65 Gbits/in.^{2} quantum magnetic disk (abstract)

Stephen Y. Chou and Peter R. Krauss
NanoStructure Laboratory, Department of Electrical Engineering, University of Minnesota, Minneapolis, Minnesota 55455

Quantum magnetic disk (QMD), proposed recently, offers a new paradigm for ultrahigh density magnetic recording.[1] In a QMD, each bit is represented by a prepatterned nanoscale single-domain magnetic pillar or bar that was uniformly embedded in a nonmagnetic material on a disk. The size and shape of each bit is well controlled during the fabrication to ensure single magnetic domain formation, therefore the magnetic moment of each bit has only two quantized states: equal in magnitude but opposite in direction. Compared to conventional magnetic disks, the QMD offers many unique advantages in writing, reading, and tracking. In this article, we report the fabrication of both longitudinal and perpendicular magnetization QMDs and their investigation with scanning electron microscopy, atomic force microscopy, and magnetic force microscopy. Both QMDs were fabricated using electron beam nanolithography, reactive ion etching, and chemical mechanical polishing. We will also discuss QMD fabrication techniques which do not involve conventional lithography. The perpendicular QMD structure consists of 50-nm-diam nickel pillars uniformly embedded in 200 nm thick SiO_2 with a surface roughness of 0.5 nm rms. The pillar array has a period of 100 nm which corresponds to a magnetic storage density of 65 Gbits/in^2—over two orders of magnitude greater than the current state-of-the-art magnetic storage density. [S0021-8979(96)80508-0]

Partially supported by ARPA N00014-93-1-0648 and ONR N00014-93-0256.

[1] S. Y. Chou, M. S. Wei, P. R. Krauss, and P. B. Fischer, J. Vac. Sci. Technol. B **12**, 3695 (1994).

Quantized writing processes in quantum magnetic disks (abstract)

Usman Suriono and Stephen Y. Chou
NanoStructure Laboratory, Department of Electrical Engineering, University of Minnesota, Minneapolis, Minnesota 55455

It has been suggested that the writing process in quantum magnetic disks (QMDs) is quantized: a write head either writes perfectly the entire bit which is a discrete single-domain element isolated from other bits with nonmagnetic materials, or it does not write the bit at all.[1] This article presents the micromagnetics demonstration of this quantized writing process. In the simulation, each QMD bit is assumed to be a polycrystalline cobalt bar of 700 nm long, 50 nm wide, and 30 nm thick, and to be oriented parallel to the disk surface. To obtain the dynamic motion of the magnetization structure of the bit, iterative energy minimization algorithm and the Landau–Lifshitz–Gilbert equation were used. The write head field is assumed to be parallel to the long axis of the bar and uniform with a strength of 2.5 times the bar coercivity. The write field has a width the same as that of the bar but a length that is only three-quarters of the cobalt bar length. It was found that even though the writing field size was smaller than the size of the bar, the magnetic moment of the entire single-domain bar can be switched from one direction to another, giving a perfect writing. The switching process occurred roughly in two stages. First, the magnetic moments got reversed in the region where the write field was applied. Second, driven by exchange force and shape anisotropy, the reversal propagated out of the write field region and reached the entire bit. It was also found that if the overlap of the writing field with the bar was less than one-quarter of the bar length in the bar long axis or four-fifths of the bar width in the bar short axis, the writing field would only temporarily perturbs the magnetic moment distribution of the bar. When the write field was removed from the bar, the magnetic moment of the bar would return to its original state. The quantized writing process in the QMD will allow the use of a smaller and therefore faster write head, can avoid the errors due to misplacement and fringing field, hence is suitable for ultrahigh-density storage. [S0021-8979(96)82108-3]

[1] S. Y. Chou, M. S. Wei, P. R. Krauss, and P. B. Fischer, J. Vac. Sci. Technol. B **12**, 3695 (1994).

 0021-8979/96/79(8)/5066/1/$10.00