A Focused Chromium Ion Beam

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Focused Ion Beams (FIBs) are an invaluable tool for the creation and observation of materials with sub-micron feature sizes. However, ion sources capable of both high brightness and low emittance operation are difficult to realize, with practical sources limited to very few atomic species. Recently, our group has demonstrated a low-emittance, high-brightness magneto-optical trap ion source (MOTIS) of chromium atoms [1].

In a MOTIS, atoms from a molecular beam are isotope-selectively captured into a cloud less than 1 mm in size and cooled to temperatures of a few hundred microKelvin using a combination of laser light and magnetic fields. The contents of this cold cloud of atoms are subsequently ionized by another laser and accelerated, using a pair of conductive electrodes, to any desired energy. Unlike a field-ionization-based source, the MOTIS technique could be used with any atomic species that can be cooled by lasers. This will broaden the use of FIB technology to a large number of new elements. So far, laser cooling has been demonstrated for the alkalis Li, Na, K, Rb, Cs and Fr, the alkaline earths Mg, Ca and Sr, the metastable noble gases He, Ne, Ar, Kr, and Xe, the metals Al, Ag, and Cr, and the rare-earths Er and Yb. New species continue to be cooled as laser technology advances. This atomic flexibility opens up a number of possibilities for the study of new types of interactions between surfaces and nanoscopic ion beam probes.

In this poster we report on our recently constructed apparatus for focusing MOTIS Cr^+ ions. A cross-sectional drawing of the elements with a simulated ion beam is shown in Fig. 1. Two conductive elements and one resistive element accelerate the ion beam to the desired energy without the need for a cross-over. The ion beam then passes through a steering quadrupolar deflector array and is focused onto the target by a three-element Einzel lens. Secondary electrons or ions ejected by the target are collected with a channel-electron-multiplier (CEM). A photograph of the deflector, Einzel lens and CEM assembly is shown in Fig. 2. The instrument will be capable of demonstrating imaging, deposition and milling modes of operation at sub-micron feature sizes.

[1] J.L. Hanssen, S.B. Hill, J. Orloff, J.J. McClelland. *Nano Letters*. **8**, 2844 (2008)

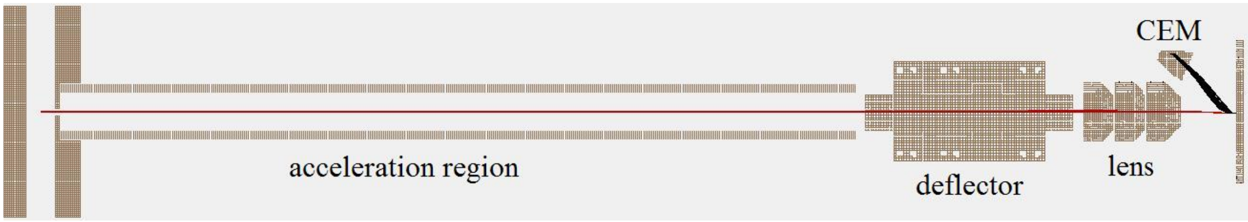

Fig. 1. Ion acceleration and focusing column cross section with simulated ion and secondary electron trajectories

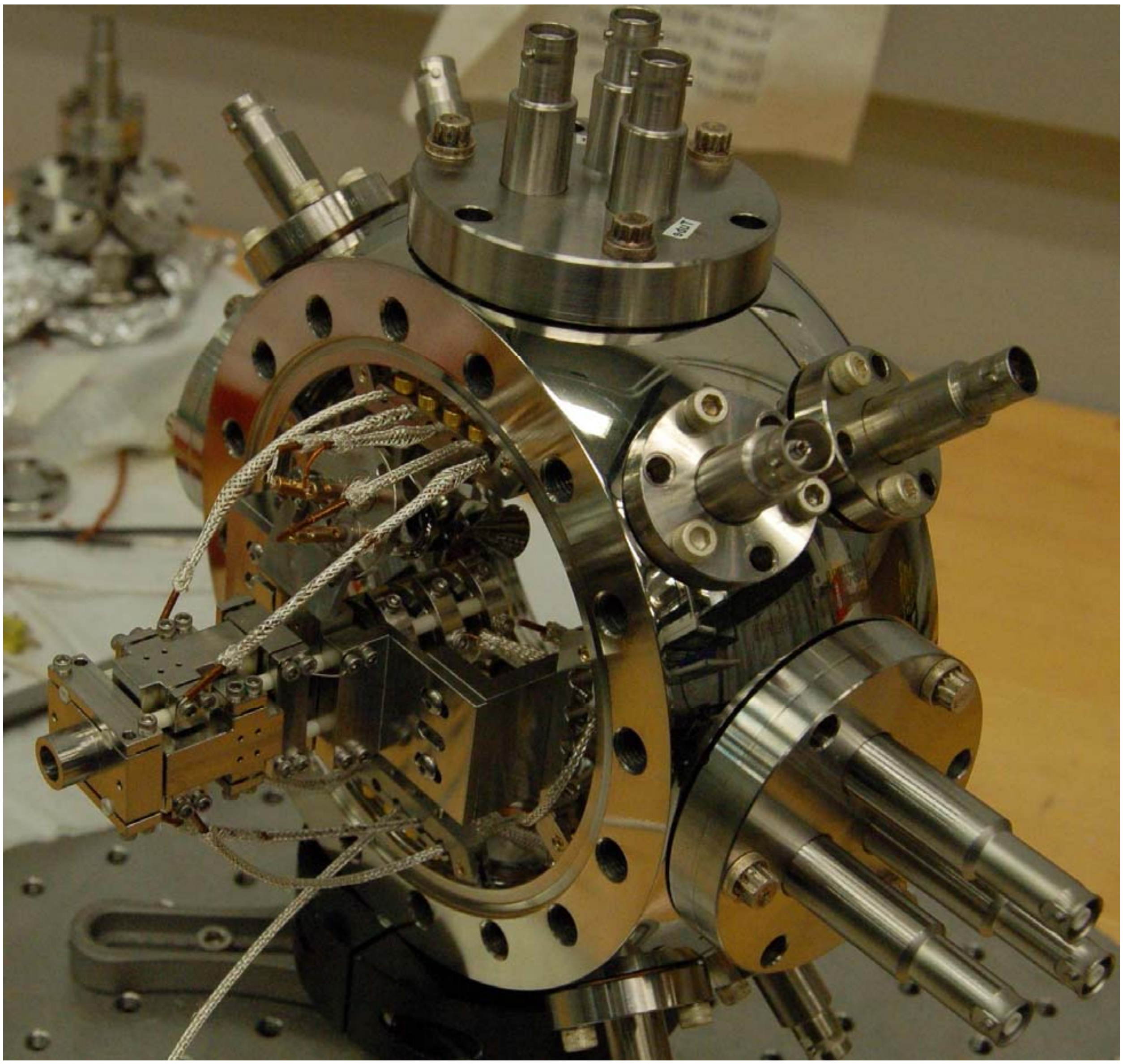

Fig 2. Photograph of the assembled ion beam focusing column. Visible elements include the quadrupole deflector (left), Einzel lens (middle) and CEM (middle upper).