Nanolithography for patterned magnetic data storage media

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We report on nanolithography for magnetic data storage employing a propylene glycol monoethyl ether ester as a chemical amplification positive tone resist (p-CAR). Using low cost 266nm-DUV interferometric lithography, this photoresist allowed us to fabricate a 18.25Gbit/in^2 dot pattern for the first time. A Lloyd's mirror laser interference set-up is a simple and useful tool for the fabrication of high-density test samples for patterned magnetic media research[1].

We characterized the new tri-layer resist that consists of a stack of BARC (Brewer Science), photosensitive p-CAR (Sumitomo Chemical) and TAR-coating (Brewer Science) at 54µW/cm^2 laser intensity. Samples were prepared by spin-coating p-CAR on BARC/silicon, softbaking on a hotplate for 90s at 110°C, and performing exposure at a variable angle of incident (Θ). After post-exposure bake of 90s on a hotplate at 105°C the resist is developed in OPD4262 for 60s, rinsed, spin-dried, and inspected by SEM at fixed magnification. Fig. 1 shows the results in a 140nm-thick p-CAR layer at Θ=30° (P=266nm) as a function of BARC thickness. Line width in the p-CAR can be tuned achieving Critical Dimensions (CD) of 39nm. Reducing p-CAR thickness to 100nm and increasing the exposure time to 70s, successful sub-50nm lithography was carried out at Θ=72° (P=140nm). Fig. 2 shows lines/spaces pattern transfer with CD 37nm into silicon by established dry etching. Fig. 3 depicts approximately 100nm-diameter dots produced by orthogonal double exposure of 21s each at Θ=45° (P=188nm) on surfaces of different reflectivity using the original resist thickness of 140nm. The standard development time of 60s was not sufficient to open the structure. Increasing the time to 90s, the dots on silicon are overdeveloped (Fig. 3B) while they are still underdeveloped (Fig. 3C) on 30nm sputtered platinum (Pt).

Nanolithography of dots on Pt was achieved by developing for 120s (Fig. 3A, inset D) using a BARC thickness of 21nm. The optimization of p-CAR interferometric nanolithography on Pt according to the findings in Fig. 1 allows for patterned magnetic media by lift-off processing using BARC as a sacrificial layer.

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[1] R. Murillo et al., Microelectronic Engineering 78-79 (2005) 260-265

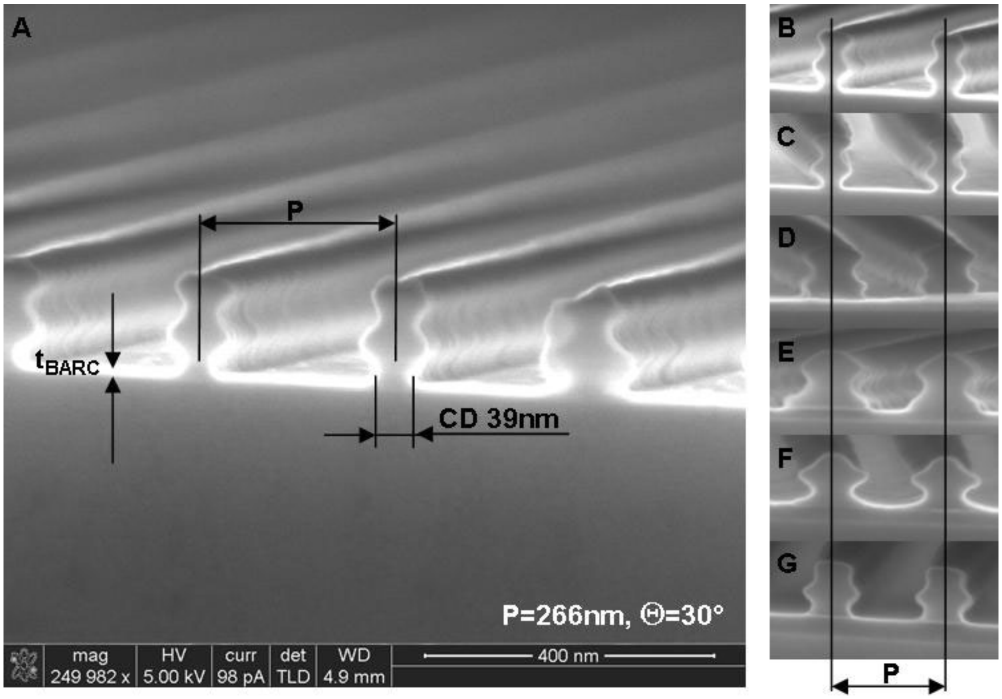

Fig.1. *Optimization of p-CAR nanolithography, P=266nm*: (A) SEM micrograph of p-CAR lines/spaces at CD 39nm, (B-G) shows the lithographic performance as a function of the BARC layer thickness, t_{BARC} equals 6, 13, 21, 29, 39, and 47nm from top to bottom, respectively, at the same SEM magnification as (A).

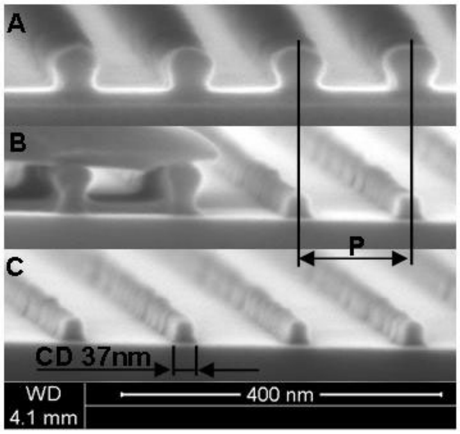

Fig.2. *Pattern transfer etch-test, P=140nm*: (A) sub-50nm p-CAR lines on 23nm BARC/silicon, (B) particle (left-hand of image) protecting resist during etching, (C) lines etched in silicon with dimensions.

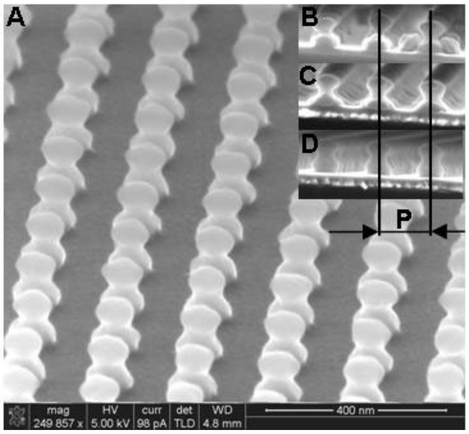

Fig.3. *18.25Gbit/in^2 dot array in p-CAR on 21nm BARC, P=188nm*: (A) Overview of optimized dots on Pt/silicon, inset shows cross-sections (B) on silicon, (C) on Pt/silicon, and (D) optimized on Pt/silicon.