
- Optimisation of co-deposition parameters for each type of nanocomposite coatings (*Ni-TiC, Ni – WC,* $Ni\text{-}TiO_2$*,* $Co\text{-} CeO_2$*, Cu-ZnO etc.*) (**CC - TES**);
- Obtaining of nanocomposite coatings on support materials at optimum parameters for performing the specific tests in working environments (**CC - ITES**);
- Characterisation of coating thicknesses, surface morphologies and composition by SEM-EDX, XRD, XPS etc. (**CEA + ECP**);
- Characterisation of adhesion, roughness and microhardness (all partners);
- Characterisation of corrosion properties of nanocomposite coatings in different specific environments (**CC - ITES + ECP**);
- Characterisation of wear – corrosion properties (tribocorrosion) of nanocomposite coatings in specific environments (fretting bidirectional mode) (**ECP**);
- Characterisation of complex passive film on nanocomposite coating materials (**ECP + CC-ITES**)

RESULTS

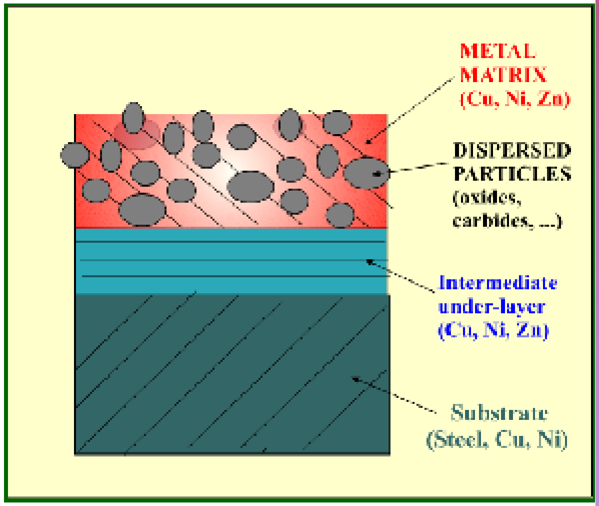
Ni/TiC (or WC) Nano Composite Coatings on Steel Support

Ni electrolyte +

TiC Nanoparticles (50 nm mean diameter)

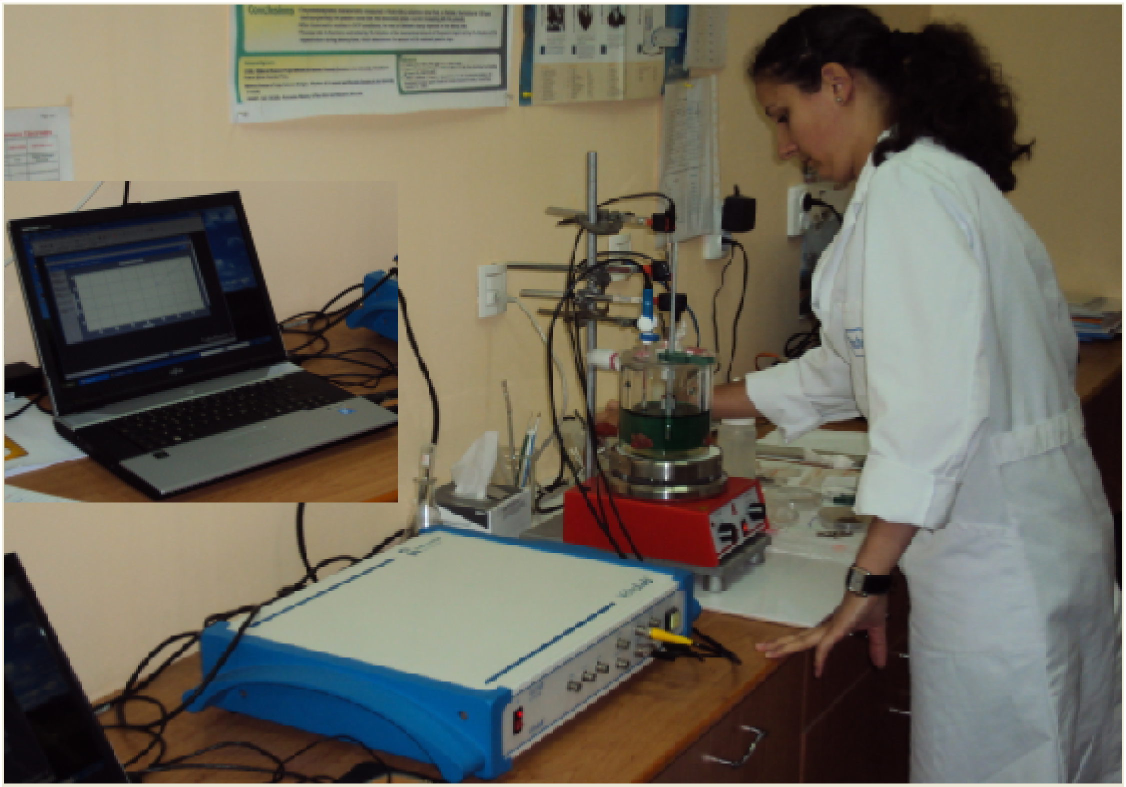
WC nanoparticles (60 nm mean diameter)

