Electrodeposited Mesoporous Silica Thin Films as Self-Assembled Hard Mask with 5 nm Periodicity

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This project was funded by following grant: NSF DMR-0213985.

Introduction

It seems likely that nanoimprint lithography will be the method of choice to commercially fabricate patterned media. However, it is unclear if current methods to fabricate the molds for nanoimprint lithography are capable of achieving the 3-4 diameter features needed for the last generation of magnetic hard drives. Recent work by Walcarius and co-workers has shown potential to produce molds with 3.3 nm diameter perpendicular pores and 5 nm pitch. This group used electrolysis of a typical mesoporous sol-gel mixture containing a cationic surfactant template. Reduction of nitrate ions and water results in formation of hydroxide ion which raises the local pH and accelerates condensation of silica. The negative voltage also causes the cationic surfactant to self-organize on the electrode surface as hemi-micelles, leading to the perpendicular orientation. Figure 1 shows TEM images from their work showing well order arrays of pores. We here report on progress with replicating the Walcarius results and demonstrating that the mesoporous silica generated can be used to electrodeposit metals, to act as a hard mask, or as the patterned media.

Results & Discussion

As observed by Walcarius, condensation does not stop once the voltage pulse ceases. This leads to the formation of balls of silica on top of the surface as seen in Figure 2. These can be minimized by rapid washing of the film and removed by adhesive tape.

Electrochemistry can be used to explore the orientation of the pores. Figure 3 shows cyclic voltammetry from ferrocene from the as made films, and from the film after removal of the surfactant template. Electrodeposition of Metals

Having demonstrated the opening of the pores Pt, Co and NiFe were electrodeposited into the pores. Figure 4 shows a top view SEM picture after Pt has been electrodeposited and the silica removed. EDS confirms the formation of Pt. Cyclic voltammetry in H₂SO₄ (Figure 5) on Pt surfaces has characteristic voltage peaks, with the current being directly proportional to the surface area. The amplitude of the current peaks give a Pt surface area consistent with growth of 80 nm high 4 nm nanopillars.

Electrodeposition of cobalt and permalloy into the was also carried out. The hysteresis loops are shown in Figure 6, and show the presence of cobalt and Ni/Fe in the silica films.

Conclusions and Future Work

Work carried out so far is consistent with the formation of perpendicular pores in mesoporous silica films. Work is currently underway to obtain cross-sectional TEM images to confirm the orientation of the pores and study how conformal the electrodeposition into the pores is. Confirmation, will open the way to explore the use of the mesoporous silica as a pattern generating agent via a variety of routes to patterned media.

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