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Large Area Patterning of Single Magnetic Domains for Bit-Patterned Media via Ion Irradiation

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Bit-patterned media (BPM) has been proposed as one of the next-generation recording media due to much higher areal densities and better thermal stability. In such media, each bit of data is stored in a discrete magnetic nanostructure (pillar/island) with perpendicular anisotropy. Ideally these bit islands are uniformly defined single magnetic domains with feature sizes around 10-20 nm, which is challenging for both the lithography step and etching process. Typically ion milling is used to transfer the lithography patterns to the magnetic layer. However, during the ion milling process, shadowing effect could cause larger feature sizes than the desired patterns from lithography. To avoid such issue, an alternative approach is directly patterning magnetic film via ion irradiation. High-energy ion beam is able to degrade magnetic films as "dead" layers. In this study, we demonstrated that Ar^+ ions in ion mill could be used as ion irradiation source to pattern $Co_{80}Pt_{20}$ alloy magnetic films, which exhibit superiority in terms of large area patterning and process simplicity. Combined with block copolymer lithography, sub-20 nm CoPt islands with uniaxial perpendicular anisotropy were achieved and appeared to approach Stoner-Wohlfarth-like single domains as showed in Fig.1. X-ray diffraction (XRD) shows that the degradation of the magnetic films by ion irradiation comes from crystal structure changes. As showed in Fig. 2, CoPt (0002) peak height for CoPt dot arrays decreases compared to CoPt films, which indicates a reduced crystallinity of magnetic material from high-energy ion bombardments. In addition, there is a small peak of fct (110) for CoPt dot arrays, which is corresponding to modification of crystal structures by ion irradiation.