COPPER NANONETWORKS USED AS CATHODES FOR ELECTRODEPOSITION OF FERROMAGNETIC METALLIC THIN FILMS

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Previous works mentioned the fabrication of ferromagnetic nanonetworks of Fe, Co and CoFe by direct sputter deposition on a porous alumina membrane (PAM) [1-3]. In this work a nanonetwork of 50 nm of copper was evaporated on the opposite face of a commercial porous alumina membrane (Anodisc™, 0.1 μm) and its use as cathode for electrodeposition of a thin porous metallic film of Ni_xFe_{1-x} is demonstrated. SEM images show the evolution of the various phases involved in the process: Figure 1. exhibits the image of the back face (opposite to filtering face) of the commercial membrane used as the fundamental substrate for all the process - an Anodisc™ with 0,1um nominal diameter pores, without any deposition on it and magnified 20,000 x, Figure 2 shows two images at 50,000x of the PAM, now with a 50nm of Cu evaporated on it, forming the nanonetwork that was used as cathode for the thin ferromagnetic film electrodeposition. The copper nanonetwork is shown after and before a quick immersion of 5s in a in a 1:100 diluted piranha solution (H_2SO_4:H_2O_2, 4:1) immediately before electrodeposition, for oxide removing and final cleanning. One can observe a small enlargement os pores due to the light etch of oxide layer and copper. On Figure 3 one can see a 20,000x SEM image of the nanostructured cathode (copper nanonetwork) after the electrodeposition of Ni_xFe_{1-x}. The result is a porous Ni_xFe_{1-x} thin film. The solution used for electrodeposition was based on that used in [4], composed by $NiSO_4$ (0.7 M) $FeSO_4$ (0.03 M), $NiCl_2$ (0.02 M) and boric acid (0.4 M), but without saccharine as leveller, and with addition of L-ascorbic acid, 1g/L, as antioxidant. The electrodeposition essay was performed during 10s, using a potentiostat Autolab™ type II, in which a copper nanonetwork piece were made as cathode, and a platinum wire coil as anode, in an electrolytic cell containing the above described solution, without agitation, at room temperature (25°C). The electric deposition method used was the galvanostatic, with the current density set on 14,5 mA/cm^2 . For calculation of the respective current, was considered the raw area of the copper nanonetwork cathode exposed to the bath, without any correction associated to porosity. Finally, Figure 4 exhibits the EDS chemical analysis of the obtained deposit, showing an approximated composition of $Ni_{74}Fe_{26}$ for the electrodeposited alloy. This result reveals a Fe atomic composition 7% richer than usual Permalloy ($Ni_{81}Fe_{19}$), which is a very soft ferromagnetic alloy (coercive field, H_C ~ 3 Oe). In [5], the patterning of pores (or antidots) on a significant area of a Permalloy thin film was performed using X ray lithography, and there was measured a change on H_C from 3 to 100 Oe, caused by such kind of structuring. The study of the magnetic characteristics of the films obtained with the new method developed in this work will be continued in our future works.

References

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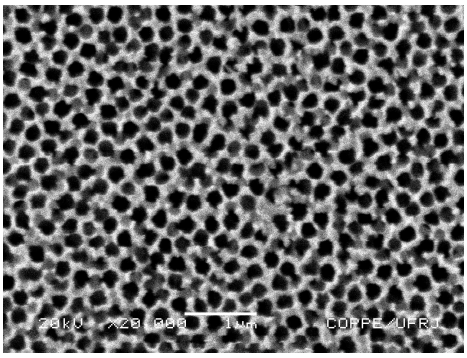

Figure 1: SEM image of back face (opposite to filtering face) of an Anodisc™ (0,1um - nominal) commercial PAM (porous alumina membrane).

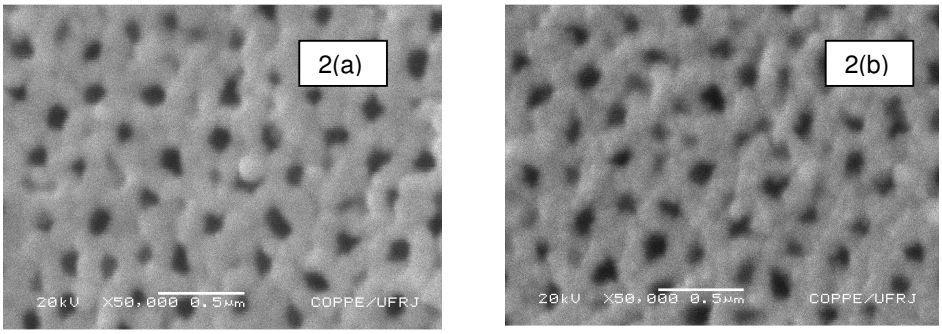

Figure 2: SEM images of the copper nanonetwork, 500 Á thick, evaporated on the verse of the Anodisc™ 0,1um PAM. (a) magnification of 50,000x (b) same nanonetwork and magnification after quick immersion (5s) in a diluted piranha solution for oxide removing. One can observe a small enlargement os pores due to the light etch of oxide layer

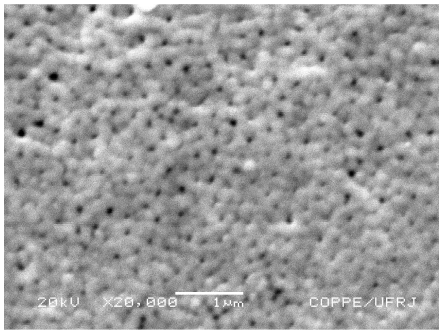

Figure 3: SEM image after the electrodeposition of Ni_xFe_{1-x} ($14,5mA/cm^2$,10s) onto the clean copper nanonetwork , magnification 20,000x.

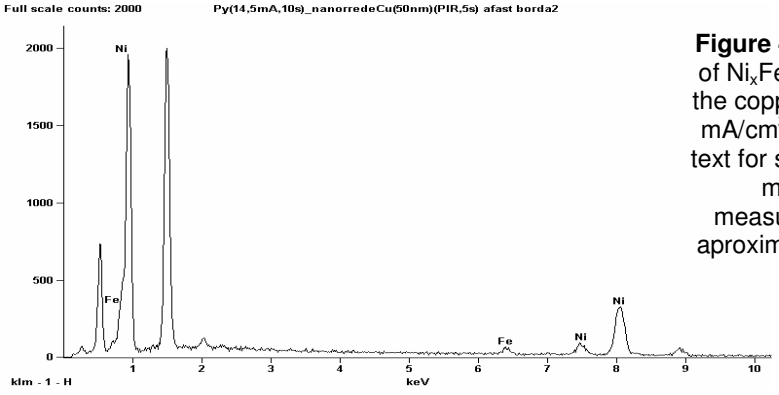

Figure 4: EDS chemical analysis of Ni_xFe_{1-x} electrodeposited onto the copper nanonetwork at j=14,5 mA/cm^2 (raw area), Δt=10s (see text for solution composition). The medium of 4 different measurements, resulted in an aproximated alloy composition of Ni_{74} Fe_{26}.