Nanoimprint Lithography: Enabling Discrete Track and Bit-patterned Media Disk Manufacturing

Dan Kercher
Hitachi Global Storage Technologies, San Jose, CA 95138

In the magnetic storage industry, bit areal density has always been a crucial benchmark for progress. Rapid annual increases in areal density are quickly driving magnetic layers towards limits in thermal stability, writability, and signal-to-noise ratio. Patterned media (PM) has been proposed as a potential solution to overcome these limits and keep the disk drive industry on track with the current trends in areal density growth. PM is a general term that encompasses both discrete track media (DTM) and bit patterned media (BPM). The PM approach will only be successful if manufacturing processes can be developed that are easily integrated with the conventional media process lines.

Nanoimprint lithography (NIL) is the key step to making PM manufacturable. The NIL tooling will deliver the high disk throughput, (>800disks per hour), resolution, double side processing, and low cost required for media production. PM uses only a single patterning step. NIL for PM has very no overlay which greatly simplifies process requirements. To successfully manufacture PM disks with NIL, high resolution templates and a clean media pattern transfer process is needed.

Naonimprint template fabrication for PM requires extremely small feature sizes and tolerance requirements, 15nm islands for 1Tb/in^2 BPM, and strict position accuracy, ~1nm 1sigma. E-beam lithography is the preferred method of pattern generation. By it self, rotary stage e-beam lithography can handle the exposures for full disk DTM patterns. However, exposures of full disk sized, high density BPM master patterns can take days. To realize these patterns innovative self-assembly methods, such as block co-polymers, can be used. Figure 1 shows 39nm pitch pillars created from ps-b-pmma patters that assembled on top of 78nm e-beam patterns[1].

After nanoimprinting, the resist patterns can be transferred into the disk surface with a series of dry etch process steps. Imprint resist has been demonstrated as a suitable material for fabricating flyable PM disks. Figure 2 shows a cross section of 76nm pitch imprint resist lines and the subsequent DTM patterns after ion milling. NIL is a clean process that is compatible with the disk industry where heads fly above media at very close distances. Figure 3 is a map of acoustic emission from a head flown over a DTM disk at 3nm height. The disturbance in the head is only caused by large servo patterns.

---

[1] R. Ruiz, E. Dobisz, J. J. De Pablo, P. F. Nealey, H. Yoshida, T. Albrecht, Solid State Technology, Sep. 2008.

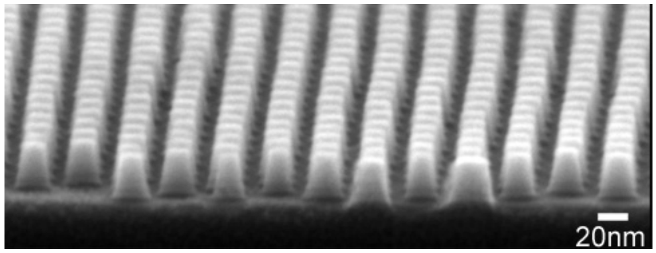

Figure 1. SEM micrographs pillars generated by e-beam plus ps-b-pmma pattern density multiplication

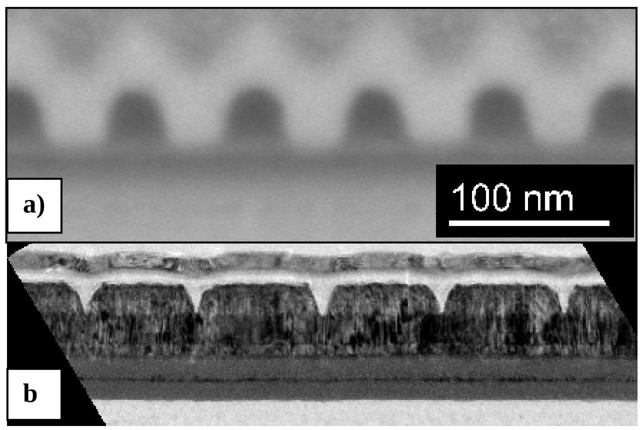

Figure 2. A SEM micrograph a) of the nanoimprint resist on media at 76nm track pitch, and a TEM image b) of the resist patterns etched into the magnetic layer.

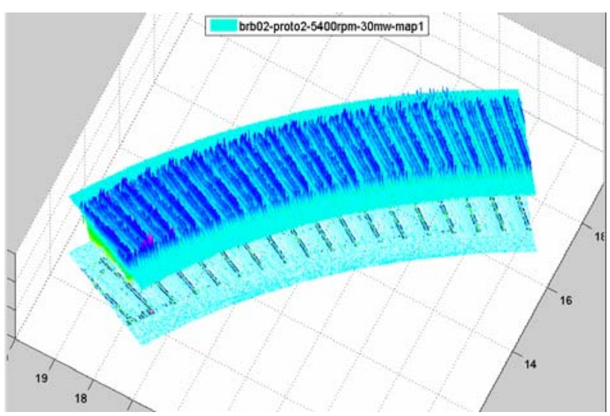

Figure 3. Acoustic emission data from a read write head flying on a DTM disk fabricated with NIL. The fly height is 3nm.