Electro – – Co – Deposition Process



$$Ni^{2+}(TiC) + 2e^{-} \rightarrow Ni/nano - TiC$$

$$Ni^{2+}(WC) + 2e^{-} \rightarrow Ni/nano - WC$$



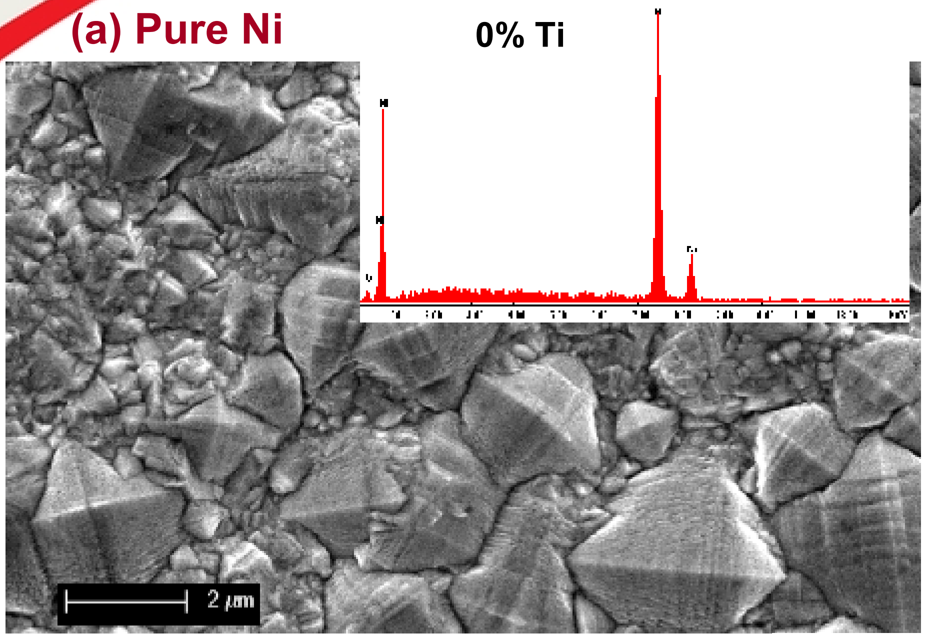
Experimental set-up to obtain nickel matrix nanocomposite coatings having nano TiC or nano WC dispersed phases included

Ni/nano-TiC
Ni/nano-WC

SEM – EDX surface analysis under j = 40 mA/cm^2 and t = 30 min of : (a) Pure Ni coatings; (b) Ni - 10 g/L TiC nanocomposite coatings; (c) Ni - 20 g/L TiC nanocomposite coatings

