Directed Self-Assembling Lithography Process for High-Density Bit Patterned Magnetic Recording Media

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Promising candidate for future high-density magnetic recording media is Bit-patterned media (BPM), where isolated magnetic dots are aligned precisely as data bits and servo control bits. Challenging issues of the BPM are fabrication process, magnetic property control, and a new system design. We have developed a self-assembled PS-PDMS diblock copolymer as an etching mask material with feature size down to 12nm-pitch (5 Tdots/in^2). The directed self-assembly (DSA) lithography was applied to control the self-assembled pattern to form circular data bits and complicated address/servo patterns.[1, 2] For further improvement, reduction of magnetic switching field distribution (SFD) is necessary to avoid write-in error. Linear dot alignment with precise control of dot pitch and position is crucial to a synchronous writing system. In this paper, achievement of DSA-BPM fabrication process is reviewed, and discussion on SFD reduction and precise pattern alignment process is presented.

Details of the fabrication process are shown in the previous papers.[1, 2] Film stack of a recording medium was NiTa (25nm) / Cr (5nm) / Pt (10nm) / $Fe_{50}Pt_{50}$ (5) / C (5nm). Substrate was heated at about 250 C during FePt deposition for transferring to the ordered phase. Polystyrene (PS) – polydimethylsiloxane (PDMS) was used for self-assembled material. Molecular weight was 8.5 kg/mol and volume fraction was 0.81(PS) : 0.19(PDMS). Resist guide pattern for DSA was fabricated by electron beam lithography. PDMS dot pattern was transferred to a carbon hard mask with RIE, and FePt layer was etched with Ar ion milling.

Figure 1 shows a SEM image of PDMS dot pattern aligned in address guides. Average dot pitch is 11.9 nm and dot pitch distribution is 14.2%.[1] SFD was estimated to be 21%. Figure 2 shows a SEM image of PDMS dot pattern aligned to post guides. A result of linearity analysis is also shown. It is found that the dot pitch distribution becomes as small as 5% when the guide post is excluded. Large dot pitch distribution as well as linearity deviation shown in Fig.2 is due to poorly placed post guides. A dark field TEM analysis revealed that FePt dots were partially transferred to disordered phase, where anisotropy energy reduced to almost zero. Micro-magnetic simulation revealed that the disordered portion caused by an etching damage result in large SFD.

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[1] Y. Kamata *et al*., IEEE Trans. Magn. **47**, 51 (2011)
[2] A. Kikitsu *et al*., IEEE Trans. Magn. (to be published).

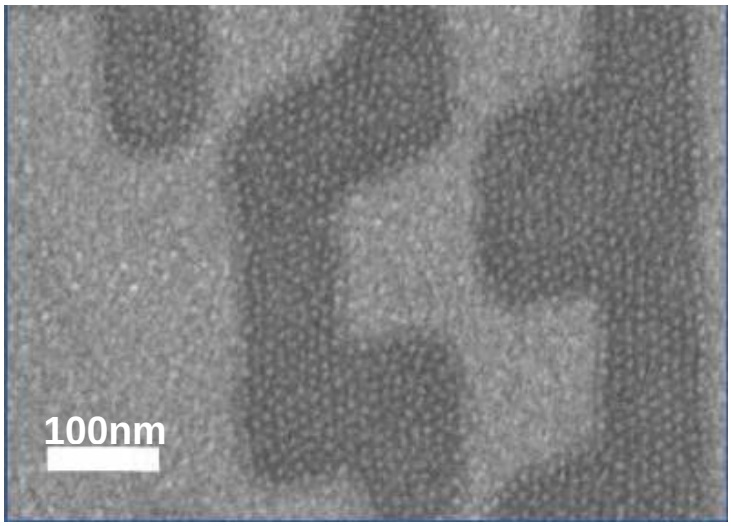

Figure 1: Plan-view SEM image of PDMS dot pattern aligned in address guides. PDMS dots are aligned in the "gray code" address pattern. Average dot pitch is 11.9 nm and dot pitch distribution is 14.2%.

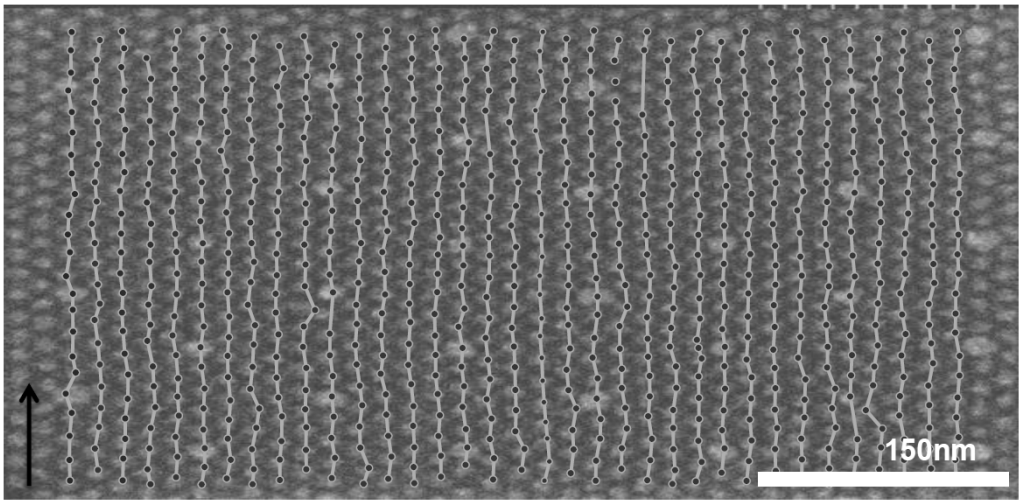

Figure 2: Plan-view SEM image of PDMS dot pattern aligned to post guides. The post guides are placed to form a hexagonal closed pack structure of PDMS dots. Diameter of the post guide is slightly larger than that of PDMS dots. Thick lines which connect each dot center are for the linearity analysis of dot alignment.