Master thesis and internship[BR]- Master's thesis : Reconstruction of Electrospray Emitted Current using Computed Tomography[BR]- Internship

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Reconstruction of Electrospray Emitted Current Using Computed Tomography

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This work aims to reconstruct the current emitted by an electrospray thruster using computed tomography, a technique that enables detailed cross-sectional imaging of the emission pattern. Electrospray thrusters, known for their efficiency in space propulsion, require precise characterization of their emission profiles to optimize performance.

The electrospray thruster is divided into two main parts: the emitter and the grid. The emitter is the part of the system where the ionic liquid (the propellant) is exposed to the electric field, ultimately generating thrust. The grid on the other hand will generate the electric field in itself. FIGURE 1 shows one of the hundred and one cones composing the emitter and how the particles are ejected from it.

An experimental setup was developed featuring ATHENA, the electrospray thruster designed by ienai SPACE, along with a tomography assembly that includes a wire collector and two motion stages: linear and rotary. This set-up is illustrated on FIGURE 2. This configuration allows for precise scanning of the thruster's emission profile.

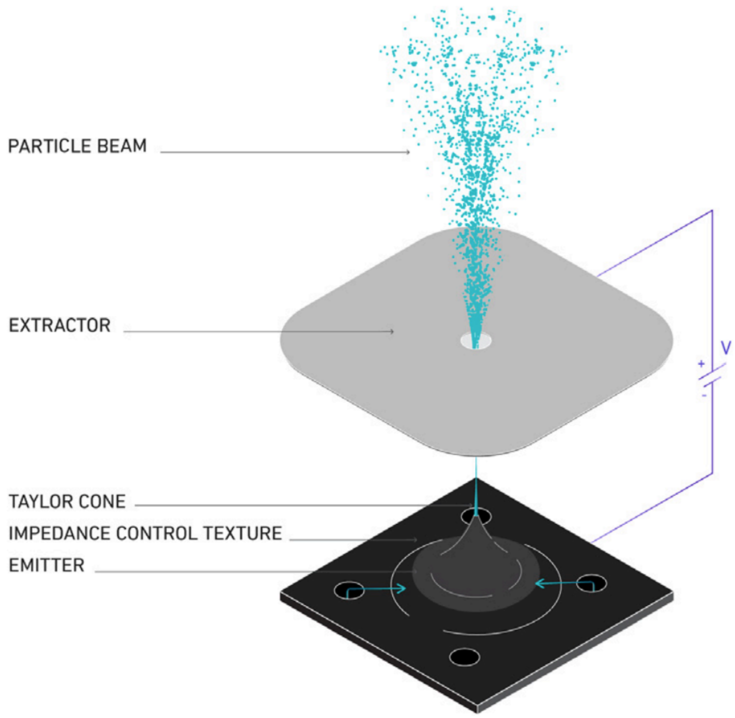


Figure 1: Electrospray

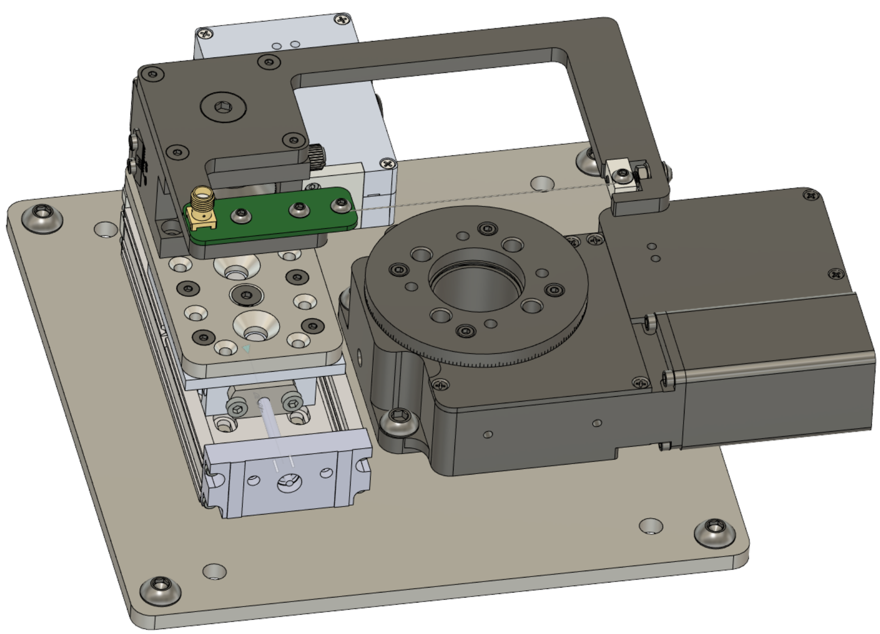
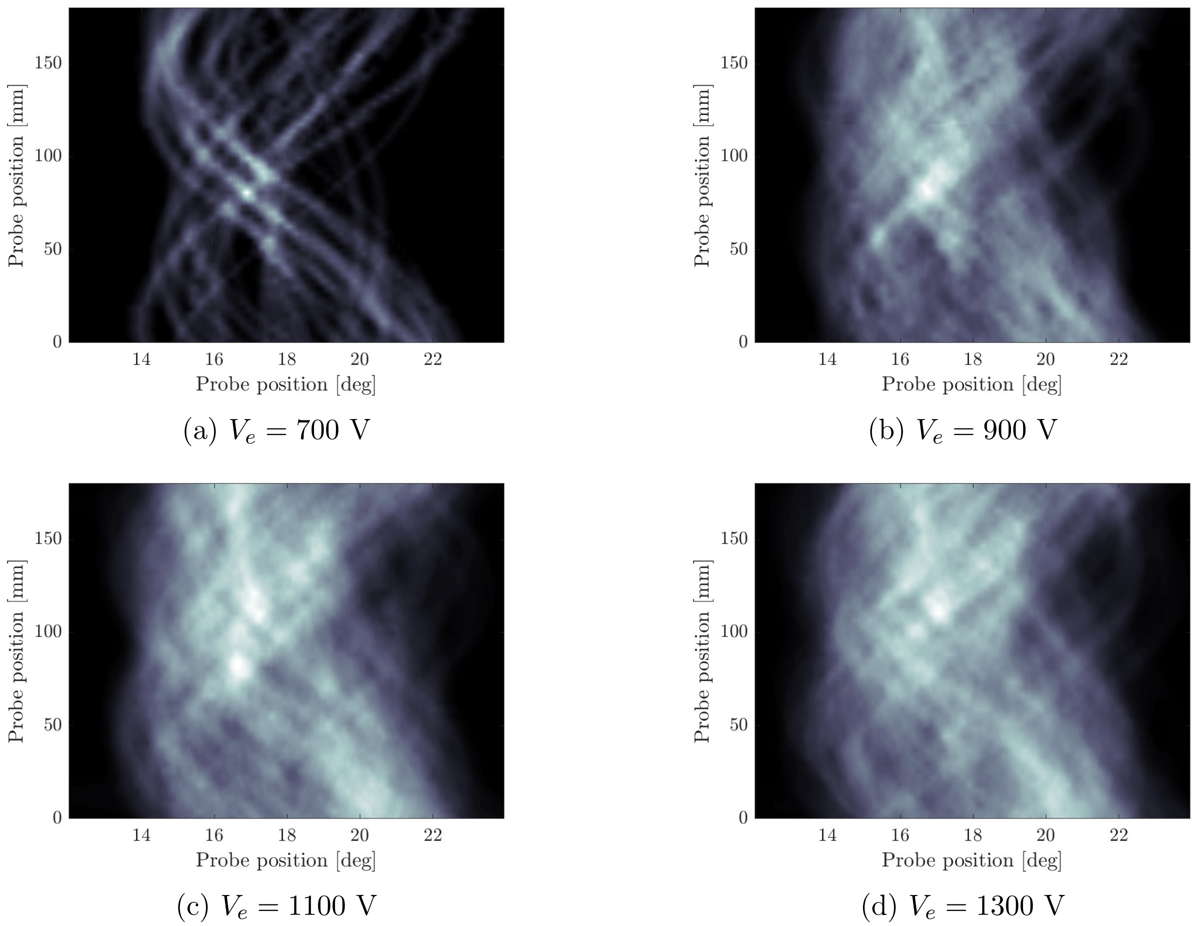


Figure 2: Set-up for tomography

To facilitate the reconstruction process, MATLAB codes were developed to simulate the emission patterns under various conditions. These simulations played a crucial role in visualizing expected outcomes and optimizing experimental parameters, such as the distance between the wire and the thruster. Data was generated across voltage levels ranging from 700 V to 1300 V, which was used to create graphical representations of current intensity as a function of the stages' positions, known as sinograms. These sinograms were then processed using the inverse Radon transform to reconstruct the emission pattern as an image.

FIGURE 3 illustrates the sinograms created from the collected data, prior to applying the inverse Radon transform. The results confirm that an increase in data points enhances the clarity and detail of the resulting sinograms. While the number of sinusoidal patterns changes with variations in voltage, the intensity information remains consistent across the sinograms. This consistency is due to the use of the same thruster throughout the testing campaign, ensuring that any variations observed in the sinograms are a result of changes in voltage rather than inconsistencies in the thruster's performance.