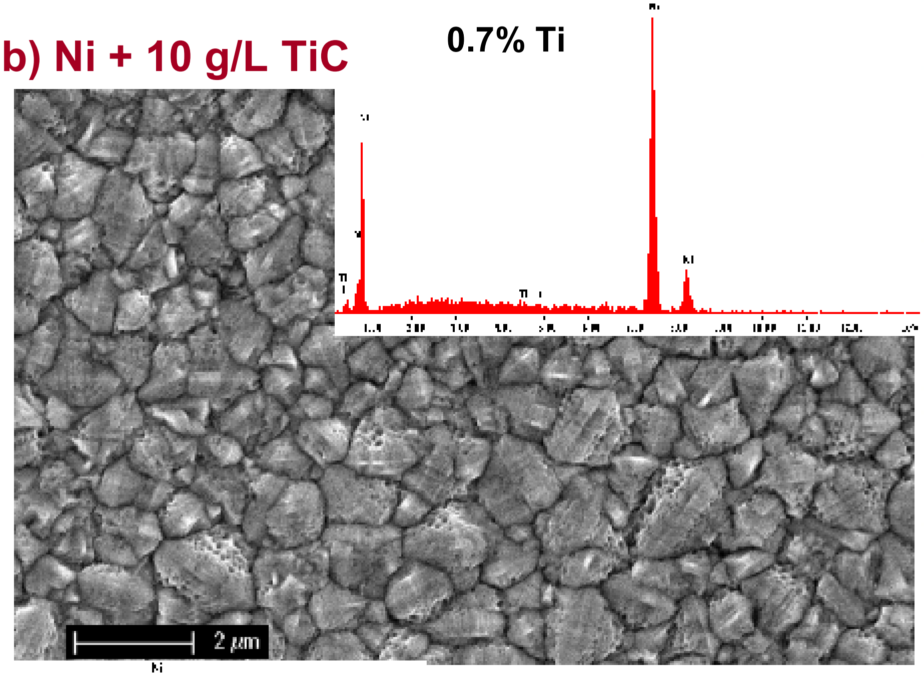
(a) Pure Ni

0% Ti



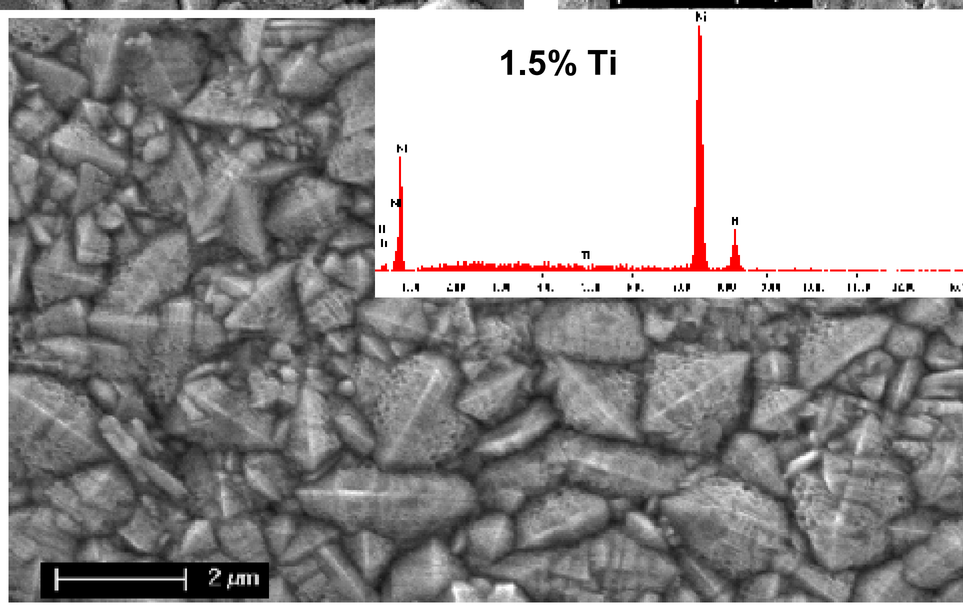
(b) Ni + 10 g/L TiC

0.7% Ti



(c) Ni + 20 g/L TiC

1.5% Ti



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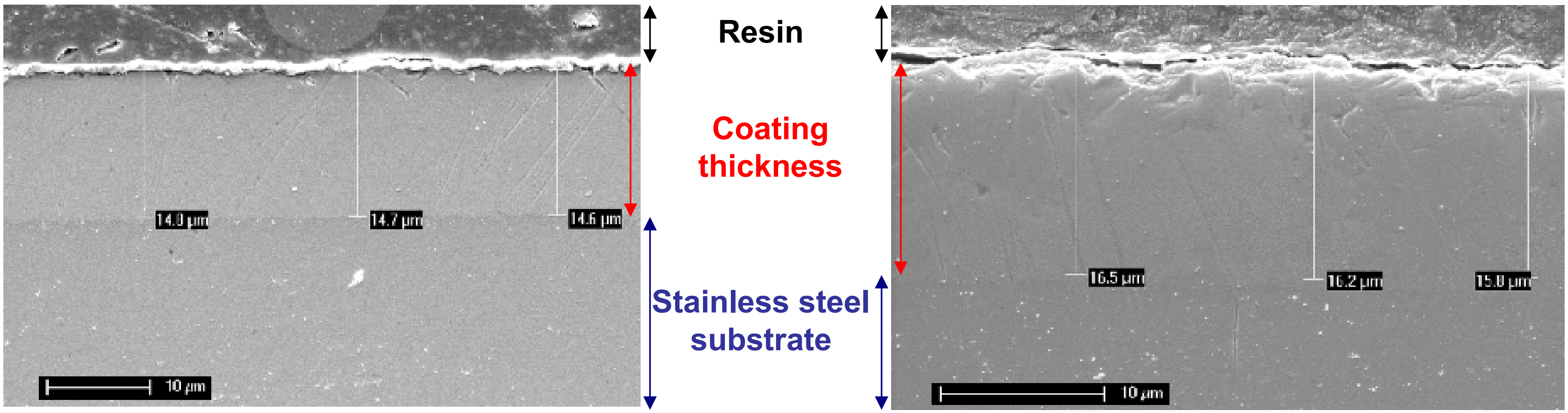
