Characterization of a Silica Nanoparticle Ion Source

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Electrosprays have been adopted in a wide variety of applications, including micro and nanoscale additive manufacturing due to their ease of control, high deposition efficiency, and precision thin-film coating [1][2]. Electrosprays are used in the manufacturing of solar cells, semiconductors, and other microelectronics [3][4] and have proven useful for drug and vaccine delivery [5]. A unique electrospray called a liquid nanoparticle ion source (LNIS) has recently been developed for spacecraft propulsion [6], and has applications for nanoparticle deposition and surface etching.

The LNIS uses a unique neat fluid called nanoparticle ionic materials (NIMs) that was developed in the Giannelis group at Cornell University as an electrolyte [7]. NIMs are materials consisting of charged nanoparticles that are neutralized via counter-ions, analogously to ionic liquids. The fluid properties of the NIMs can be tailored by the selection of nanoparticles and neutralizing canopy, including the charge-to-mass ratio. A simplified diagram of an individual nanoparticle and polymer canopy system is shown in Fig. 1. The NIMs fluid used in this work is based around silica-oxide nanoparticles with an average diameter of 15 nm neutralized by a Jeffamine M-600 polymer canopy, though the size, material, and polarity of the nanoparticles and neutralizing polymers can be tailored to the needs of the application.

This work describes and characterizes an ion beam from an LNIS using a capillary feed system. Time of flight mass spectrometry (ToF-MS) will be used to determine the charge to mass ratio of the multiply charged nanoparticles and estimate the total mass flow of the ion beam. Retarding potential analysis (RPA) will be used to measure the energy profile of the ion beam. A quartz crystal microbalance (QCM) will be used to measure the etching rate of a conductive film driven by the ion beam. Finally the emitted beam current will be measured for extracting potentials up to $\pm$ 10 kV.

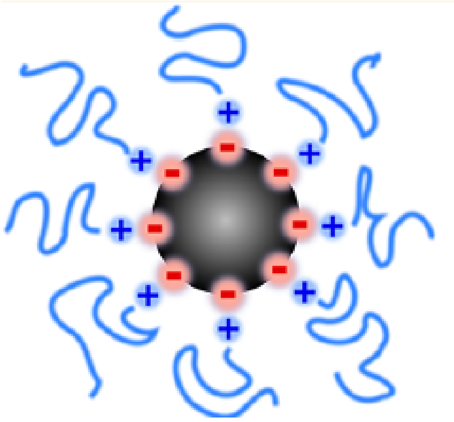

Figure 1: Silica-oxide nanoparticle surrounded by polymer canopy

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