Batch Fabrication of Cantilever Array Apertured Probes for Scanning Near-Field Optical Microscopy

Y. Zhang, K. E. Docherty and J. M. R. Weaver
Department of Electronics and Electrical Engineering, University of Glasgow, Glasgow, G12 8LT, UK
e-mail: y.zhang@elec.gla.ac.uk

Scanning near-field optical microscopy (SNOM) is a technique which enables the acquisition of optical images with a resolution beyond the diffraction limit. This technique has been used for imaging surfaces as well as lithography with nanoscale optical resolution. However, as in other scanning probe microscope, the quality of SNOM imaging strongly depends on the probe used in the experiment. Although a lot of study has been devoted to the fabrication of SNOM probes, problems still remain, especially in respect of the definition of the apertures used to confine the optical field. Reproducible and batch fabricated apertures are particularly important for array probes which are proposed as part of the "SNOMIPEDE" project in order to dramatically decrease scanning time for imaging or increase throughput of near-field optical lithography.

In the present study, a novel batch fabrication method for cantilever array apertured probes has been developed. Apertured probes consisting of 16 parallel silicon oxide cantilevers have been fabricated on 3 inch <100> oriented 200 μm thick n-type silicon wafers. The fabrication involves three stages. The first stage is fabrication of silicon oxide cantilever array integrated with pyramid tips. Fabrication of this stage is based on KOH etching and thermal oxidation. The second stage is to define apertures on the apex of pyramids coated with 150 nm thick aluminum by direct-write of electron beam lithography (EBL) and subsequently pattern-transferred with reactive ion etch. In this way, flexibility to produce apertures of different shapes with excellent dimensional control is realized. Circular apertures with diameter of 100 nm as well as cross-shaped apertures with line width of about 50 nm have been fabricated on tops of pyramids, as shown in Fig. 1 and 2, respectively. At the last stage of fabrication, the cantilever array probes are released through wet etch. Tetramethylammonium hydroxide (TMAH) solution with addition of silicon and ammonium persulfate has been used, which anisotropically etches silicon without attacking either aluminum or silicon oxide. Fig. 3 shows an optical image of a batch fabricated cantilever array probe. Base on optical throughputs measured from these probes (shown in Fig. 4), the diameter variation of the batch fabricated 100nm circular apertures is deduced to be about ± 5 nm, indicating that very good reproducibility has been achieved by the present batch fabrication.

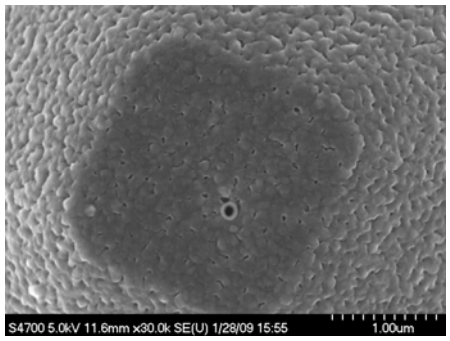

Figure 1: SEM image of a circular aperture.

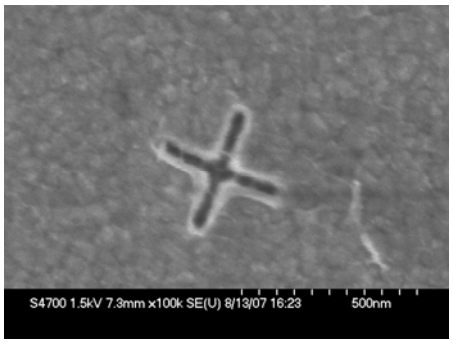

Figure 2: SEM image of a cross aperture

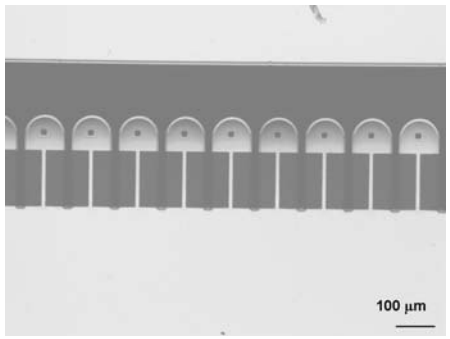

Figure 3: Optical image of a cantilever array apertured probe.

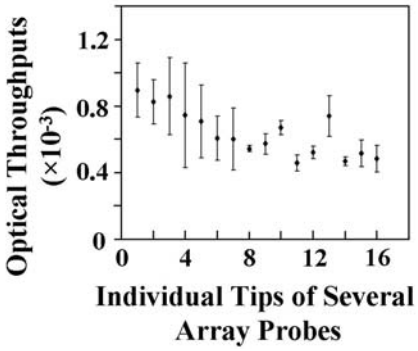

Figure 4: Measured optical throughputs of 16 individual tips from several array probes.