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JSCS–3314 *Extended abstract*

Magnetic effects in electrochemistry*, **

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Abstract: The effect of imposed magnetic fields onto the electrodeposition of magnetic (nickel) and non – magnetic (copper) metals was analysed. Also, magnetic properties of electrochemically obtained nanocontacts were examined. An effort to establish a possible correlation between the morphologies of the nanocontacts and the effect of the very large ballistic magnetoresistance (BMR effect) was made.

Keywords: nickel, copper, magnetic field, nanocontact.

The effect of an imposed magnetic field on the electrodeposition of magnetic and non – magnetic metals

The effect of imposed magnetic fields on the electrodeposition of nickel was examined. Nickel deposits obtained without and with, low strength magnetic fields (up to 500 Oe) applied both perpendicularly and parallelly to the electrode surface, were analysed by the SEM technique. Nickel was electrodeposited from a Watt solution with the addition of coumarin, at cathodic potentials of – 1000, – 1200 and – 1300 mV/SCE. At cathodic potentials of – 1000 mV/SCE and – 1200 mV/SCE, the obtained nickel morphologies were consistent with the predictions of the magnetohydrodynamic (MHD) theory.[1] The nickel deposits obtained under parallelly oriented magnetic fields had more uniform structures than the nickel deposits obtained without and under perpendicularly oriented magnetic fields. The nickel deposits obtained under perpendicularly oriented magnetic fields were very similar to those obtained without any applied magnetic field.

At a cathodic potential of – 1300 mV/SCE, a dramatic difference was observed between the nickel morphologies obtained without and under a perpendicularly oriented magnetic field (the expected MHD effect was zero !). The nickel de-

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posit obtained under a perpendicularly oriented magnetic field had a very developed 3D arboreous-bead-dendritic structure. On the other hand, the nickel deposit obtained without the presence of a magnetic field was very rough, with a clearly visible clustered structure.[1, 2]

The obtained nickel morphologies were then compared with those of copper. Copper was electrodeposited from an acid sulfate solution at a cathodic potential of – 500 mV/SCE.[1] Based on the fact that the copper deposits obtained both with and without a perpendicularly oriented magnetic field had dendritic structures, the observed difference between the nickel deposits with and those without a perpendicularly oriented magnetic field, is essentially ascribed to the magnetic properties of nickel.

Magnetic nanocontacts and the balistic magnetoresistance effect (BMR effect)

Electrodeposition is the most important way of preparing nanocontacts, including those showing ferromagnetic properties.[3] From a practical point of view, one of the most important magnetic properties of electrochemically obtained magnetic nanocontacts is their magnetoresistance. Magnetoresistive effects are studied for applications in new technologies, for example, for magnetic reading heads, the development of which is required by permanent efforts for decreasing the size of electronic devices.[4]

Ballistic magnetoresistance is observed in Ni, Co, NiFe and Fe nanocontacts obtained by electrodeposition.[1,2,4-7] Some of the electrodes which were used for the electrodeposition of nanocontacts and which showed very large magnetoresistive effects are: photolithographically patterned thin film microstructures of $Ni_{81}Fe_{19}$ alloy,[1,2] "T" configuration of wires which can be from magnetic (Ni, NiFe) and non-magnetic (Cu) materials,[5,6] and specially fabricated copper thin films.[4,7] In these nanocontacts, magnetoresistive effects up to 1000 % have been observed.

It was shown that it is not possible to find any correlation between the morphology of the electrochemically obtained nanocontacts and the very large magnetoresistive effect. The morphologies of Co – Co nanocontacts were very rough, consisting of a very large number of small nano-sized cobalt grains. The morphologies of Fe – Fe nanocontacts were a very developed dendritic structure formed from a very large number of small sponges. The needles which formed the sponges had nano-sized dimensions and it was supposed that the needle were responsible for the very large BMR effect of nanocontacts. The morphologies of $Ni_{81}Fe_{19}$ – $Ni_{81}Fe_{19}$ nanocontacts were like "bridges" between adjacent parts. The size of these "bridges" was less than 1 μm.

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И З В О Д

МАГНЕТНИ ЕФЕКТИ У ЕЛЕКТРОХЕМИЈИ

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Анализиран је утицај примењеног магнетног поља на електохемијско таложење магнетних (никла) и немагнетних метала (бакра). Промена морфологије за време електрохемијског таложења никла под утицајем вертикално оријентисаног поља се приписује утицају магнетног поља на магнетне особине никла. Такође, у раду су испитане и магнетне особине електрохемијски добијених магнетних наноконтаката. Учињен је покушај да се успостави веза између морфологије наноконтаката и високог ефекта балистичке магнеторезистенције.

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