Using rockets in nanomanufacturing

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Ionic Liquid Ion Sources (ILIS) are devices with applications ranging from space propulsion to nanomanufacturing. Ionic liquids are room temperature molten salts, or mixtures of cations or anions that are liquid at room temperature without need for a solvent. The cations are usually large organic molecules, while the anions may be complex organic or simple inorganic ions. An example, 1-ethyl-3-methylimidazolium tetrafluoroborate, EMI-BF_4, is shown in Figure 1(a).

In ILIS, a micro-tip emitter is covered with ionic liquid and biased to a high voltage with respect to a downstream metallic extractor, see Figure 1(b). The electric field causes the liquid to deform into a sharp meniscus. At the apex of the meniscus, the electric field is high enough to trigger evaporation of ions from the liquid. The resulting beam can be used to propel spacecraft, from nanosatellites on near-Earth orbits to deep space missions, or to treat materials.

ILIS could be advantageous in materials processing: the large variety of ionic liquids available gives ample choice of chemistries tailored to different purposes. For example, irradiation of silicon using ILIS with EMI-BF_4 results in enhanced etching, thanks to the capability of the fluorine in the ion beam to create volatile species that prevent the redeposition of dislocated atoms[1]. Furthermore, ILIS have the crucial advantage of providing negative ions by simply reversing the polarity of the power supply. Irradiation with negative ions can mitigate charging during treatment of dielectric substrates[2]. Ion species available with ILIS include monoatomic species such as I^- or Cl^-, or kilodalton organic molecules. ILIS are also bright point sources with properties that could make them amenable to operation in a focused ion beam (FIB) column[3].

This talk will review the emission properties of ILIS[4], the advancements in improving the reliability and lifetime of the ion sources, the achievements in materials processing, and discuss the opportunities and challenges in the implementation of ILIS in wafer-scale etchers and in FIB applications.

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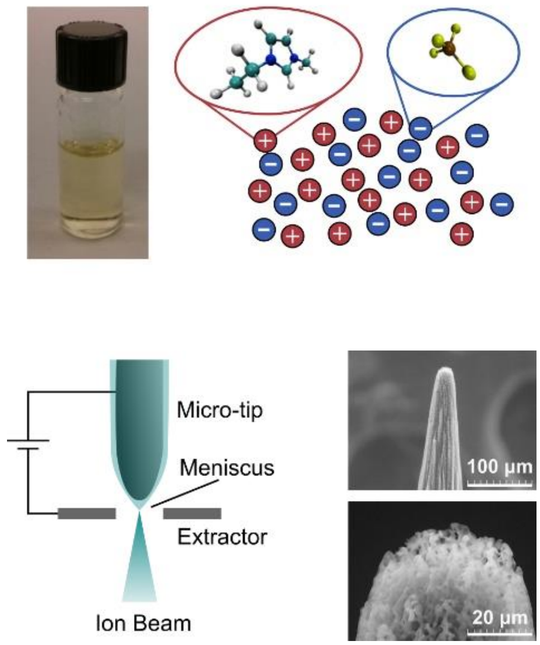
(a)



(b)

Figure 1: (a) The Ionic liquid 1-ethyl-3-methylimidazolium tetrafluoroborate, EMI-BF_4 (b) ILIS Schematic and scanning electron micrographs of a porous ILIS emitter tip.