

# ELECTROCHEMICAL PROCESSES

## Electrodeposition of nanocrystalline Ni–Re alloy coatings

O. L. Bersirova, V. S. Kublanovsky

Institute of General & Inorganic Chemistry NAS Ukraine, Kiev, Ukraine

*e-mail: bersibol@ukr.net*

Rhenium is a refractory metal with a unique complex of properties that makes rhenium and its alloys perspective for a variety of applications – electrical, catalytic, energy, biomedical, etc. [1]. The main processes for Re and its alloys fabrication are powder metallurgy, chemical vapor deposition, electrodeless deposition. Electroplating at room temperature using non-toxic baths can become a successful alternative and also provide the deposition of uniform Re coatings.

Rhenium belongs to a group of metals that are difficult to produce by electrolysis of aqueous solutions, mainly because of its very low overpotential for hydrogen evolution. The electrodeposition of pure Re is associated with low current efficiency and coating quality. However, by adding a nickel salt to the bath, thick Re-rich (> 90 at. %) coatings were obtained with high current efficiency (> 90 %). Ni–Re coatings are characterized by a high electrocatalytic activity, low overpotential for hydrogen evolution, large extension of the surface and good corrosion resistance. It is advisable to obtain Ni–Re alloys by electrodeposition from sulphamate bath in DC mode. The coating of steady composition can be deposited in sulphamate bath at pH 5.0 with low current density.

The main objective of the current work was to investigate the effect of operating conditions on the chemical composition, surface morphology, structure, and corrosion properties of electrolytic deposits [2–11].

Rhenium codeposition with nickel was studied. Ni–Re alloys were electrodeposited in DC mode from sulphamate baths at current densities ranged from 0.1 to 5.0 A dm<sup>-2</sup> at temperature of 15 °C. Coatings were characterized by means of scanning electron microscopy, X-ray dispersive energy spectroscopy, X-ray diffraction spectroscopy. Fig. 1 shows typical SEM images of selected samples.

Smoothness and brightness of the deposits were strongly related to the conditions of the electroplating process (current density and bath composition, temperature).

Most of Ni–Re deposits obtained were compact, exhibited metallic shine and were adhered to the electrode (substrate) material. The fine hairline cracks appeared on the coatings surface of Ni–Re alloys with Re-content 58 at.%. At current densities of 0.3–1.0 A·dm<sup>-2</sup> the resulting coatings were brittle. The increase in the current density above 3.0 A·dm<sup>-2</sup> led to spongy deposits and almost halved the Re content in the deposit. Nano-grained Re–Ni alloys with

Re-content from 5 to 8 at.% were electrodeposited onto Cu from sulfamate electrolytes at 15 °C.

The grain size of the deposits was estimated from the full width at half maximum of the most intense diffraction line by Scherrer's equation. Re-containing alloys were nanocrystalline, the grain size was 5–35 nm. Test results in Fig. 2 present the effect of current density on the rhenium atomic content and grain size in Ni–Re coatings.

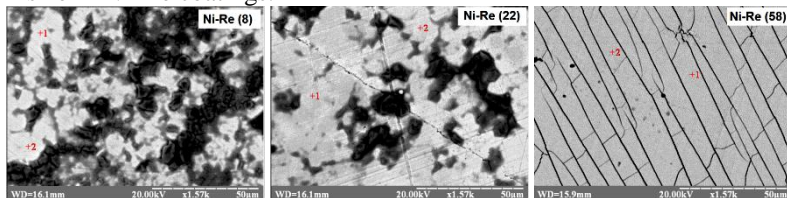


Fig. 1. SEM micrographs of Ni–Re coatings plated on Cu substrate in sulphamate baths at different current densities,  $\text{A dm}^{-2}$ : 5 (a), 3 (b), 0.3 (c),  $T = 15^\circ\text{C}$

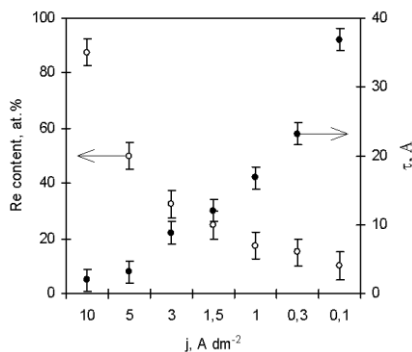


Fig. 2. Effect of the current density on the rhenium content and grain size

## References

1. O. Bersirova, S. Byk, V. Kublanovsky. Ukr. Khim. Zh. (2017) 5 : 50.
2. V. Kublanovsky [et al.]. Physicochem. Mech. of Mater. (2008) 7 : 308.
3. V. Kublanovsky [et al.]. Protect. of Met. & Phys. Chem. of Surf. (2009) 45 : 588.
4. V. Gromova [et al.]. Metallofiz. Nov. Tekh. (2006) 28 : 83.
5. O. Bersirova [et al.]. Physicochem. Mech. of Mater. (2004) 4 : 620.
6. O. Bersirova [et al.]. Chemija (2003) 14 : 16.
7. O. Bersirova, A. Królikowski, V. Kublanovsky. Ochrona przed korozja (2002) 11A : 149.
8. O. Bersirova, V. Kublanovsky, H. Cesiulis. ECS Transactions (2013) 50:155.
9. O. Bersirova, V. Kublanovsky. Russ. J. of Appl. Chem. (2009) 82 : 1944.
10. O. Bersirova, V. Kublanovsky. Materials Science (2012) 48 : 197.
11. H. Cesiulis [et al.]. Proc. of BALTTTRIB 2009 (2009) : 253.