Lithium Ion Source for Focused Ion Beam Microscopy

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Focused ion beam microscopy has a number of potential advantages as an alternative to electron microscopy, such as decreased penetration depth, smaller interaction volume, and the possibility of reaction-based imaging. However, ion sources of appropriate species with sufficiently low emittance, high brightness, and narrow energy spread are difficult to realize. A magneto-optical trap ion source (MOTIS) has the promise of producing high quality beams of low-mass ionic species that are well suited for microscopy without sample damage from sputtering [1]. The MOTIS uses photoionized laser-cooled neutral atoms to create a low emittance, high brightness beam of ions whose ion optical properties are comparable to or better than those of liquid metal ion sources. The MOTIS paradigm can be extended to create ion sources from any atomic species that can be laser-cooled, e.g., Li, Na, K, Rb, Cs, Fr, Mg, Ca, Sr, He, Ne, Ar, Kr, Xe, Al, Ag, Cr, Er, and Yb. This flexibility allows the atomic species of the source to be tailored to the specific application: microscopy with light ions, milling with heavy ions, and nanoscale implantation of a variety of elements, either in large quantities or in the single-atom regime using atom-on-demand techniques [2].

We report on the construction of a MOTIS used to produce a beam of lithium ions. A lithium atomic beam is slowed with a permanent-magnet Zeeman slower and trapped in a magneto-optical trap located between two parallel plates, which serve as extraction electrodes. Laser light at 670 nm for the trap and the slower is provided by a diode laser-tapered amplifier combination, and ions are created by photoionization with 350 nm laser light. We will discuss aspects of the design and performance of the ion source, shown in Fig. 1. A core brightness of 2.25 A cm^{-2} $sr^{-1}eV^{-1}$ has been reported in a Cr source, which produced 1.4 pA of current [1]. We have extracted more than ten times this amount of current from our lithium source (Fig. 2) highlighting its potential as a high brightness source for light ion microscopy.

[1] J. L. Hanssen, S. B. Hill, J. Orloff, and J. J. McClelland, Nano Letters **8**, 2844 (2008).
[2] S. B. Hill and J. J. McClelland, Applied Physics Letters **82**, 18 (2003).

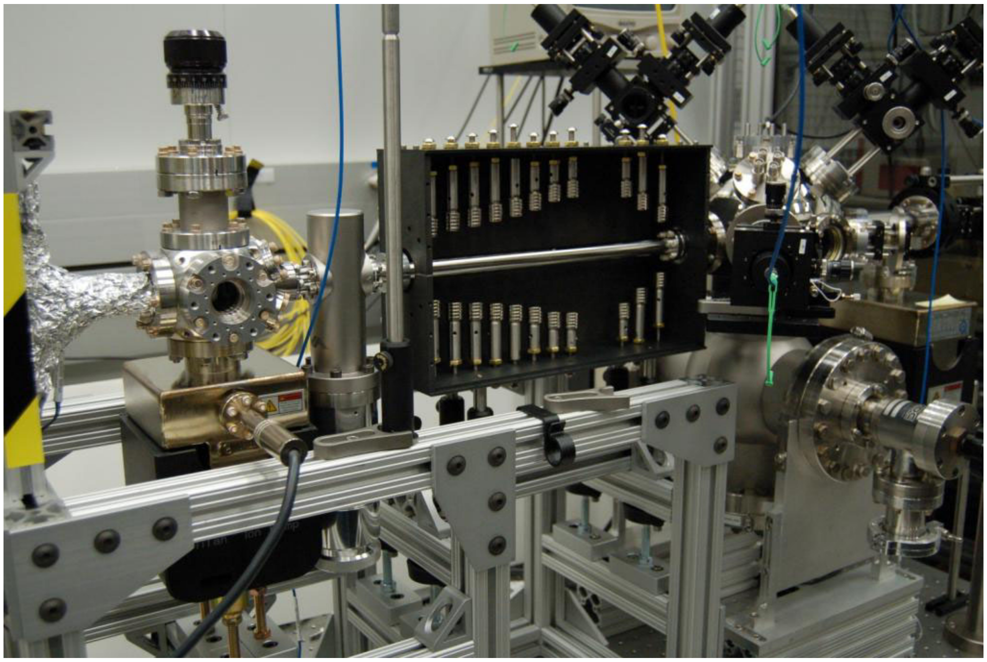

Fig. 1: Magneto-optical trap ion source (MOTIS) for producing a lithium ion beam.

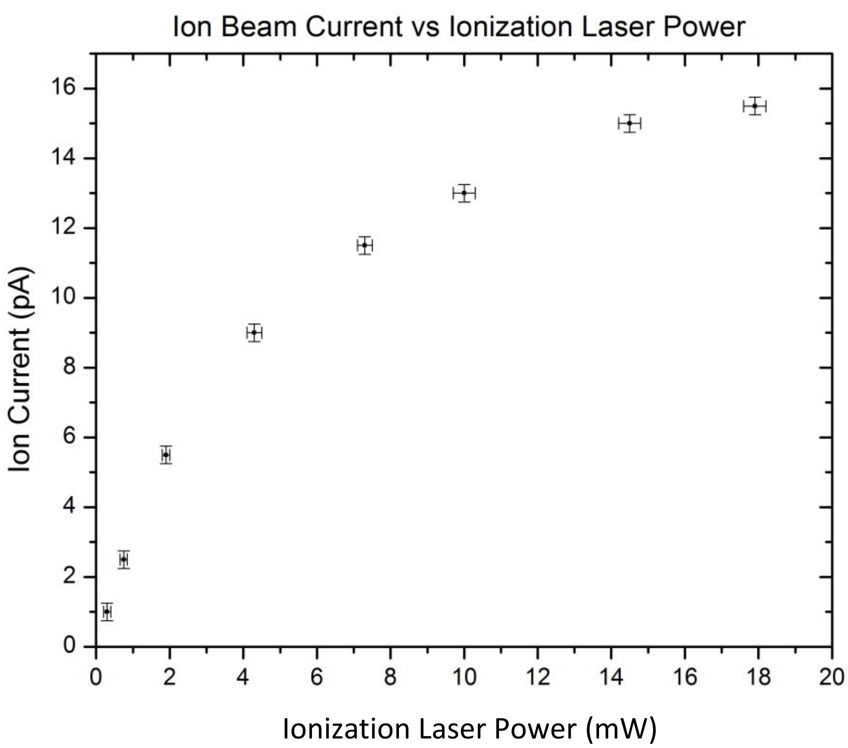

Fig. 2: Lithium ion current (measured using a Faraday cup) extracted from the magneto-optical trap ion source (MOTIS) as a function of the power in the ionizing laser beam.