Laser-Micromachined Carbon Xerogel Ionic Liquid Ion Sources for Focused Ion Beams

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Ionic Liquid Ion Sources (ILIS) produce ion beams through field-evaporation from room temperature molten-salts. The ionic liquid wets a micro-tip emitter, which is placed in front of an extractor aperture (Figure 1). By applying a potential difference of the order of 1-2 kV, the ionic liquid is deformed into a sharp meniscus. The electric field on the apex of this meniscus can reach 1 V/nm, triggering ion evaporation. It is estimated that these ion sources have brightness comparable to that of Liquid Metal Ion Sources[1]. Furthermore, the beam contains ion populations with energy spreads in the order of 6-8 eV[2], thus making the source amenable for focusing. The possibility of extracting both positive and negative ions, as well as reactive ion species capable of accelerated etching[3], make ILIS an attractive alternative for focused ion beam applications.

Traditionally, externally wetted tungsten emitters[4] have been used in ILIS. However, externally wetted tips are poorly wetted by ionic liquids, and thus suffer from a limited liquid supply and are prone to off-axis emission. Recently, porous carbon xerogel substrates have been mechanically polished into microtip emitters[5]. The carbon xerogel substrate can be synthesized with a pore structure that favors transport of ionic liquid towards the emission site, and these mechanically polished tips were demonstrated to produce a pure ion beam.

In this work, we report the fabrication of carbon xerogel microtips via laser micromachining. This technique is more repeatable than mechanical polishing, and could potentially be used to produce arrays of sources for etching applications. A 200 mJ, nanosecond laser (1248 nm) is used to ablate material from the carbon xerogel to form a pillar structure with a micrometer-sized tip (Figure 2). We will report on the source stability characterized by a channeltron detector connected to a fast response (< 10 ns) amplifier, as well as on the results from time-of-flight spectrometry and retarding potential energy analysis. The performance of the source in a high-energy regime (15-30 keV beam energy) will also be discussed, in order to assess the feasibility of implementing these ion sources in a FIB column.

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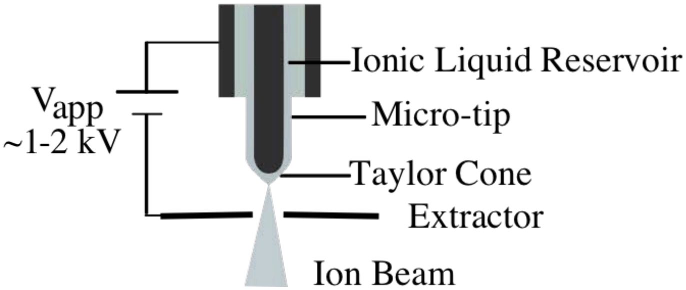

Figure 1: Basic ILIS configuration.

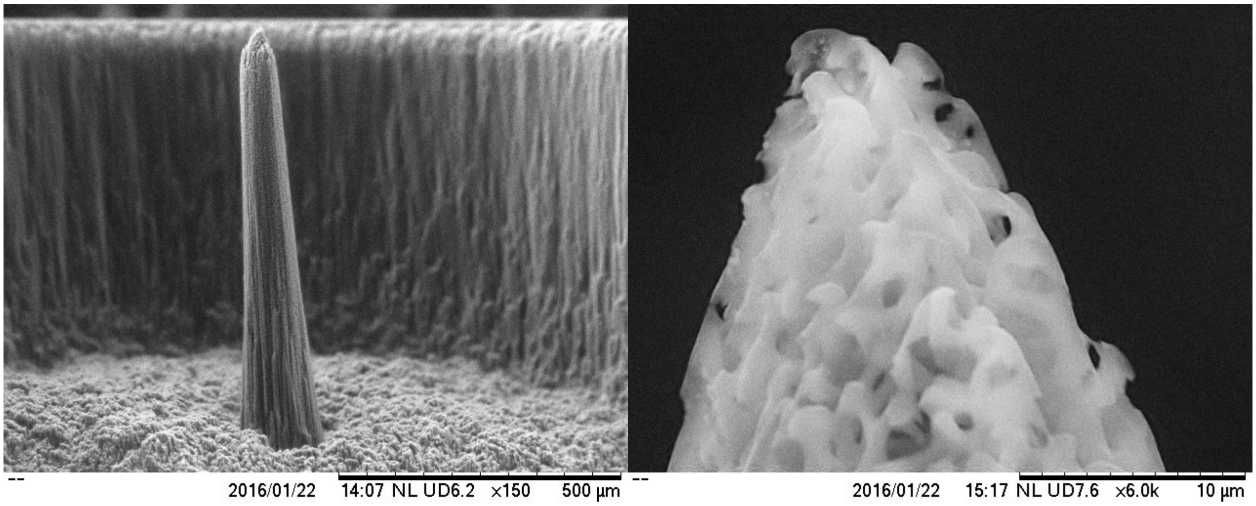

Figure 2: Scanning electron microscope images of laser-micromachined carbon xerogel tip. Tip height is 737 µm, and the apex has been sharpened to an approximate radius of 3 µm.