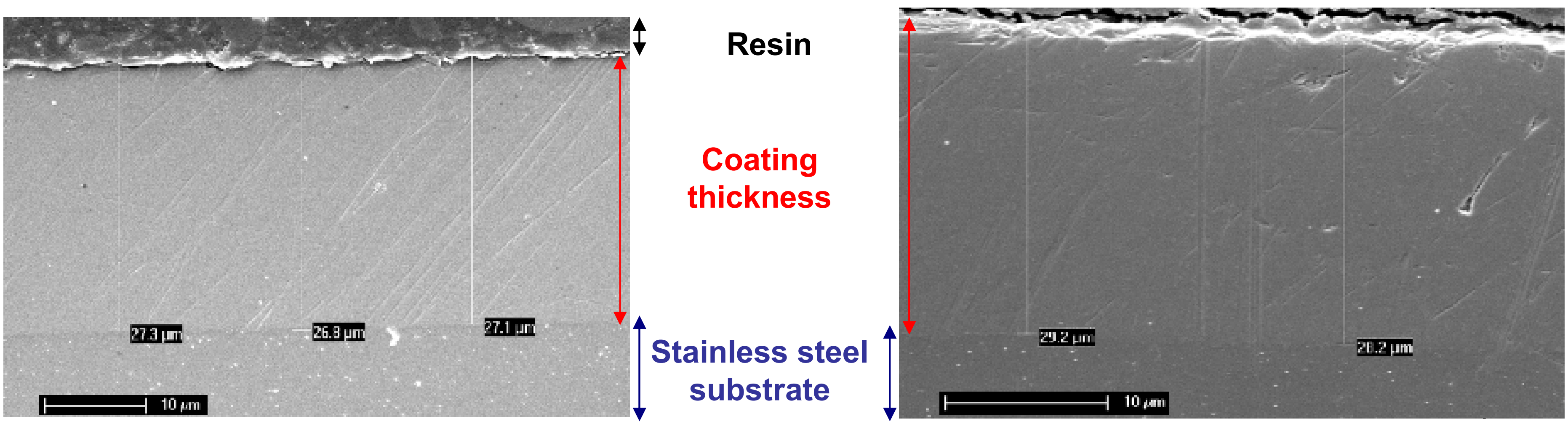
Cross sectional scanning electron micrographs of Pure Ni coatings and Ni - 10 g/L TiC nanocomposite coatings under j = 60 mA/cm^2, (a) t = 15 min and (b) t = 30 min

