Fabrication of dense non-circular nanomagnetic device arrarys using self-limiting low-energy glow-discharge processing

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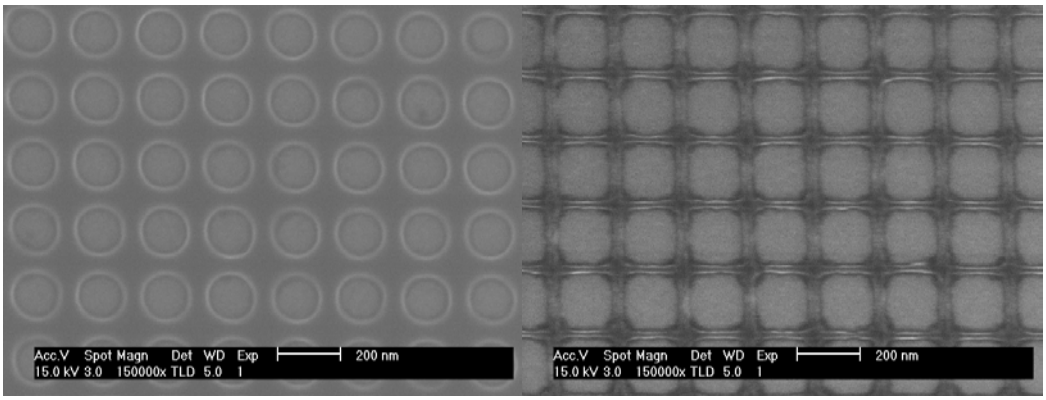
Recently, self-limiting ion milling (SLIM) was demonstrated to fabricate high-density, periodic arrays of square and hexagonal patterns from circular patterns in PMMA.[1] The SLIM process was demonstrated in a custom built Ar mill system, limiting its potential impact. In this work, the SLIM process is adapted to a reactive ion etcher, a common processing tool in micro and nanofabrication. In addition, a systematic approach was used to investigate and understand the SLIM process.

The precursor pattern consists of an array of circles printed on a square lattice in poly(methyl methacrylate) (PMMA) via electron beam lithography. The etch process is investigated by varying the precursor diameter and PMMA thickness. The pitch of the precursor is fixed at 200 nm. The SLIM process is carried out with an Oxford Plasmalab 100 RIE with an Ar processing pressure of 7.5 [Torr] at 70 [W].

A successful SLIM process is shown in Fig. 1, where circles are transformed into squares via Ar milling in an RIE. The quality of the square patterns depends greatly on precursor circle diameters and the initial PMMA thickness. The width of the squares, however, depends only on the pitch of the precursor.

The lateral and vertical etch rates of the SLIM process are measured with an SEM and AFM respectively. The lateral etch rate, Fig. 2, shows the self-limiting characteristic of process. The etch rate varies depending on the precursor diameter, but slows down asymptotically as the pattern diameter approaches ~180 [nm]. On the other hand, the vertical etch rate is a constant 58 [nm/min] across all sample configuration.

[1] V.A. Parekh *et al.*, *Nano Letters*, **7**, 10 (2007)



(a) (b)

Figure 1: SLIM transformation: (a) A circular precursor pattern is transformed into (b) squares after Ar milling in an RIE.

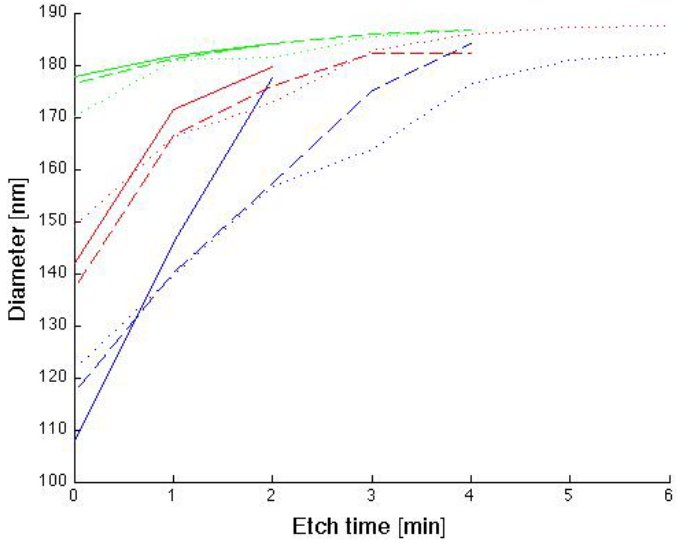


Figure 2: Lateral etch rate: The lateral etch rate depends on the (line color) diameter of the precursor pattern and not the (line type) thickness of the precursor film.