Nanoimprint Masters for Patterned Media

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Patterned media is expected to be important for disk drive manufacturing for densities > 500 Gb/in^2. The required throughput of hundreds of disks per hour makes imprint lithography the leading candidate to lithographically pattern the disks. The desired imprinted pattern on the disk is very closely spaced pillars ≤ 35 nm center-to-center. Since imprint lithography is a 1X stamper reproduction process, the first generation master must be made by e-beam lithography. It is anticipated that one master will require a week or more to exposure in a high resolution e-beam tool and will be very expensive. Therefore it is imperative that one master will make many stampers and/or generations of stampers. A master will imprint its inverse image into a stamper. The stamper can imprint its inverse image directly onto the substrate or into another generation stamper. Depending on the optimal master fabrication process and manufacturing stamping process for the disks, the master could be either tone; i.e. holes or pillars. The optimal tone of the quartz master for manufacturing of patterned media disks has not yet been determined. We discuss fabrication processes, resolution, and metrology issues for making quartz masters of both holes and pillars.

Quartz masters were spin coated with PMMA resist, followed by thermal evaporation of 10 nm of Al for reflectivity and electrical conductivity. Monte Carlo simulation shows the Al layer to cause < 0.5 nm broadening of a 100 kV e-beam. Several array patterns of period from 80 nm to 35 nm were exposed in a VB6, high resolution lens system at 100 kV. After exposure the Al layer was removed with a wet chemical etch. The masters were rinsed in water, dried in nitrogen and developed ultrasonically at 5 ^{0}C in 3:1 isopropanol: water. The samples destined for pillar masters were ion beam deposition coated with a Cr alloy etch mask which was lifted off ultrasonically in hot NMP. Both tones of masters were etched in an inductively coupled plasma reactor with CF_4 and HCF_3. The resist was stripped from the hole masters and the CrMo was etched from the pillar masters. SEM cross sections of a quartz hole master showed the etch depth to be dependent on the hole diameter with a depth of 80 nm for 52 nm diameter holes and a depth of 45 nm for 28 nm diameter holes. This was faithfully replicated in the imprinted pattern. Shown in Fig. 1 is a 35 nm period quartz pillar master that was etched to a 80 nm depth. The integrity of the etch mask is manifested by the flatness of the tops of the pillars. The uniformity of the base of the pillars, was best determined by examination of the daughter replica. Fig. 2 shows a 45 nm period pillar (a) master, (b) the replicated daughter stamper, and (c) the imprinted pattern. One can see in the daughter stamper the nonuniformity in the base of the etched quartz pillar. The etch uniformity and fidelity at the base of the master has great implications on the imprinted pattern and the base layer of the imprinted pattern. A with a pattern density of 527 the Gb/in^2 was successfully replicated into an stamper and imprinted, but the defect rate needs improvement. The issues of the fabrication of pillar and hole masters will be discussed with the implications for successfully imprinted patterns for patterned media.

