Microsc. Microanal. 8 (Suppl. 2), 2002
DOI 10.1017.S1431927602105514

Applications (Fun and Practical) of FIB Nano-Deposition and Nano-Machining

Michael W. Phaneuf

Fibics Incorporated, 556 Booth St. Suite 200 Ottawa, Ontario Canada K1A 0G1 (info@fibics.com)

The use of focused ion beam (FIB) systems for nano- and micromachining is well documented [1-3], as is the FIB's capability for deposition of metals and insulators [4, references contained in 5]. FIB has been successful in direct-write lithography applications, and even the engraving of half-tone photographic images [6]. FIB depositions of silicon oxide can be made to tailor the index of refraction [7] resulting in depositions that run from transparent to opaque for visible light.

This presentation will discuss the combined use of FIB deposition of tungsten and silicon oxide and their subsequent FIB machining to form "nanostructures" with at least one dimension on the sub-micron scale (Figure 1). With some effort and creativity, FIB depositions can be made to span free space (arches and more complex structures) or to form structures with aspect ratios of 50:1 or greater. "Nano-tools" can be fabricated such as drill-bits and chisels (Figure 2). FIB machining has already been demonstrated to improve probes used in atomic force microscopy (AFM) and near-field scanning optical microscopy (NSOM) [8, 9]; combining these approaches with FIB nano-deposition and nano-machining will permit the production of NSOM tips with near-AFM spatial resolution as well as the already achieved improved optical resolution (Figure 3).

FIB "tungsten" depositions have been measured by quantitative electron probe microanalysis (EPMA) to contain approximately 5 wt.% C, 15 wt.% Ga and 80 wt.% W, with resistivity better than 160µO·cm. The effect of annealing on these parameters will be presented [10]

References

1. M.J. Vasile, R. Nassa, J. Xie, H. Guo, Micron **30** (1999) 235-244.
2. V.P. Dravid, Microsc. Microanal. **7** (Suppl. 2: Proceedings) (2001) 926-927.
3. V.P. Dravid, S. Kim and L.N. Brewer, Microsc. Microanal. 6 (Suppl. 2: Proceedings) (2001) 504-505.
4. D.Stewart, A. Doyle and J. D. Casey , SPIE **2437** (1995) 276-283.
5. M.W. Phaneuf, *Micron*, **20**, (1999) 277-288.
6. L.E. Erickson, H.G. Champion, J.W. Fraser, R.J. Hussey, P. Schmuki and C. Porco J. Vac. Sci. Technol. B **15** (6), 2358–2361 (1997).
7. Private conversations / Unpublished work of Micrion Corporation (now FEI Company). Thanks to Drs. Ganesh Sundaram, Neil Bassom and J. David Casey Jr.
8. R.S. Taylor, J. Li, M. Phaneuf, Monologue of the 2nd Asia-Pacific Workshop on Near-Field Optics, Beijing, 1999.
9. S. Pilevar, K. Edinger, W. Atia, I. Smolyaninov, C.Davis, Appl. Phys. Lett. **72** (1998) 3133-3135.
10. Fibics thanks Dr. Rod Packwood, Emeritus EMPA Scientist, Materials Technology Laboratory, Natural Resources Canada for the EMPA of our W depositions and useful discussions, and Dr. Rod Taylor, Institute for Microstructural Sciences, National Research Council of Canada for collaborative work on improving NSOM probe tips.

FIG. 1. FIB deposition can produce features 200 nm or less in thickness. FIB milling can produce even finer results. This structure required approximately 30 minutes of FIB time to produce.

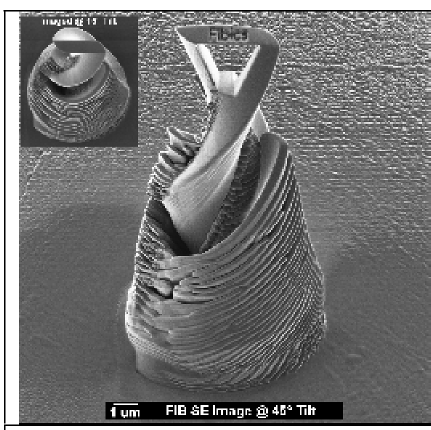

FIG. 2. FIB deposition of tungsten can produce "drill bits" and other complex structures which can be further FIB machined to a final shape.

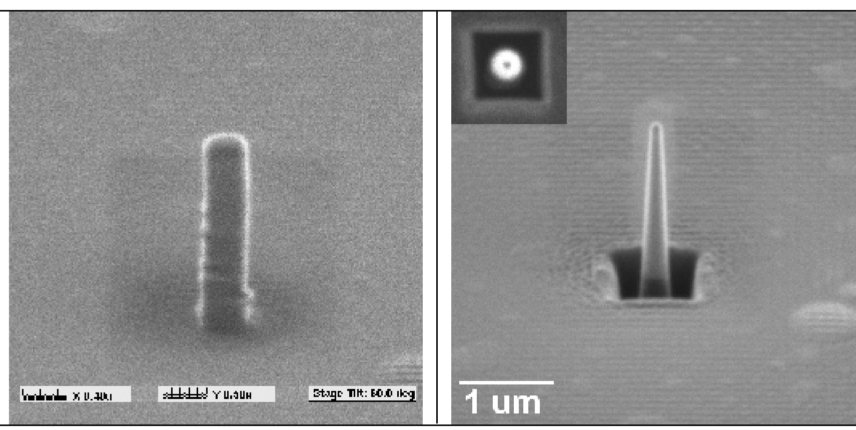

FIG. 3. Production of an "AFM tip" on virtually any surface. FIB deposition of tungsten or silicon oxide can produce 200 nm or thinner columns with aspect ratios than can exceed 50:1 (left). Subsequently, these columns can be FIB machined to a point (right) with a radius of curvature less than 40 nm (inset at 0° tilt).

https://doi.org/10.1017/S1431927602105514 Published online by Cambridge University Press