Negative-tone E-beam Resist Patterning for more than 1 Tbit/in.^{2} Bit-patterned Media NIL Mold

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Nanoimprint lithography (NIL) is the one promising candidate for fabricating a patterned media to be used in the next generation of hard disk drives (HDD). It is expected that the pitch will become as small as about 20 nm for more than 1 Tbit/in.^{2} bit-patterned media (BPM) in 2014 or 2015. Electron-beam (EB) lithography techniques realize to fabricate NIL molds, and the developments with positive-tone EB resist, which are ZEP-520A[1] or chemically amplified resist (CAR)[2], have been mainstream so far. However, negative-tone EB resist process is necessary when we consider master or replica mold fabrication process. So negative-tone EB resist processes were developed. In this paper, we will discuss three kinds negative-tone EB resist (Nega-A, Nega-B and Nega-C) patterning performances with 100kV xy-stage EB writer (Jeol/JBX-9300FS) for process development and with rotary stage EB writer (Pioneer/EBR-402) for BPM pattern formation.

Nega-A: It is non-CAR targeting high resolution. The sensitivity is around 2500 uC/cm^2. So it is not suitable for large area writing for development or trial fabrication of BPM. 25 nm pitch pillar array were resolved as shown in Figure 1. Higher packing density process is under development with thinner resist thickness.
Nega-B: It is non-CAR targeting higher sensitivity around 1000 uC/cm^2 for full-area patterning. 24 nm pitch land and groove was resolved as shown in Figure 2. Resist material is being improved for better edge roughness and better sensitivity.
Nega-C: It is high sensitivity CAR and the sensitivity is 100~150 uC/cm^2, which is higher than ZEP-520A. The minimum resolution of pillar pitch is 32 nm as shown in Figure 3. The target is for guide patterning for directed self-assembly of BPM patterning.

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[1] H. Kitahara et al.: Jpn. J. Appl. Phys. 49 (2010) 06GE02.
[2] M. Hoga et al.: Microelectronics Engineering (To be published)

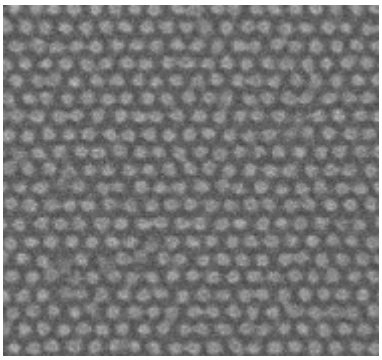

Figure 1: SEM image of hexagonal pillar array of Nega-A resist on silicon written by EBR-402. X-direction pitch is 27.2 nm and y-direction pith is 23.6 nm.

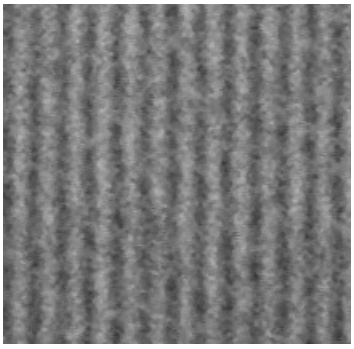

*Figure 2: S*EM image of land and groove pattern of Nega-B resist on silicon written by JBX-9300FS. Pitch is 24 nm.

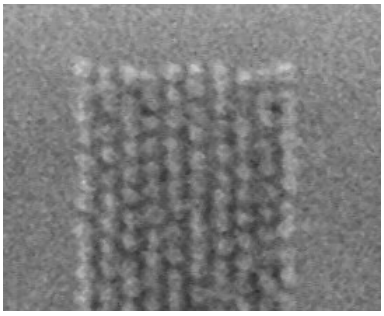

*Figure 3: S*EM image of square pillar array of Nega-C resist on silicon written by JBX-9300FS. Dot pitch is 32 nm.