Fabrication and Testing of 1.5 Terabit/in^2 Bit-Patterned Media for Thermally-Assisted Magnetic Recording.

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For thermally-assisted magnetic recording (TAR) to become a reality, improvements need to be made in both the recording head and the magnetic media. At present, it is often difficult to evaluate the resolution of the plasmonic antenna in the recording head, due to a lack of magnetic media available for thermally-assisted recording at high density. We have found that bit patterned media is suitable for high density TAR, and have previously reported on achieving densities up to 1 Terabit/in^2.[1]

In that previous work, a combination of e-beam lithography and directed self-assembly were used to create etched Si pillars, and we then sputtered the magnetic media onto this patterned substrate. Unfortunately, the media deposited in the trenches between the pillars contributes background magnetic noise that makes going beyond 1 Terabit/in^2 very difficult. In this paper, we discuss an alternative approach for patterning the media. First we deposit a thin metallic seedlayer and then the magnetic media (Co/Pd multilayer) onto the substrate. The media is then capped with 20 nm of diamond-like carbon (DLC). A thin (6 nm) layer of HSQ is spun onto the wafer and exposed in hexagonal and rectangular BPM patterns at densities up to 1.5 Terabit/in^2 (dot pitch = 21 nm on a square lattice). To achieve the contrast required for these densities, we use a NaOH/NaCl solution to develop the HSQ.[2] The HSQ serves as the mask for reactive ion etching the DLC into a hard mask, such as that shown in Fig. 1. The DLC is then used as the mask for ion milling the media down to the top of the Au seedlayer. Following milling, the DLC is removed with a low-bias reactive ion etch, and a thin layer of fresh DLC is deposited to protect the media during magnetic recording operations. During all phases of fabrication, extreme care was taken to develop processes that would avoid damaging the sidewalls or top surface of the media, as we found such damage would drastically lower the coercivity of the media, rendering it unsuitable for magnetic recording.

In Figure 2, we show data from a magnetic drag tester on a square BPM lattice of 1.5 Tbit/in^2. A TAR head with an integrated plasmonic antenna was used to write data to the [Co/Pd] multilayer media pillar array. The coercivity of the pillars was too high to be written with a conventional recording head. However, near-field heating of the pillars from the antenna tip during nanosecond laser pulses reduced the coercivity enough to allow the media to be oriented by the write head. A simple 1T data pattern could be correctly written for up to about 20 islands before an on-track or off-track error occurred.

[1] B.C. Stipe, *et al.*, Nature Photonics **4**, pp. 484 (2010).
[2] S.W. Nam, *et al.*, JVST B **27**, pp. 2635 (2009).

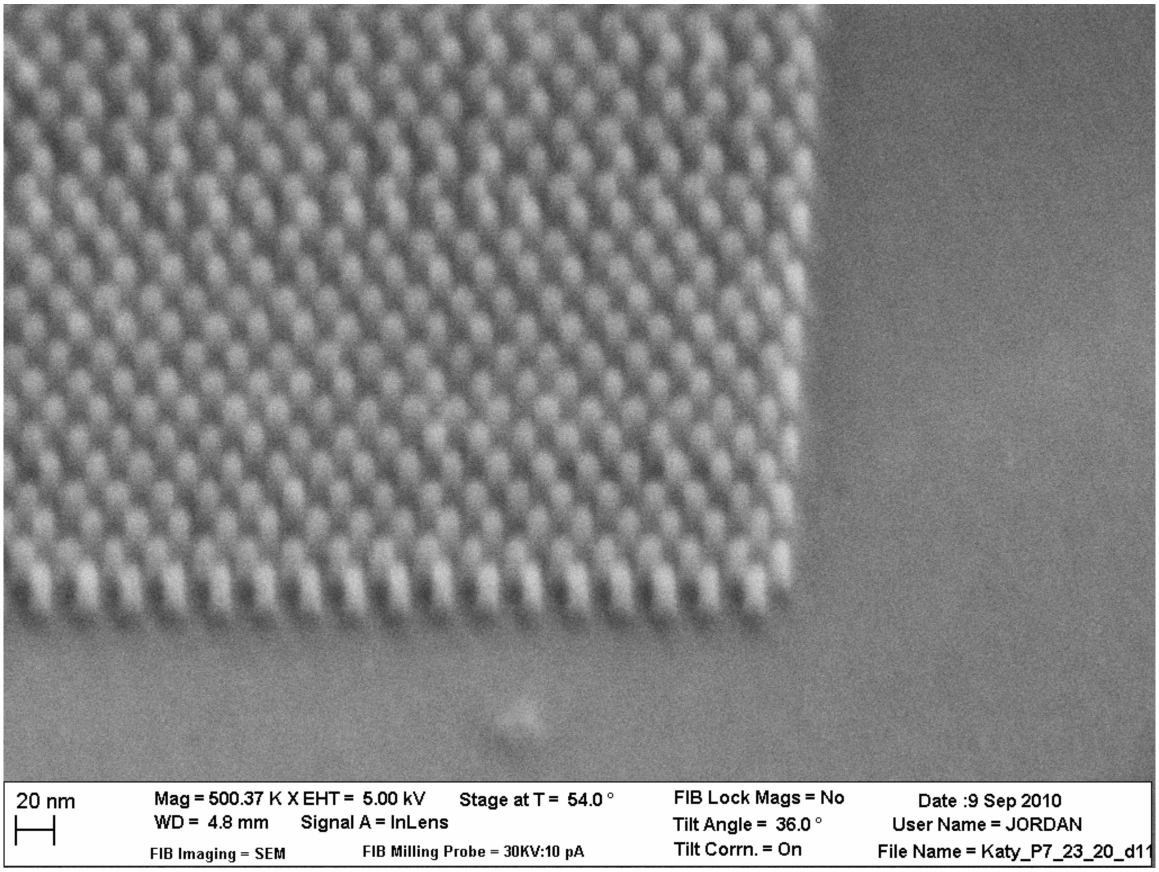

Figure 1: hcp array of 20 nm tall DLC pillars with a 23 nm period in the x-direction corresponding to a density of 1.4 Tbit/in^2. The ability to cleanly transfer the HSQ pattern into the DLC is evidence that the "scumming" often observed in high density HSQ exposures was not present.

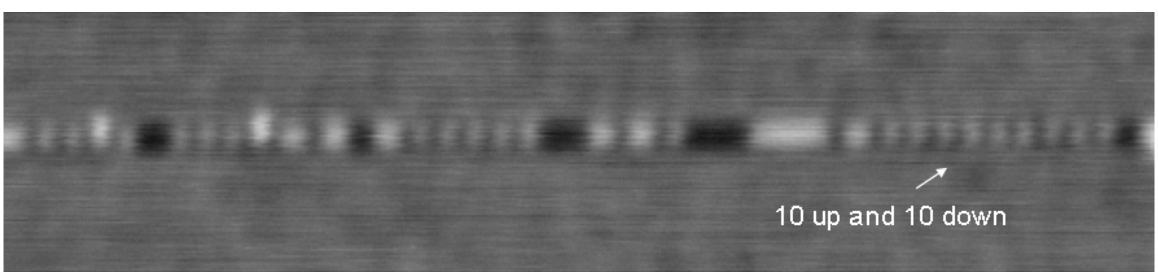

Figure 2: Magnetic image of a data track written by the integrated TAR head formed by scanning the head's read sensor. Sample is a square array of [Co/Pd] mulitlayer dots at 21 nm period formed by transferring a DLC hardmask into the underlying magnetic film. The sample was DC erased before being written with the TAR head. The density is 1.5 Tb/in^2.