Pure Ni | **Ni + 10 g/L TiC**

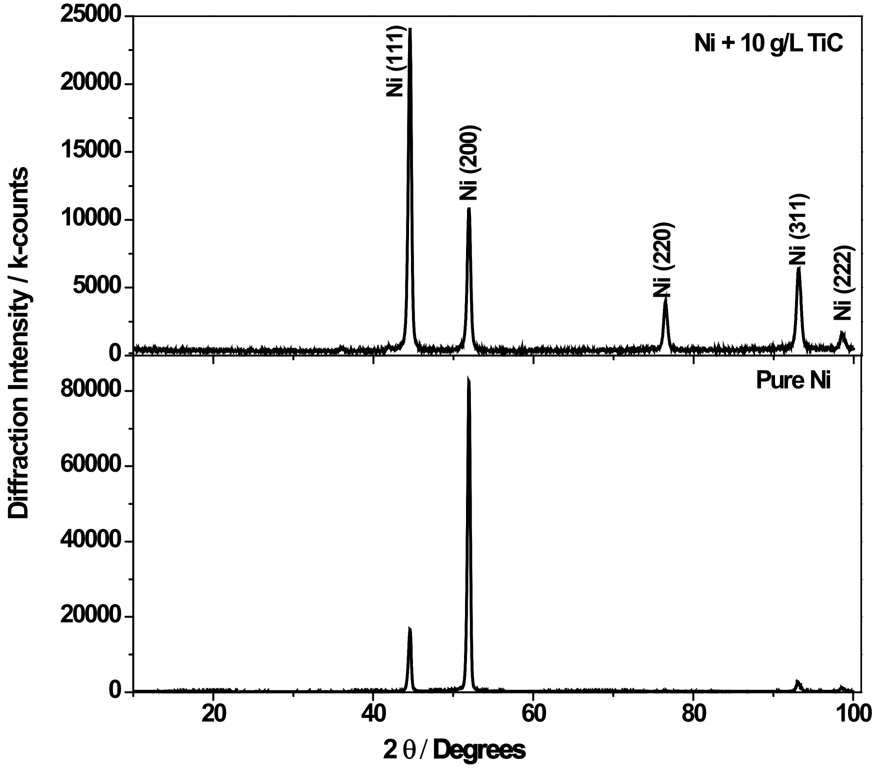


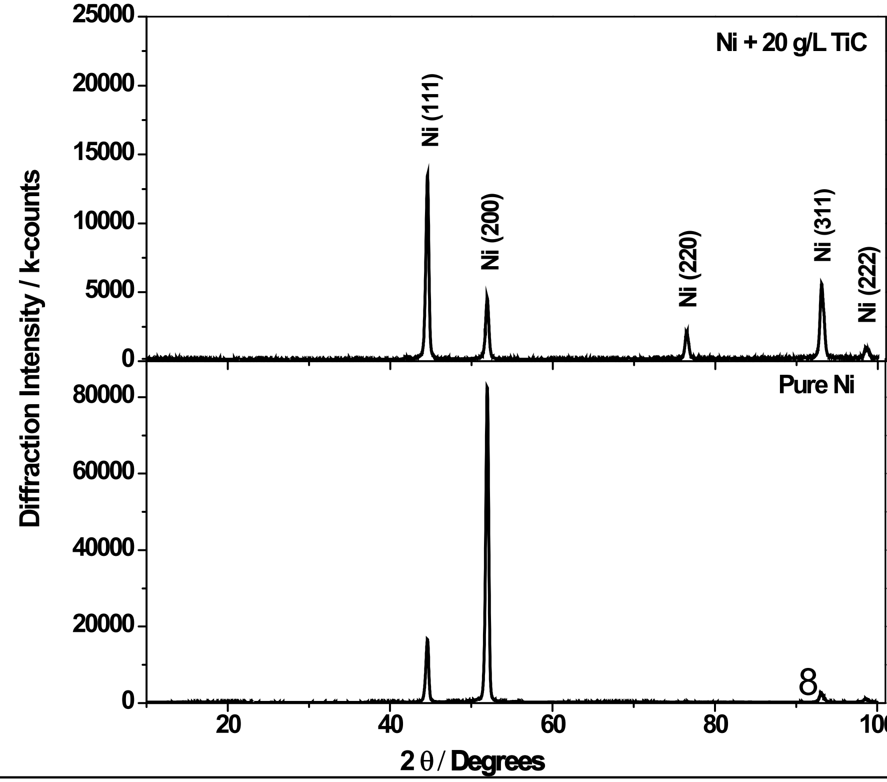
(a) t = 15 min



(b) t = 30 min