The resulting images of the current aligned with the simulation predictions, and revealed non-uniform emission across the thruster. These results are observed on FIGURE 4. As the voltage increases, the emission spots become more defined, offering a clearer understanding of the emission pattern. This improved clarity at higher voltages highlights the correlation between applied voltage and emission site visibility, further validating the simulation's predictive capability. This non-uniformity, although expected due to manufacturing tolerances, provides valuable insights into the thruster's performance characteristics. The detailed analysis of these images suggests that certain regions of the thruster may require design modifications to improve emission uniformity.



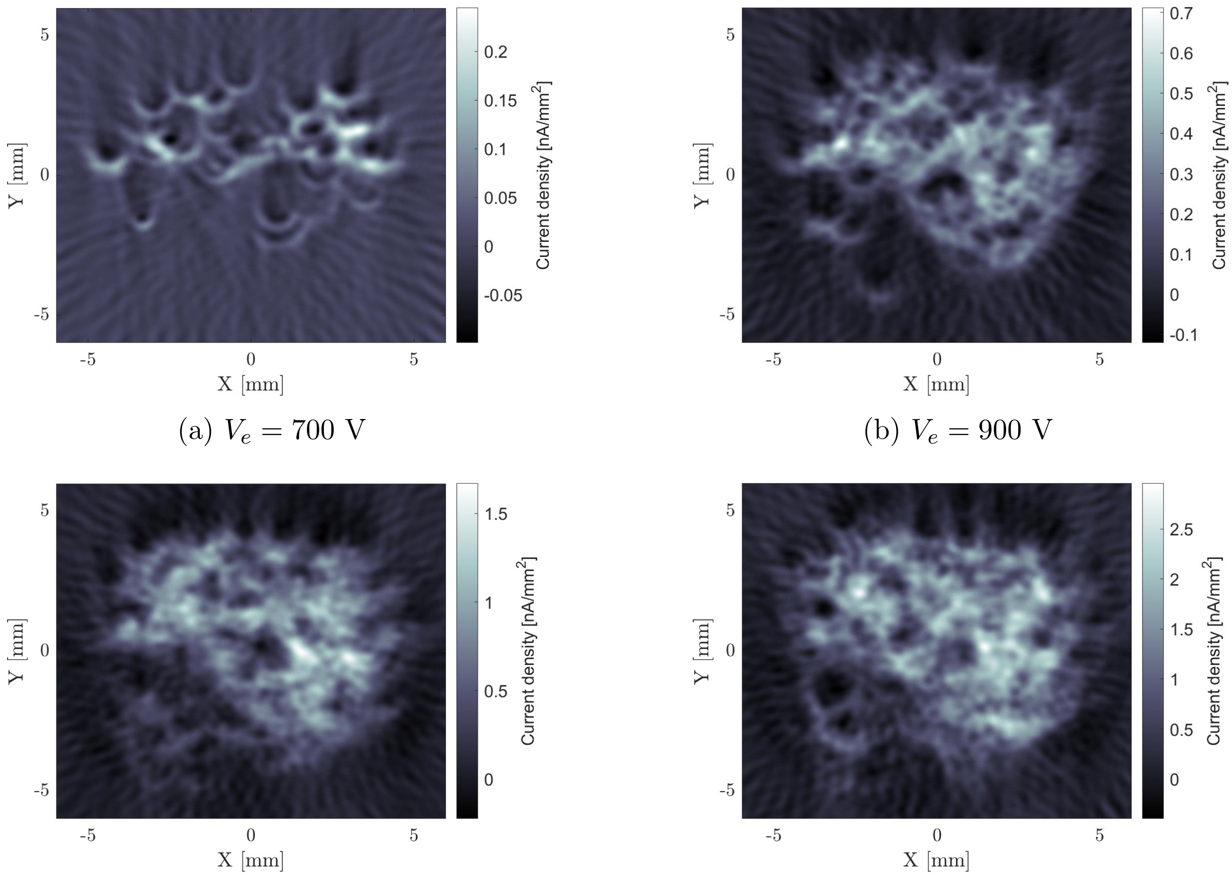
(a) $V_e = 700$ V

(b) $V_e = 900$ V

(c) $V_e = 1100$ V

(d) $V_e = 1300$ V

Figure 3: Sinograms



(a) $V_e = 700$ V

(b) $V_e = 900$ V

(c) $V_e = 1100$ V

(d) $V_e = 1300$ V

Figure 4: Intensity maps