Applications of the Cesium Low Temperature Ion Source

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We present the latest results from FIB and FIB+SIMS systems featuring the Cs^+ Low Temperature Ion Source (LoTIS). When compared with other ion sources 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.

We will review applications of LoTIS tested on Vectra and v600 FIB systems. These include high resolution imaging, long depth-of-focus imaging, successful circuit edit operations on 10 nm node integrated circuits, high-precision machining of gold, and demonstration of the high grain-visibility imaging in copper and steel offered by LoTIS.

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 can generate beams exceeding 20 nA. LoTIS is composed of a several discrete stages that collect, compress, cool and finally photoionize a cesium atomic beam [2].

The talk will conclude by showing initial results from a new high resolution FIB/SIMS hybrid system called SIMS:ZERO; this system is being built in collaboration with the Luxembourg Institute of Science and Technology (LIST). SIMS:ZERO will be capable of high-resolution FIB operations while also providing a new material analysis information channel through the application of Secondary Ion Mass Spectrometry (SIMS). For many target materials Cs^+ will generate orders or magnitude more secondary ions than other ion ions. In addition LoTIS is can provide over 100x more current into a given spot than the Cs^+ ion sources used for SIMS today.

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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).

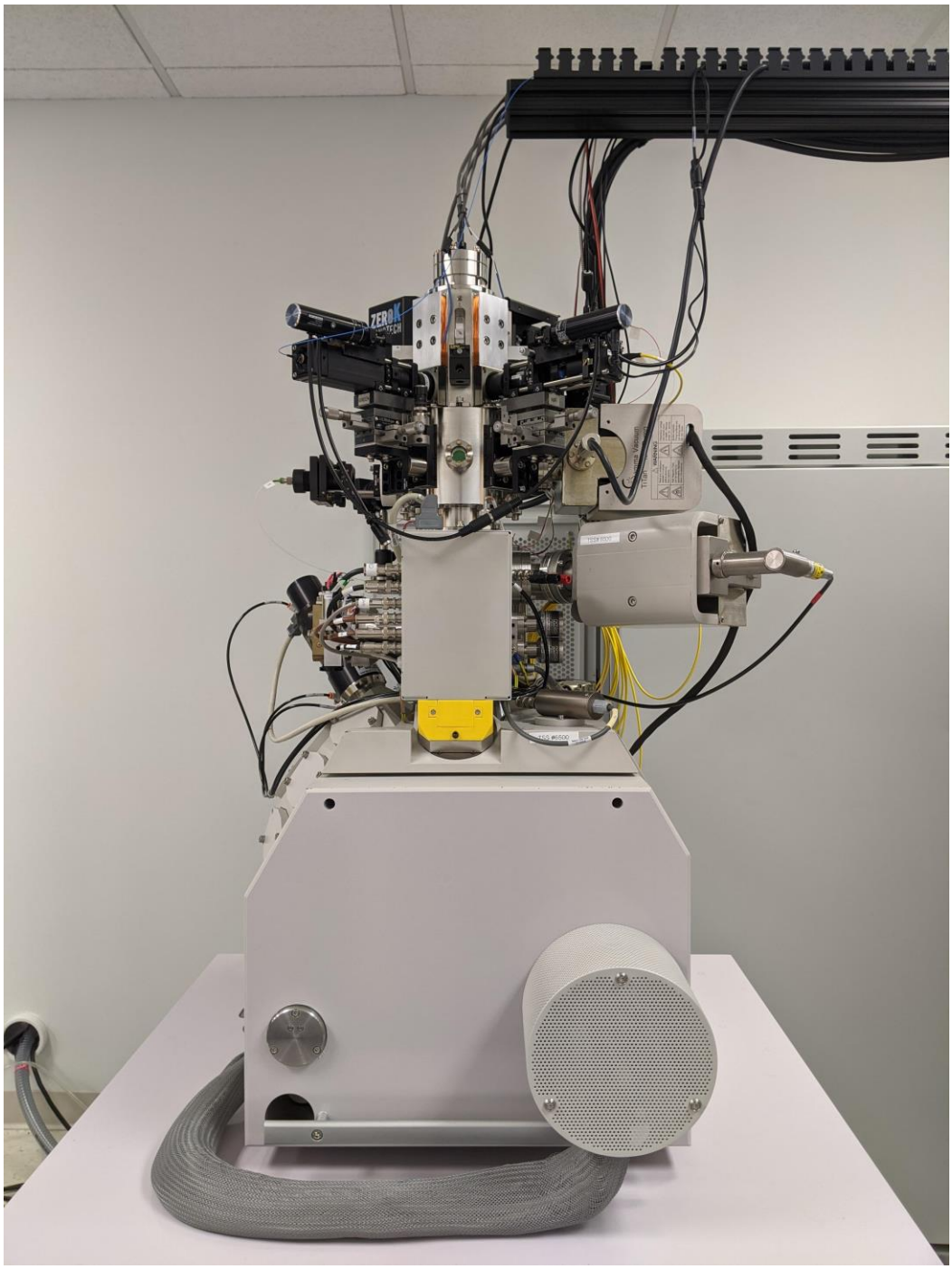

Figure 1: Cs LoTIS on a v600 FIB: zeroK's in-house FIB:ZERO is a retrofit of LoTIS to a Thermo-Fisher v600 platform. This upgrade improves the resolution to <2.0 nm at 10 keV and enables new contrast mechanisms. This system is also equipped with a platinum GIS. The SIMS spectrometer will be added in March 2021 to create the SIMS:ZERO platform.