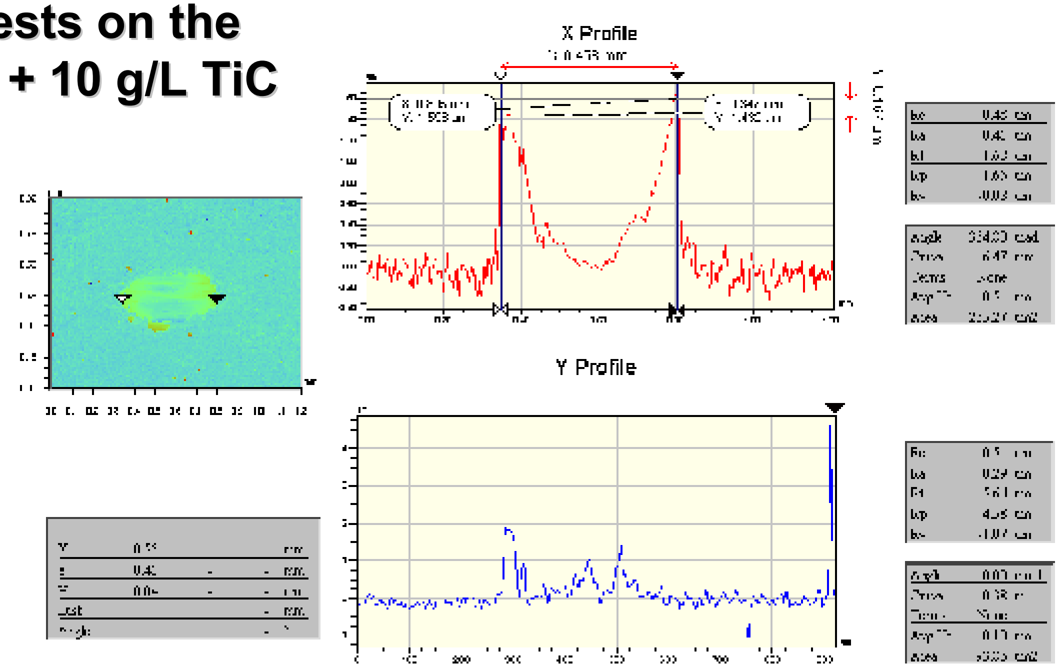
X-ray diffraction patterns of Ni coatings with various TiC concentrations in the electrolyte prepared under j = 60 mA/cm^2 and t = 30 min



