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Patterned Media Based on Soft/Hard Composite Nanowire Array of Ni/CoPt

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Introduction

One of the critical issues in utilizing the L1o phase magnets for patterned media is the difficulty of magnetic switching of the high coercivity material with industrially viable magnetic fields available in the write heads. For fabrication of patterned media with desirable high density of ~1 terabit/in^2 or higher, one of the possible approaches is to use a template with vertically aligned nanopores such as the anodized aluminum oxide, and fill the nanopores with high coercivity material.[1] For easier switching, a composite nanowire geometry consisting of soft magnetic nanowire lower part and hard magnetic L1o nanowire upper part, as illustrated in Fig. 1, has been prepared by electrodeposition into anodized aluminum oxide (AAO) nanopores with ~20-30 nm diameter, ~100 nm tall. The nanopores were filled with ~80 nm long soft magnet (Ni) followed by ~20 nm tall hard magnet (CoPt). The microstructure and magnetic properties were investigated.

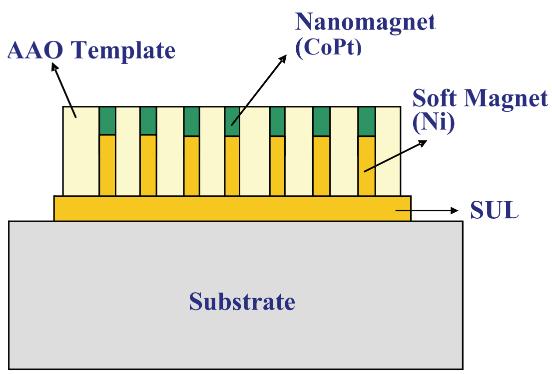

Fig. 1. Schematics of the composite nanowires inside the AAO template.

Experimental

The AAO templates with nanopore array were prepared by sputter deposition of ~500 nm of Al on top of Au-metallized Si substrates. Anodization was carried out in 0.3 M oxalic acid at a constant DC potential of 20V using a platinum cathode. The first segment of the two-step nanowire structure was deposited using DC electrodeposition and a nickel based electrolyte solution containing 0.065 M boric acid and 0.045 M nickel sulfate hexahydrate. The CoPt nanowires were deposited via DC electrodeposition bath composition consisting of 0.01 M cobalt sulfate, 0.01 M diamminedinitritoplatinum, 0.085 M sodium acetate, 0.052 M triethanolamine and 0.094 M sodium carbonate with a pH adjusted to 6.3 with sulfuric acid.[1] The as-deposited nanowires within the AAO pores were then annealed at 700ºC for 1 hour for conversion to $L1_0$ phase. The microstructure was characterized using scanning electron microscopy (SEM) and energy dispersive X-ray analysis (EDX). Magnetic properties were measured with an alternating gradient magnetometer (AGM) with 14 KOe maximum applied field.

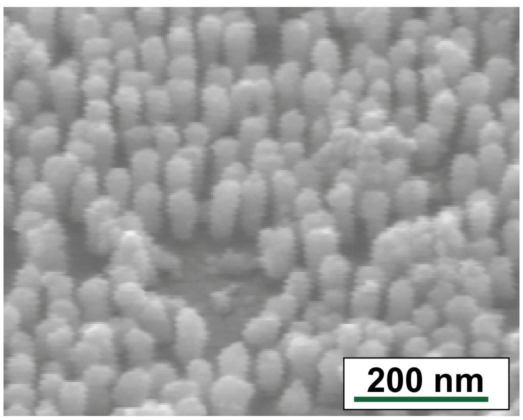

Fig. 2. SEM micrograph for Ni/CoPt composite nanowire array.

Results and Discussion

Shown in Fig. 2 is an SEM image of the Ni/CoPt composite nanowire array after removing the AAO matrix by etching. The composite nanowires consist of ~80 nm long Ni wires (as confirmed by SEM of samples with electrodeposited with Ni nanowires only) on top of which ~20 nm tall CoPt wires are deposited. The diameter of the nanowires is ~25-30 nm. To see the influence of the two-step composite structure, separate samples with Ni and CoPt nanowires of the same height were prepared and annealed using the identical conditions. M-H hysteresis loops along the perpendicular direction are presented in Fig. 3 which shows the comparative data for the Ni nanowire only (100 nm tall), CoPt nanowire only (100 nm tall), and Ni/CoPt composite nanowires (80 nmNi + 20 nm CoPt) after the $L1_0$ conversion annealing.

The Ni nanowires exhibit relatively soft magnetic coercivity of 242 Oe, while the CoPt nanowires show a very high coercivity of at least 10.97 KOe. The two-step Ni/CoPt nanowires exhibit an intermediate coercivity of ~1.96 KOe. While the two-step nanowire structure, composition, and magnetic properties have not yet been optimized, the data seems to indicate a trend that the presence of the soft magnetic bottom reduces the coercivity of the CoPt nanowires placed on top. This decrease may be caused by exchange interactions or by the longer Ni nanowires serving as magnetic-field-concentrating poles which would increase the effective applied field on the CoPt portion of the composite nanowire in contact. The significant decrease in the coercivity would make it much easier for magnetic data writing. Another possible explanation for the drastic drop in coercivity for the Ni/CoPt composite nanowires is the interdiffusion during annealing between the Ni and CoPt segments resulting in the formation of a ternary $L1_0$ alloy of Co-Pt-Ni. The results for further optimization and analysis of materials and processes, as well as implications for potential patterned media applications, will be discussed.

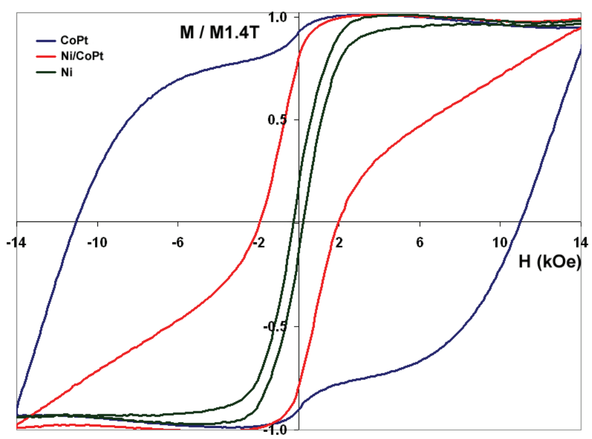

Fig. 3 – Comparative MH loops.

1. A. I. Gapin, X. R. Ye, J. F. Aubuchon, L. H. Chen, Y. J. Tang, and S. Jin, *J. of Appl. Phys.* In press, (2006).