

Crisp, high aspect-ratio, C-shaped nanoapertures fabricated in evaporated aluminum using focused helium ions

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As part of a program exploring photoelectrons as sources for multiple beam electron beam lithography we are developing a source that features a 'C'-shaped aperture in metal to generate a sub-20nm light source using surface plasmon resonance. Previous work has shown that such concentration can be achieved at 980nm¹ but we are planning on using much shorter wavelengths to excite a rugged photocathode such as CsBr. For this the 'C' aperture comprises a pattern of trenches in 40nm thick metal that are 20nm wide and have square corners (radius no more than 5nm). The metal chosen is aluminum evaporated onto a substrate of fused quartz.

Initial attempts to achieve the required geometry employed electron beam lithography and also focused Ga⁺ ions, but were unsuccessful. The technique then adopted was to use a focused beam of helium ions in a commercially available instrument (Zeiss ORION[®] PLUS) to mill directly the required trenches. The ion energy was 34.9 keV, the beam current 0.7 pA and the estimated beam diameter 1 nm.

The results (fig 1) indicate that this technique was successful. Despite the graininess of the evaporated film the trenches are well defined and the corners have the required tight radius of curvature. The time taken for each aperture was about 1 minute.

It appears that the re-deposition that occurs when milling with Ga⁺ ions is much less in evidence when using helium ions. This is one aspect that we are continuing to study. It is also possible that even higher aspect-ratio structures might be possible if the milled material were sputter-deposited rather than thermally evaporated. Other parts of the continuing program are to evaluate a variety of structures that our simulations indicate are candidates for yielding photoelectron sources of diameter 10nm or even less.

¹ J. Leen, P. Hansen, Y. Cheng, A. Gibby, and L. Hesselink, Applied Physics Letters **97**, 073111 (2010)

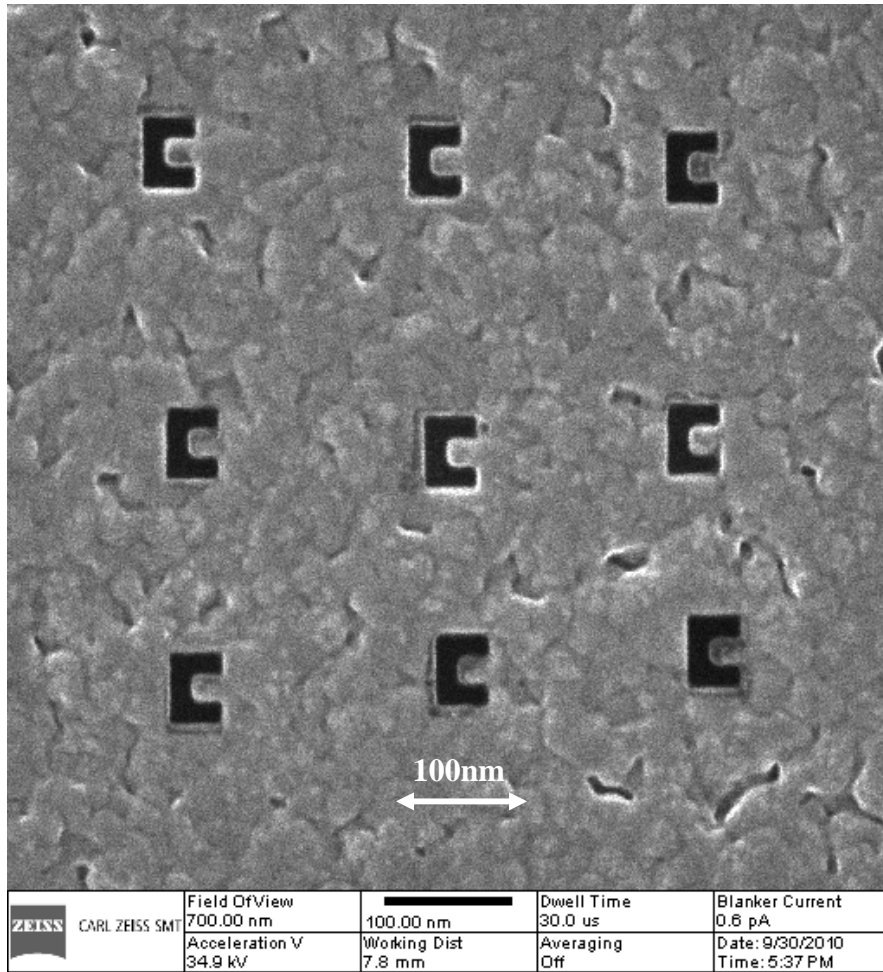


Figure 1: ‘C’ apertures with 20nm lines with square ends milled in 40nm Al using focused He ion beam.