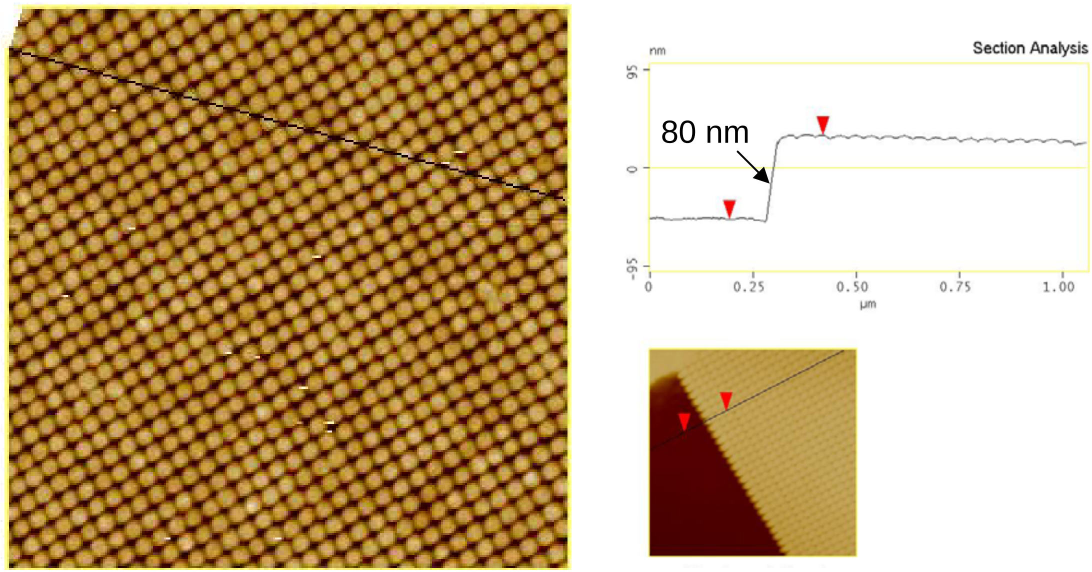
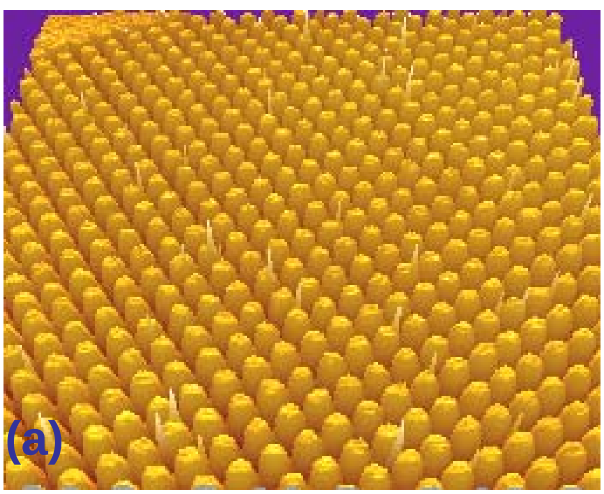


Figure 1. AFM of 35 nm period (527 Gb/in2) quartz pillar master with etched pillar height 80 nm.



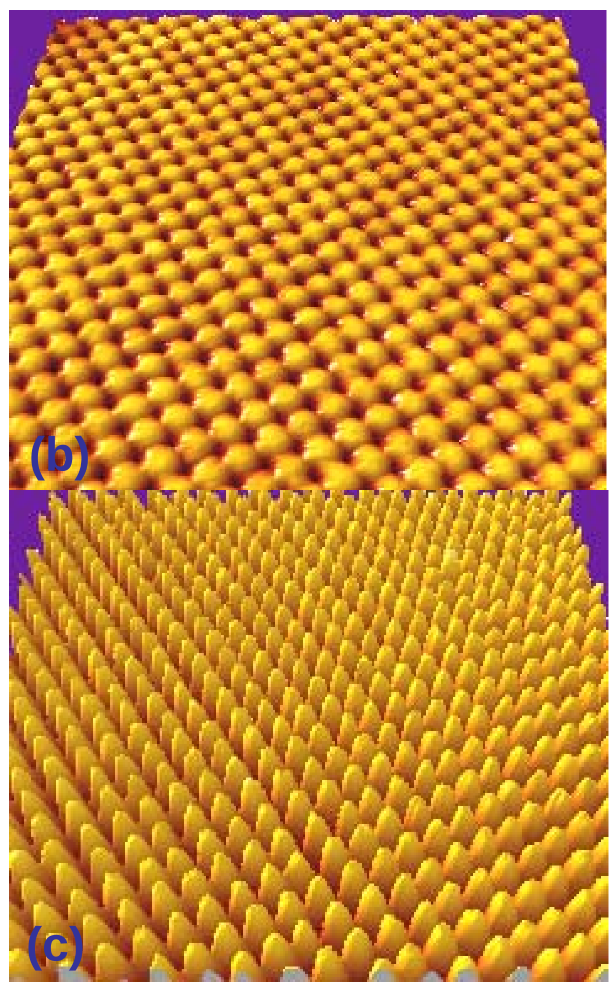


Figure 2. AFM of 316 Gb/in^2 pattern from quartz pillar master: (a) Master (b) Daughter Stamper (c) Imprint