Focused Ion Beam System Employing a Low Temperature Ion Source

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Measurements and images are presented from a commercial focused ion beam system retrofit with a Cs^+ Low Temperature Ion Source (LoTIS)[1]. Spot sizes as small as (2.1 ± 0.2) nm (one standard deviation) and brightness values as high as (1.3 ± 0.1) x 10^7 A m^{-2} sr^{-1} eV^{-1} are observed with a 10 keV, 1.0 pA beam. The measured brightness in this configuration is over 13 times higher than the highest brightness observed in a Ga^+ liquid metal ion source (LMIS). The source also has a very small energy spread, less than 0.3 eV. The demonstrated 2 nm spot size is over a factor of two better than can be achieved with a Ga LMIS in the base platform at 40 keV. Brightness and spot size measurements at a variety of higher beam currents up to nearly 1 nA are also presented.

The FIB platform used was a commercial system optimized for circuit edit applications. The Ga LMIS that is standard for this system was removed and replaced with LoTIS. The focusing column, including the objective lens, stigmation, and deflection elements was not altered. Images were acquired, and milling patterns effected, using the original system software. Owing to voltage standoff requirements, the present prototype is limited to a beam energy of 10 keV. The present system should in principle be capable of providing currents up to 4 nA.

This LoTIS-FIB prototype has the highest brightness and smallest spot size recorded to date in a heavy ion source system. The present system also demonstrates that LoTIS can be retrofit to existing systems to achieve significantly higher performance than when used with the Ga LMIS for which they were designed. The data presented suggests a high potential for this ion source technology to improve the capabilities of nanomachining FIB systems.

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[1]B Knuffman, AV Steele, J Orloff, and JJ McClelland. *J. Appl. Phys.* **114**, 4 (2013).

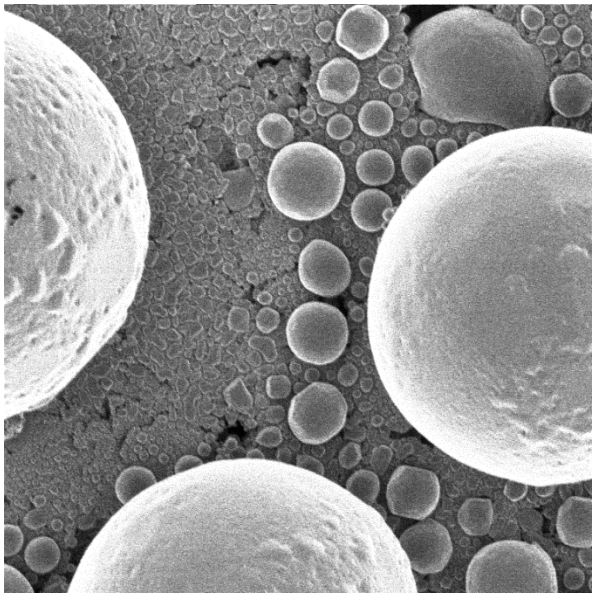

Figure 1: Tin Spheres on Carbon: Image taken using the LoTIS-FIB system. The field of view is 10 µm.