A Study of Pattern Density on Magnetic Coupling for Bit Patterned Media

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Magnetic recording has been playing an important role in the development of non-volatile memory devices. The storage capacity of existing hard disk drives based on perpendicular magnetic layer is predicted not to exceed 1-1.5 Tbit/in^2. Due to its isolated nanodots as the unit storage cell, bit patterned media (BPM) has been proposed as the future recording media to achieve higher areal density of 10Tbit/in^2.Various fabrication techniques including directed self assembly of block copolymer and nanoimprint lithography have been proposed to create bit patterned media [1, 2]. Amongst them, direct deposition of magnetic material onto pre-patterned array of nanodots defined by electron beam lithography has its advantages of controlling the uniformity of nanostructures. One of the key challenges is to isolate the magnetic interaction between individual dots since magnetic material is deposited into the trench between the dots during metal deposition [3].

In this paper, we investigate the impact of pattern density on the magnetic switching behavior for bit patterned media. Electron beam lithography is used to pattern negative-tone hydrogen silsesquioxane (HSQ) resist into 1.5µm by 1.5µm arrays of nanodots with a diameter of 30nm and height of 20nm. Fig. 1(a) shows an example of 50nm pitch dots with hexagonal packing. The nanodots are subsequently deposited with Co/Pd multilayer with a perpendicular magnetocrystalline anisotropy. We study the effect of pattern density on magnetic switching behavior using magnetic force microscopy (MFM). Fig. 1(c) and (d) are the MFM images of rectangular packing of 75nm pitch (referred to 75Rec) and hexagonal packing with 50nm pitch (referred to 50Hex) respectively. 75Rec shows most of bits are magnetized in one direction (black dots in Fig. 1(c)) while 50Hex has two opposite magnetizations along the perpendicular easy axis (black and white regions in Fig. 1(d)). We attribute the difference to magnetic coupling mediated by the trench material. In the case of high density pattern (i.e. 50Hex), there is less room for magnetic material to "squeeze" into the bits during metal deposition, leading to higher degree of magnetic isolation. It is reflected as black and white regions in Fig. 1(d). On the other hand, the presence of abundant trench material in 75Rec could lead to inter-connected dot. To further validate our result on the impact of pattern density on magnetic coupling, we intend to perform magneto-optical Kerr effect (MOKE) analysis to study the magnetic hysteresis loop of each bit patterns.

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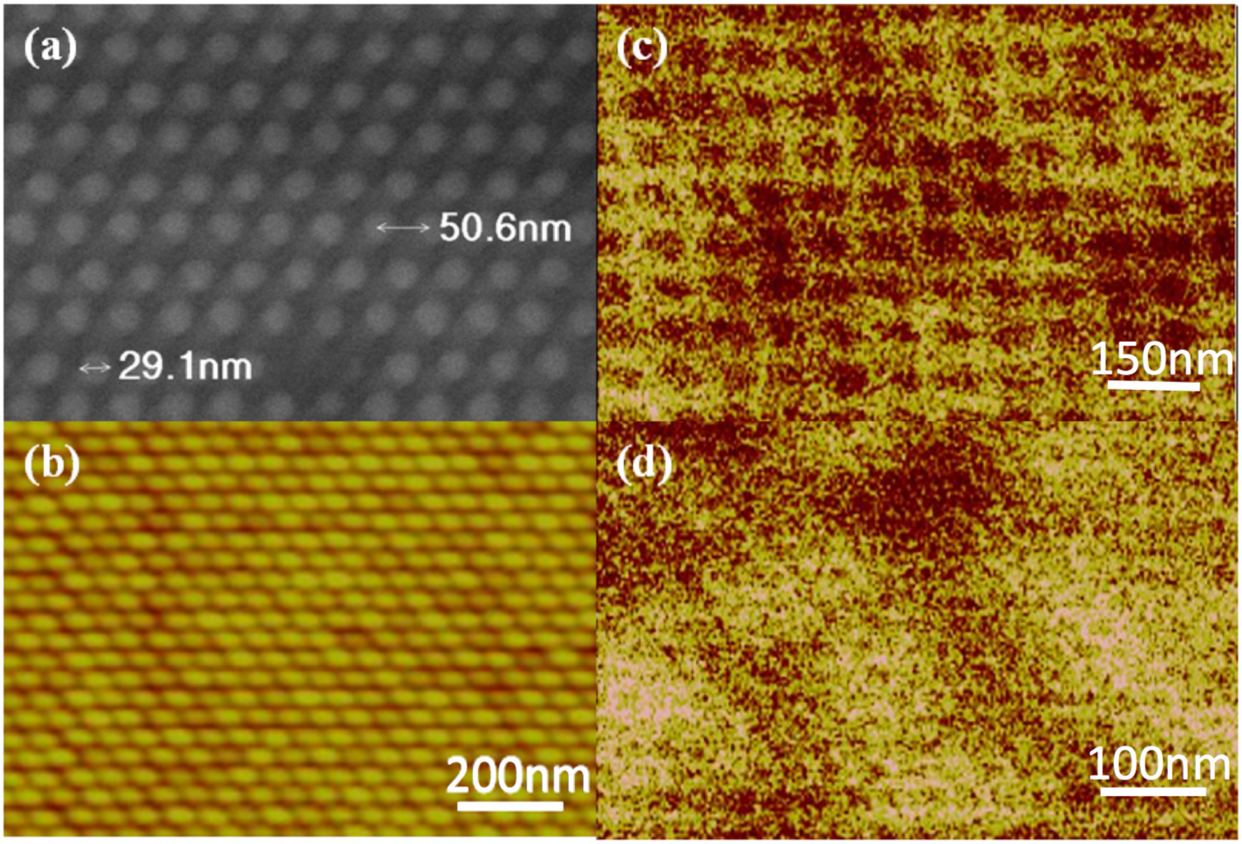

Figure 1 (a) scanning electron microscopy (SEM) image after deposition of magnetic multilayer showing nanodot of diameter of approx. 30nm and pitch of 50nm in hexagonal packing (b) atomic force microscopy of 50nm pitch hexagonal packing (c) and (d) magnetic force microscopy (MFM) images of 75nm pitch rectangular packing and 50nm pitch hexagonal packing respectively.