The Cesium Low Temperature Ion Source

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We present the latest results from all-new prototype Cs^+ Low Temperature Ion Source (LoTIS) retrofitted to a commercial FIB platform. When compared with other ion sources used in FIBs LoTIS can deliver very small spot sizes, high sputter rates, high yields of secondary ions, and a wide range of beam currents from pA to many nA.

Previously we reported spot sizes as small as (2.1 ± 0.2) nm (one standard deviation) are observed with a 10 keV, 1.0 pA beam. Brightness values as high as $(2.4 \pm 0.1) \times 10^7$ A m-2 sr-1 eV-1 are observed near 8 pA [1]. The measured peak brightness is over 24 times higher than the highest brightness observed in a Ga liquid metal ion source (LMIS). This system has generated beam currents up to 5 nA; we expect to report significantly higher currents by the time of this presentation.

The Low Temperature Ion Source (LoTIS) source is composed of a several discrete stages that collect, compress, cool and finally photoionize a cesium atomic beam [2]. High brightness and small spot sizes are achieved owing to the extremely low (10 μK) temperatures that may be achieved in the neutral atomic beam prior to photoionization.

We will present a description of the Cs^+ LoTIS-FIB system, together with a tour of results collected with this system to date. These include: brightness and spot size measurements at a variety of beam currents, high resolution images acquired using the system, and successful circuit edit operations.

The talk will conclude by examining benefits this ion source stands to deliver to Secondary Ion Mass Spectrometry (SIMS) applications. Here LoTIS is can provide over 100x more current into a given spot than today's Cs^+ ion sources. We will present some total-ion images as well as some rudimentary TOF-SIMS results obtained in this system.

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[1] A. V. Steele, A. Schwarzkopf, J. J. McClelland, and B. Knuffman. *Nano Futures*. **1**, 015005 (2017).
[2]B Knuffman, AV Steele, and JJ McClelland. *J. Appl. Phys.* **114**, 4 (2013).

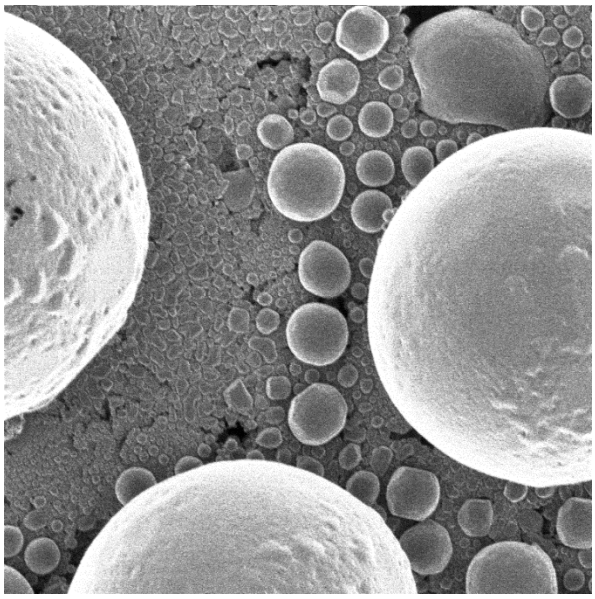

Figure 1: Tin Spheres on Carbon: Image taken using the LoTIS-FIB system. The field of view is 10 µm.