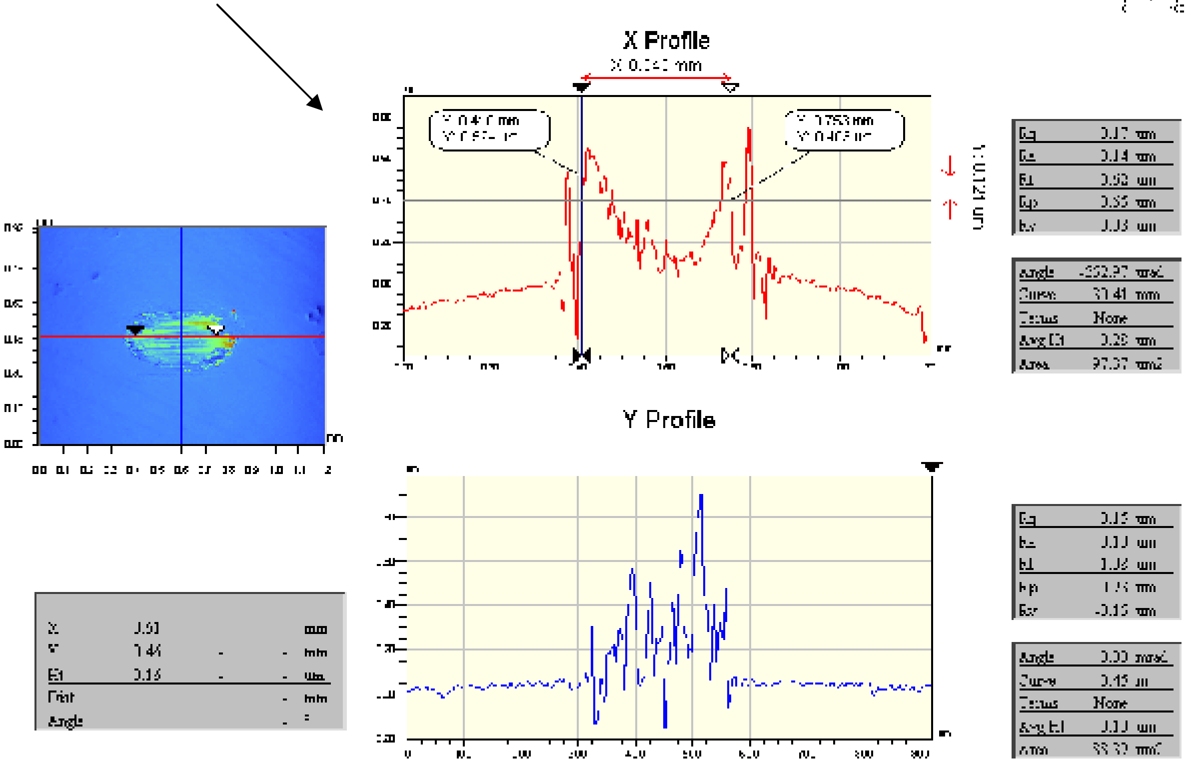


Fretting tests on the samples Ni + 10 g/L TiC

Profilometry measurements on wear track before polishing the sample surface



Profilometry measurements on wear track after polishing the sample surface



The results are still in work for synthesize and interpretation the data obtained

Some samples are at CEA for characterization

Partners advantages

► The collaboration with the French institutions shall make it possible to put together different complementary knowledge about the complex phenomena of nano structured composite functional layers and corrosion – tribocorrosion characterisation;

► Obtention and complex characterisation of nanocomposite coatings by electrochemical processes, with potential innovation impact in the field of nanomaterials and nuclear industry applications;

► The techniques available in the three laboratories CC - ITES (Romania), LISL – CEA (France) and LGPM (France) and together with the competence of the research groups/teams are complementary and cover the broad field of testing procedures and data necessary for the advanced tribocorrosion studies on nano and structured composite functional layers (mechanics, tribology, metallurgy, electrochemistry, surface analysis, ultramicrotopography, etc.)

► Such collaboration shall lead to obtaining new composites nanostructurated materials, a field which both European and international research and innovation efforts converge to.

Cooperation perspectives

► Creating the polls of excellence in the field of nanostructured functional surfaces obtained by co-deposition of nanosized ceramic dispersed phases with metals, corrosion – tribocorrosion by UDJG-CC - ITES (RO) and CEA Saclay – Ecole Centrale Paris (F);

► International visibility of research teams from both countries, through publications, international conferences, etc.

►Training of Human resources to improve the research qualities by young researchers and PhD students mobility.

► Joint publications.