Master Pattern Formation of Bit-Patterned Media by E-Beam Direct Drawing

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Bit-patterned media (BPM) is the most promising candidate for the next-generation magnetic recording. It consists of ordered array of isolated magnetic dots and is expected to overcome the thermal fluctuation problem. Development of the fabrication process is a pressing issue to realize BPM. For master template fabrication, two approaches of pattern formation are hopeful. One is e-beam direct drawing and the other is self-assembly using a block copolymer (BCP). Even in the case of self-assembly process is used, guideposts or/and lines are required to form long-range ordering self-assembled dots along concentric circles. Therefore, master pattern drawing using a rotary stage e-beam tool is a key technology to realize BPM. We developed a rotary stage e-beam tool EBR-401, which had a 100 kV e-beam column, a high-precision r-θ stage system and a stage error correction system, for patterned media mastering in 2008. The performance for discrete track media (DTM) fabrication was reported in previous paper.[1)] In this paper, we introduce our latest e-beam tool EBR-402 and report our experimental results of BPM patterning.

Since the tolerance of the track run-out will become tighter according to rise of areal density, we developed new rotary stage for EBR-402 to improve the repetitive run-out (RRO). An air bearing made of porous carbon was adopted for the rotary stage. As a result, higher Fourier components above 3^{rd} order of RRO were reduced to be all less than 1 nm as shown in Fig. 2. The experimental results of BPM patterning are shown in Fig. 3 and 4. As the experimental conditions, the acceleration voltage was 100 kV, the beam current was 15 nA, and the beam size was less than 5 nm. Figure 3 shows SEM images of 500 Gbit/in^2 BPM with servo pattern. A positive-tone resist ZEP-520A (ZEON Corporation) was used. The track pitch and bit pitch of data area are 33.4 nm and 38.6 nm, respectively, and the servo track pitch is 66.8 nm. Figure 4 shows a resist pattern of dot array with an areal density of 1 Tbit/in^2. A high-resolution negative-tone resist supplied by Dai Nippon Printing Co., Ltd. was used. The track pitch and bit pitch are 23.6 nm and 27.2 nm, respectively. Details and further results of experiments will be discussed. By combining with self-assembly technique, it can be expected that BPM master templates with areal density beyond 2 Tbit/in^2 will be realized.

[1)] H. Kitahara *et al.*: Jpn. J. Appl. Phys. 49 (2010) 06GE02

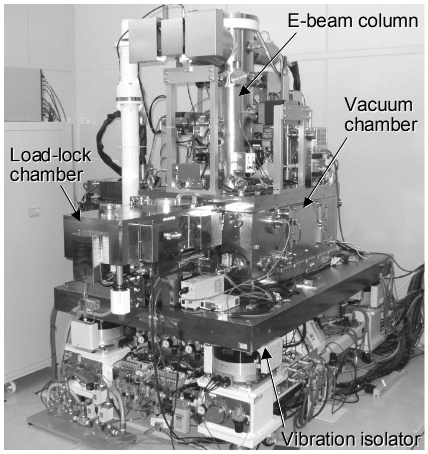

Fig. 1. Outside view of EBR-402.

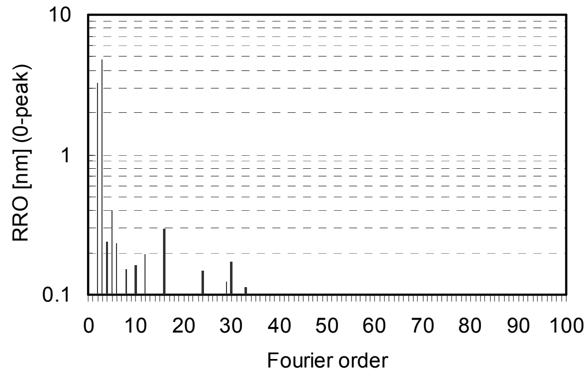

Fig. 2. RRO of new rotary stage at a rotation speed of 600 rpm.

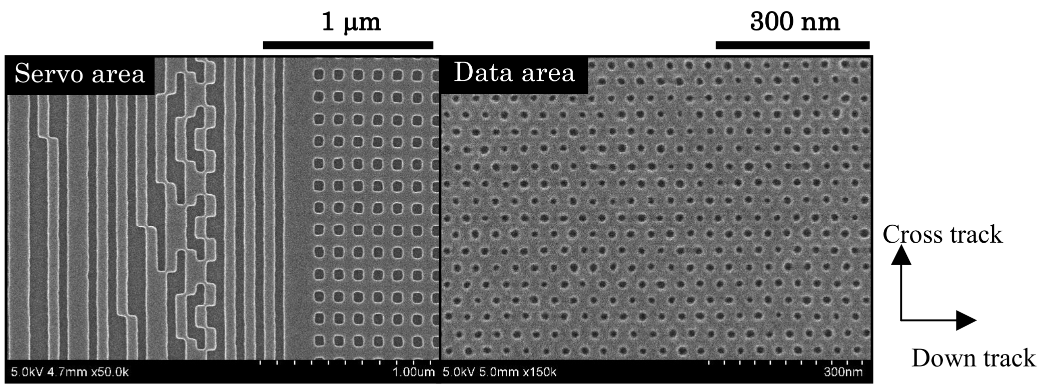

Fig. 3. SEM micrographs of BPM pattern with areal density of 500 Gbit/in^2 (data track pitch: 33.4 nm, bit pitch: 38.6 nm, servo track pitch: 66.8 nm, resist: ZEP-520A).

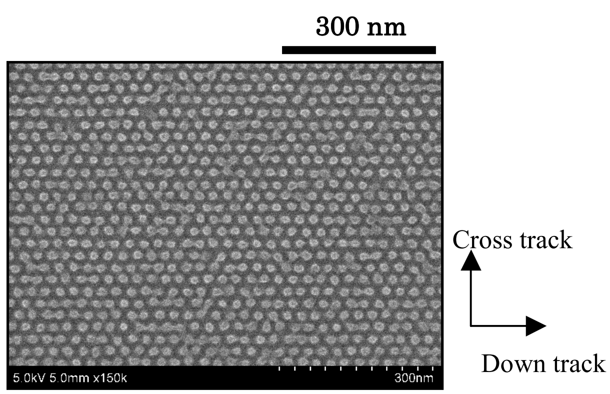

Fig. 4. SEM micrograph of dot array pattern with areal density of 1 Tbit/in^2 (track pitch: 23.6 nm, bit pitch: 27.2 nm, resist: high-resolution negative-tone resist supplied by Dai Nippon Printing Co., Ltd.).