

Final Report

Project acronym: NiWRe-Alloys

Project number: 8195

M-ERA.NET Call 2020

Period covered: 01/07/2021 to 30/06/2024

Publishable project summary

The aim of the project “Electroplating NiW and NiRe alloys as functional alternative coatings (NiWRe-Alloys)” was to develop two new nickel alloy electrolytes for the electrochemical deposition of nickel-tungsten (NiW) and nickel-rhenium (NiRe) as functional layers. There were two main application fields: (1) coatings in mechanical manufacturing will be able to substitute hazardous and high toxic chromium (VI) electrolytes, and (2) the filling of polymer microstructures will enable the substitution of expensive gold as X-ray absorbing material. For each application field at least one demonstrator (TRL6) was developed at the end of the project.

At the beginning of the project, the project team defined the specifications of hard chrome layers (e.g. corrosion, wear, hardness) and for the gratings (e.g. low nickel incorporation rate, high current yield). A variety of coatings were carried out in beakers in laboratory tests. The influence of the concentration of the bath ingredients, temperature, pH value and current density on the nickel alloy layers produced was examined. The deposited nickel alloy layers were characterized (corrosion, wear, X-ray absorption). The first results and the cost-effectiveness showed that NiW layers with a low tungsten content are suitable as a hard chrome replacement and NiRe layers with a high rhenium content are suitable as a gold replacement for X-ray gratings.

After the basic formulations for the NiW and NiRe electrolytes were determined, the electrochemical coating process was further optimized and the layers produced were characterized in detail. Coatings were also carried out in larger volumes and the influence of adding additives was examined. At the end of the project, a piston rod was coated and tested as a demonstrator for a hard chrome replacement layer with NiW and a grating with NiRe as a gold replacement. At the end of the project, the formulation for a stable and usable NiW electrolyte will be defined. The deposited NiW layers are dense, crack free and can be hardened by tempering. Hardening at 500°C in air results in hardness values ranging from 1000 to 1200 HV0.01 which is comparable to that from hard chrome layers. The corrosion resistance is comparable to Ni-Layers and lower than hard chrome layers of similar thickness, the corrosion resistance of NiW layers which are deposited on intermediate layers of Cu (similar to the system Ni on Cu) is increased. The W content achieved in the films was between 17 at% and 24 at%. The upscaling (30 liter bath) and the development of the bath control is in the final step (project elongation for partner 2, IKS) A formulation for a stable and usable NiRe electrolyte was also defined. The coated grating structures (14.5 µm period, 100 µm thickness) were deposited with NiRe layers with 54 atomic percent of rhenium and a current efficiency of 98%. These gratings showed good uniformity over a large area in terms of fringe visibility and good structural uniformity. Although the reference Au gratings still show two to three times better fringe visibility compared to the NiRe demonstrator grating, there was an improvement in grating absorption and in uniformity as the thickness of NiRe gratings increases. The fringe visibility of NiRe gratings is good at low energy and improvement still need to be made for high energy.

² PC: project coordinator, WPL: work package leader, P: participant
research organisation (RES), university (UNI), SME, large enterprise (LE), NGO, etc.

³ young researcher: young researcher means researchers in the first 10 years (full-time equivalent) of their research activity, including the period of research training, since gaining a university (or equivalent institution of higher education) degree giving access to doctoral studies in the country in which the degree was obtained (the degree must entitle the holder to embark on doctoral studies, without having to acquire any further qualifications) and who have not yet obtained a doctoral degree.