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Enhancement of anomalous codeposition in the synthesis of Fe-Ni alloys in nanopores

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Permalloy ($Ni_{80}Fe_{20}$) is one the most widely used magnetic materials due to its very soft magnetic properties and near zero anisotropy and magnetostriction which make it specially suitable for many different magnetic applications. However, the electrodeposition of alloys formed by metals from the iron-group is quite complicated due to the effect called anomalous codeposition, where the less noble metal deposits preferentially to the noblest one, making difficult to control the composition of the alloy.

Taking into account that the properties of Permalloy are extremely dependent on the particular composition $Ni_{80}Fe_{20}$, we have studied the effect of anomalous codeposition when plating in polycarbonate templates in order to control the composition of Permalloy electrodeposited nanowires. We have found that the composition of NiFe electrodeposited nanowires depends not only on the electrochemical parameters but also on the geometry of the working electrode. In particular, the iron concentration is much higher in nanowires than in thin films for growth potentials around -1.0 V (vs. Ag/AgCl).

There is also a gradient of composition along the length of the nanowores, specially in the range in which the reduction of Fe^{2+} is diffusion controlled ions whereas there is kinetic control for Ni^{2+} ions. Homogeneous nanowires can be obtained either for low overpotentials (Fe rich nanowires) and for large negative potentials, where the wires tend to have the ion concentration of the electrolyte.

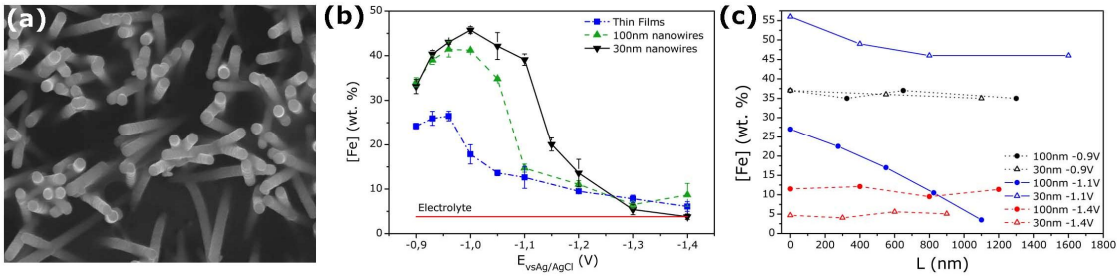

Figure 1: (a) SEM image of electrodeposited nanowires, (b) Fe concentration in the different samples as a function of the plating potential, (c) Fe concentration along the length of nanowires electrodeposited at three different potentials.