Filtering and Energy Characterization of Ion Species from Ionic Liquid Ion Sources for Focused Ion Beam Applications

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Ionic Liquid Ion Sources (ILIS) are charged particle sources with characteristics that make them suitable for Focused Ion Beam (FIB). ILIS work in a similar fashion as Liquid Metal Ion Sources (LMIS), but use ionic liquids, which are mostly organic room-temperature molten salts, capable of being electrostatically stressed to trigger ion emission under vacuum. The source consists of an electrochemically sharpened tungsten needle mounted on a loop structure (Fig.1). A voltage difference of 1-2 kV is applied between the tip and a downstream electrode aperture to extract the ions, which could be directed towards a FIB column.

ILIS share characteristics with LMIS that make them suitable for FIB applications, such as the emission of ions with no intervening droplets[1], and low energy spreads[2] (Fig 2). In addition, ILIS bring potential advantages for a FIB system, such as stable emission at currents below 1 μA, the ability to extract either negative or positive ions, and the reactive nature of some of the ions, that makes ILIS apt for fast etching with no chemical assistance[3].

The width of the energy spread is essential to minimize the beam spot size in a FIB system, and this work aims to measure the energy profile of the different species contained in the ILIS beam. An ionic liquid composed of anions A+ and cations C- will produce ion beams with composition $(AC)_nA+$ or $(AC)_nC-$, depending on the extraction polarity, where *n*, the degree of solvation, is the number of neutrals attached to the ion, and is usually *n*=0, 1, and sometimes 2. While the full beam from different ILIS shows narrow energy distributions, it is likely that sharper signals would characterize individual degrees of solvation, because their extraction energies must defer from each other when field-evaporated, and some ions with $n > 0$ break up into lighter fragments during flight. A magnetic filter has been preliminary used to separate ion species in ILIS.[4] For instance, ion fragments have been isolated and their energies characterized, although refinements on the setup are being made to improve the signal-to-noise ratio and the ion optics required to establish the energy properties of all emitted species. Once separated, the selected species will be directed to a basic FIB column in order to measure the filtered-beam spot size and compare it to the spot size of the full beam (Fig. 3[5]). These experiments will provide relevant information about the potential of ILIS in FIB.

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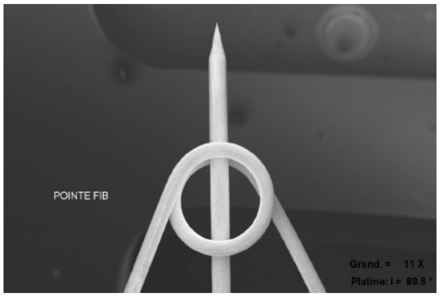

Figure 1. ILIS configuration showing the sharpened tip and loop reservoir.

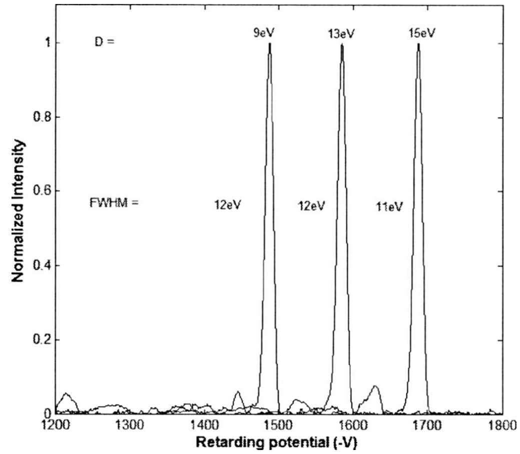

Figure 2. Energy spectra of the liquid BMI-I, obtained using the Retarding Potential Analyzer technique. Note the low energy spreads and energy deficits.

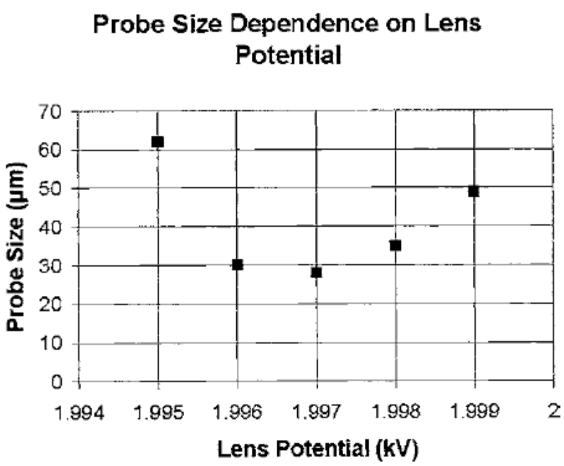

Figure 3. Spot size of an ILIS based on the liquid EMI-BF4, focused using an Einzel lens and deflection plate assembly. The probe size of the beam with no filtering can be brought down to 30 μm.