CHARACTERIZATION OF Ni-Fe NANOWIRES: EFFECT OF TEMPLATE MATERIAL AND DEPOSITION CONDITIONS

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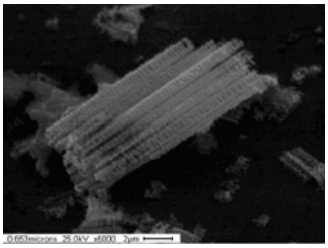
Introduction

The objective of this research was to experimentally observe and understand the effect of structure and morphology of Ni-Fe nanowires on their magnetic characteristics. Arrays of ordered nanowires are attractive in the field of electronics, storage and biology: ranging from bio-sensing to cell manipulation to cancer therapy. Towards this objective, Ni-Fe nanowires were electroplated in different templates (porous silicon, alumina, and polycarbonate) with changing deposition conditions (current density, magnetic field during electroplating). Then, the structural and magnetic characteristics were studied to obtain the required structure/property relationship for potential bio-sensing applications.

Experimental

First, the nanoporous templates were prepared either by anodization (porous silicon) or acquired from commercial vendors (alumina, polycarbonate). Ths diameter of the pores was 40-300nm and length up to 100µm. Next, electrodeposition of Ni-Fe was performed under three magnetic field conditions a) no MF, b MF parallel to template, c) MF perpendicular to template, from a sulfate based electroplating bath at a current density of 3.5 mA/cm^2..

Results and Discussion



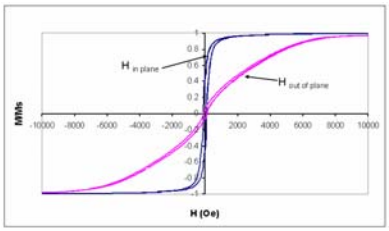


Fig. 1: SEM image of a released Ni-Fe nanowires, Fig 2: Mmagnetic Characteristics of Ni-Fe nanowires deposited in polycarbonate. H- in plane - MF perpendicular to template, H - out of plane - MF parallel to template

We find that, in general, application of magnetic field perpendicular to the template plane during the electrodeposition forces the Ni-Fe grains to grow with c-axis along the orientation of applied magnetic field, enabling strong texturing. These result in strong perpendicular anisotropy in all templates. This is also evident in the XRD peaks with show enhanced peaks for Ni-Fe and Ni. The polycarbonate template exhibits the highest perpendicular anisotropy. This is because of higher pore density in alumina template (10^9 cm^{-2}) resulting in small inter-pore distance (50-100 nm). The interwire interaction plays an important role in decreasing the squareness factor. The coercivity is the range of 100-200 Oe. In case of polycarbonate, because of rough internal surface and deviation between the pore axis and surface normal of the template, it shows not very large squareness. For porous silicon, in addition to nanowires, there is also evidence of wire breakage, discontinuous wire growth, branching, resulting in competition between magnetocrytalline and shape anisotropy. In addition, we also measured the magnetic characteristics for small diameter wires (< 50 nm) in all templates. We find an interesting process of decrease in magnetization, beyond saturation magnetization in both directions..

Conclusions

The magnetic characterization results show that perpendicular anisotropy is highest in polycarbonate template with MF perpendicular during electroplating. We are currently exploring the magnetization process in < 50 nm diameter nanowires.

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References

[1] Aravamudhan, S., *et al*., Presented at Nanostructure Fabrication, Gordon Research Conferences, Jul 16-21 (2006).