Multi-domain storage in graded bit patterned media

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Tremendous effort is invested in the fabrication of bit patterned media (BPM), requiring novel approaches to lithography and pattern transfer. To achieve an areal density beyond 1 Tb/in^2, the resolution of the lithography system must be below 16 nm. To alleviate the lithographic requirements for BPM, a multi-domain storage in graded bit pattern media (GBPM) design is proposed. Unlike conventional BPM, which stores a single bit of information on a single magnetic island, the GBPM stores two bits on each island where each bit is separated by a domain wall. This recording strategy doubles the bit density along the track, effectively increasing the areal density by 50%.

GBPM is fabricated by irradiating BPM with low energy He ions at an angle as shown in Fig. 1e. The resist on the BPM serves as an ion block layer, protecting parts of the bits from irradiation damage. This partial irradiation produces a binary anisotropy distribution in every bit where the undamaged region is magnetically hard and the damaged region becomes magnetically soft. The soft region reverses at a lower field than the hard region and a domain wall can exist at the interface. This property enables a single physical bit/island to hold 2 magnetic bits.

A scanning magnetoresistance microscope (SMRM) was used to reveal stable multi-domain bits in GBPM, Fig. 2. A SMRM is a variant of scanning probe microscopy, which scans a recording head in contact with the sample; enabling reading and writing experiments to be performed on prototype BPM. It is important to mention that reversal of the binary domain bits always begin at the top half where it is softer/irradiated. The position sensitive reversal was also observed in write synchronization experiments where a 4 nm write pulse of various intensity and delay is applied to switch a bit into a single or binary-domain state.

Multi-domain storage is an option for future generation storage, but its viability at smaller bit diameter requires more research. An interesting outcome is experimental evidence that reversal of bit patterned media is strongly influenced by defect sites with low anisotropy. Since defect sites occur randomly within the magnetic film, it may be favorable to define the nucleation sites to combat write synchronization errors.

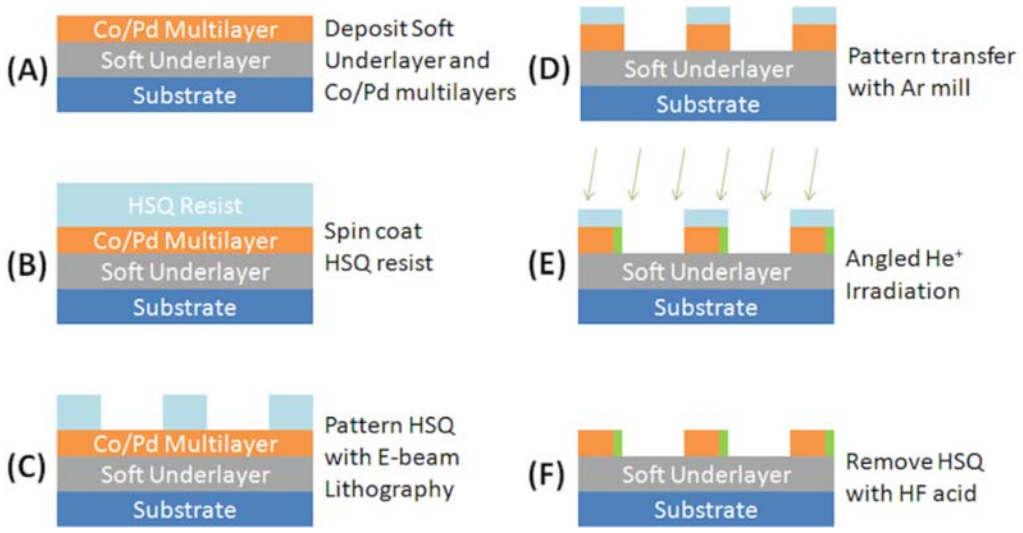

Figure 1: Graded bit patterned media fabrication: (A) The magnetic film consisting of a Permalloy soft underlayer and Co/Pd recording layer is deposited on a substrate. Then, (B) 109 nm of HSQ is spin coated and (C) patterned with an electron beam. Next, the (D) pattern is transferred through the recording layer with an Ar mill. The residual resist (79 nm) serves as an ion stopping layer against 1.8 keV He ions. Then, (E) the sample is irradiated at a 45-degree angle to expose half of each bit. The process is complete with the (F) removal of the resist by dipping in HF.

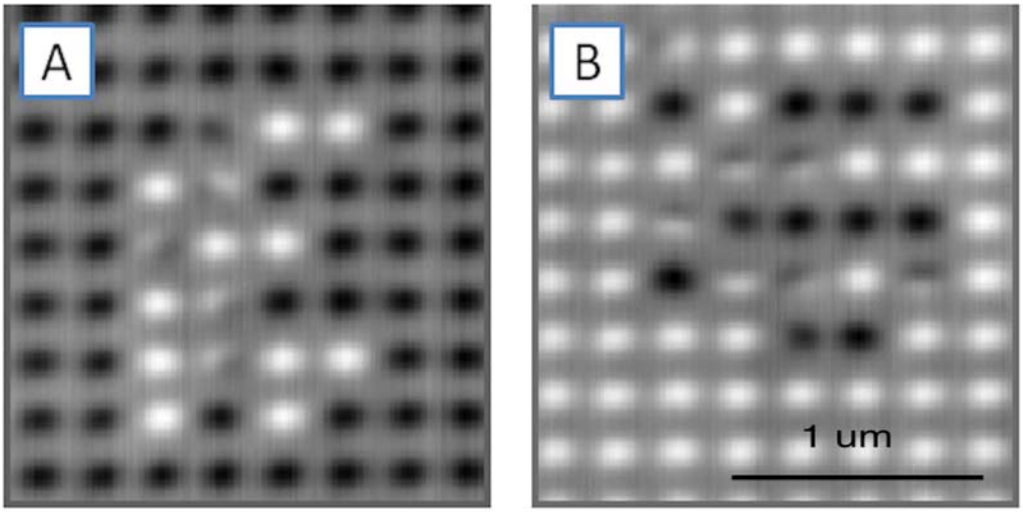

Figure 2: Multidomain Bits: An SMRM reveals that the bits can support a binary domain state. To observe the binary domain states, the sample was initially erased and then a 1 um x 2 um area is reversed such that (A) black bits are reversed to white and (B) white bits are reversed to black.