CHALMERS

Characterization of Electrodeposited Fe-based Metallic Coatings: Toward a Sustainable Approach

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Licentiate seminar will be held in VDL, Hörsalsvägen 7A,
Chalmers University of Technology in Göteborg,
on Thursday, March 22nd, 2018 at 13:15

Discussion leader will be Associate Professor Caterina Zanella,
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Abstract

Electrodeposition has rapidly grown in the last 50 years and it has been applied to deposit metals and alloys with complex shapes or to produce fully dense nanostructures and amorphous coatings. Thanks to the achieved improved properties of the electrodeposited materials, electrodeposition has been applied in a wide set of applications including protective coatings, and magnetic and electronic applications. The integration of sustainability with technological progress has become one of the major challenges in our modern society. To fulfil this important goal within the area of electrodeposited materials, it is of major importance to develop innovative metallic coatings deposited with a sustainable approach. This means the use of environmental-friendly electrolytic baths for the deposition of properly designed alloys without or with minimum amounts of scarce or toxic elements.

This work deals with the characterization of Fe-based metallic coatings electrodeposited with a sustainable approach. Characterization studies have been performed on Fe-W coatings and Sn coatings. The study on the Sn coatings has been performed as a preliminary investigation to be then followed up by the deposition and characterization of binary and ternary Fe-Sn coatings. Different techniques such as Scanning Electron Microscopy (SEM), Electron Back Scatter Diffraction (EBSD), Transmission Electron Microscopy (TEM), X-ray Diffraction (XRD), Glow Discharge Optical Emission Spectroscopy (GD-OES), and Nanoindentation were used to characterize the structure and the properties of the coatings.

It was found that the as-deposited structure of the Fe-W coatings changes with increase of the W content: a nanocrystalline, a mixed nanocrystalline-amorphous, and a fully amorphous structure was found when raising the W content from 4 up to 24 at.%. The thermal stability of Fe-W alloys increases with the W content, i.e. the Fe-W sample with 24 at.% W retains the amorphous structure up to 600 °C. Co-deposited C and O impurities in the coatings lead upon annealing to the formation of phase not expected from the Fe-W diagram: Fe_6W_6C, Fe_3W_3C, and $FeWO_4$ phases. Longer annealing treatments resulted in the gradual dissolution of the carbide phases and the crystallization of the Fe_2W phase. The annealing treatments improved considerably the hardness of the as-deposited Fe-W samples. The maximum hardness of 16.5 GPa was measured for the sample with 24 at.% of W after annealing for one hour at 600 °C. Sn coatings were deposited from two different electrolytes, i.e. a chloride-based and a methane sulfonic acid (MSA) electrolyte. It was found that the additive used acts as a highly effective inhibitor in the chloride-based electrolyte. Its addition lead to a decrease in the limiting current density, suppression of H_2 evolution, and to changes in the grain structure of the deposited Sn samples. The same effects are not observed in the MSA electrolyte.

Keywords: Electrodeposition, coatings, iron alloys, electrodeposited tin, structural characterization