Chip Scale Focussed Electron Beam Induced Etching of a Silicon Nitride Membrane with Unique Beam Writing Strategies.

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Focused beam induced processing has been studied and written about in the literature, mostly concerning the use of an ion beams for milling and patterning of materials[1]. FEBIP, or focused electron beam induced processing has received more attention within the last decade, though most of the work has been in the area of electron beam induced deposition (EBID). Recently, the use of FEBIP has received new attention in the research community as the continual scaling of device geometries has emphasized the need for techniques which can pattern materials on the nanometer scale not only for deposition, but for etching as well[2]. One such area is in the fabrication of nanopores within a silicon based membrane for use in both biosensing and nano-electronic applications. We present our work using FEBIP processes to etch nanopores within a silicon nitride membrane. We utilize an electron beam rastered in concentric rings rather than a position fixed beam to reduce charging of the membrane and the effects of gas depletion in the etched region. This method provides greater control of the hole dimensions and reduces the amount of peripheral etching that causes the hole dimensions to enlarge. Charging and the associated beam position drift are critical for this process and cannot be completely eliminated by adjusting the process physical parameters, such as beam energy. Therefore, it is necessary to make periodic corrections to the beam position, either by referencing the developing structure itself or by referencing separate marks. We discuss ways of further refinement and automation of this process and the challenges for bringing the process to the wafer level. Figure 1 shows four images of a hole being fabricated by the method we describe here.

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[1] (a) R. M. Langford, P. M. Nellen, J. Gierak, Y. Fu, MRS Bulletin, Vol. 32, May 2007; (b) P. M. Nellen and R. Brönnimann, Meas. Sci. Technol. 17 (2006); (c) A. Lugstein *etal*., J. Vac. Sci. Technol. B 22(6), Nov/Dec 2004; (d) K. Wang *etal*., J. Vac Sci. Technol. B 21(3), May/Jun 2003 (d) K. Wang *etal*., J. Vac Sci. Technol. B 21(3), May/Jun 2003;

[2] (a) N. Vanhove, P. Lievens, and W. Vandervorst, J. Vac. Sci. Technol. B 28(6), Nov/Dec 2010; (b) T. Bret etal., J. Vac. Sci. Technol. B 27(6), Nov/Dec2009; (c) M. G Lassiter and P. D. Rack, Nanotechnology 19 (2008)

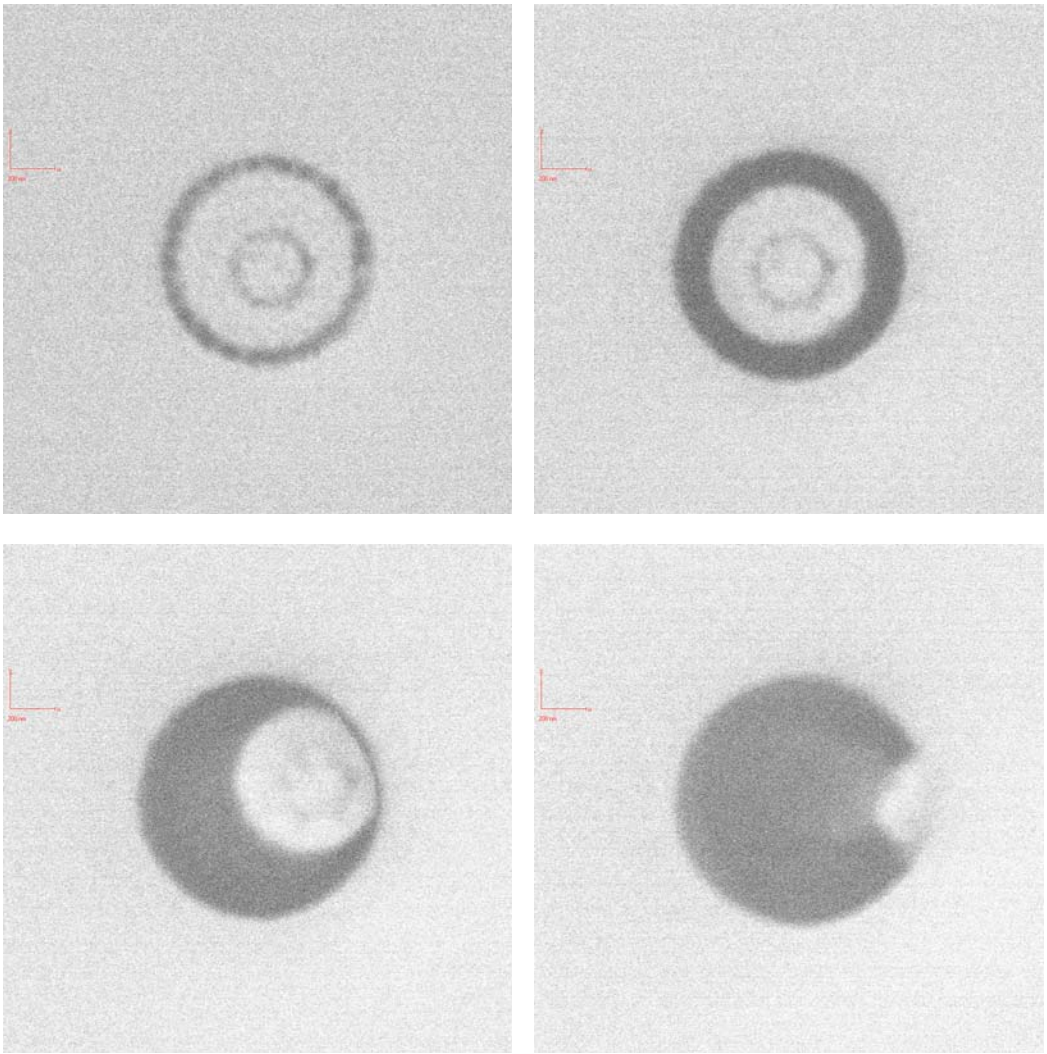

Figure 1. a) start of etching procedure b) continued etching c) start of breakthrough of the diaphragm d) collapse of center material