MEMS Fabrication of a Microelectrode for Local Electrode Atom Probe Microanalysis

K. R. Kuhlman and V. White

California Institute of Technology, Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA 91109-8099, USA

The Local Electrode Atom Probe (LEAP) shows great promise for extending the atom probe technique to a wide range of materials characterization problems as the numerous abstracts discussing the LEAP in this symposium suggest. One essential component of the LEAP is the local extraction electrode used to apply a voltage pulse to the sample (Figure 1). A conical microelectrode designed at the Jet Propulsion Laboratory (JPL) will be fabricated using microelectromechanical systems (MEMS) techniques, X-ray lithography and electroplating (Figure 2). This technique produces multiple, uniform microelectrodes on a single wafer with very smooth surfaces and a high degree of quality control.

Tapered structures are not traditionally fabricated using lithography, as the tools are optimized for structures that are purely vertical from the substrate. However, techniques are available to fabricate structures with non-orthogonal symmetries.[1,2] In these techniques, a rotating substrate and a well collimated synchrotron X-ray source are used to create these conical structures. A thick layer of X-ray photoresist is deposited on a silicon wafer. An X-ray mask is then grown directly on this photoresist. The wafer is then given an angled exposure, and the holes in the opaque regions of the mask create angled exposed areas within the resist. If the wafer/mask structure is rotated, another region of resist is exposed. If the rotation is continuous, the angled walls of a tapered structure are swept out. The precision of the taper is largely determined by the resolution of the mask, the thickness control of the resist and the position control of the rotating stage.

Similar tapered structures have been fabricated using this technique. A 500 micrometer thick layer of polymethylmethacrylate (PMMA) photoresist will be deposited on a silicon wafer. A mask consisting of circular holes 50 micrometers in diameter will be deposited on the PMMA. After exposure and development, nickel will be electroplated into the structure. Previous work with this technique resulted in sidewalls that were smooth to the nanometer scale.

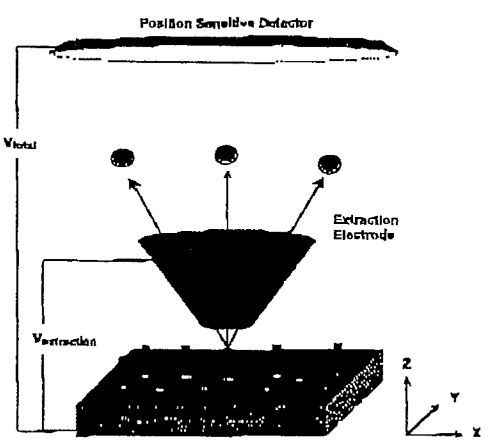

Figure 1. A schematic illustration of the MEMS fabricated extraction microelectrode designed at JPL.

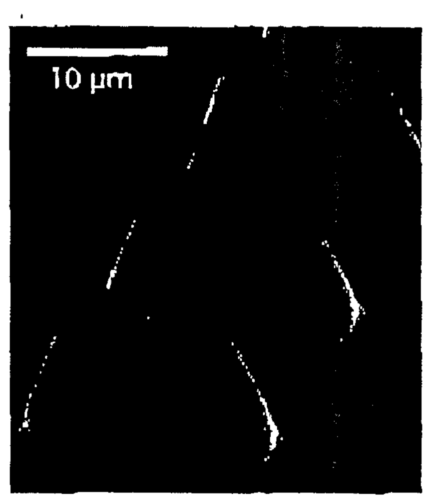

Figure 2. Tapered structures fabricated using nonorthogonal X-ray lithographic techniques.

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[1] White, V., C. Herdey, D. D. Denton and J. Song (1997). "X-ray fabrication of nonorthogonal structures using "surface" masks." *Journal of Vacuum Science & Technology B* 15(6): 2514-2516.
[2] Feinerman, A. D., R. E. Lajos and D. D. Denton (1996). "X-ray lathe: An x-ray lithographic exposure tool for nonplanar objects." *Journal of Microelectromechanical Systems* 5(4): 250-255.