Ion energy distributions from the impact of an atmospheric dielectric barrier discharge plasma jet on surfaces

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Abstract: In this contribution, we report measurements of ion energy distribution functions (IEDF) of ions from a helium dielectric barrier jet by energy-resolved molecular beam mass spectrometry. The plasma generates plasma bullets impacting a 50 µm orifice for species sampling. In the case of a dielectric orifice, a high-energy tail in the IEDF is observed, whereas the IDEF is centred below 1 eV for a metallic orifice. This is consistent with simulations from the literature.

1. Introduction

Atmospheric-pressure plasma jets are an important application of plasmas for biomedical applications. A typical dielectric barrier discharge plasma jet consists of a quartz capillary with two ring electrodes wrapped around to launch an ionization wave (plasma bullet) along the effluent. When these streamers impact a surface, ions may contribute to the species flux.

This contribution addresses the question of whether energetic ions may reach the surface in the highly dynamic environment of an impinging streamer. Because the electric field at the streamer head is very large, one may speculate that high-energy ions can reach the surface at considerable energy within a mean free path length. Here, we use molecular beam mass spectrometry (MBMS) with an energy filter to study the ions from a dielectric barrier discharge plasma jet.

2. Methods

The plasma setup follows a previously published design [1]. A dielectric barrier plasma jet in helium expands into open air. The plasma bullets impinge on the orifice of the MBMS system at a distance of 13 mm. The species are sampled from the plasma with a 40 µm metallic orifice or with a 50 µm ceramic orifice. The MBMBS setup is described elsewhere [2].

3. Results and Discussion

Figure 1 shows time-resolved IEDFs of O_2^+ ions from a metallic (top) and a ceramic orifice (bottom). The left panels show the IEDFs at different times. These IEDFs are extracted from the measured 2d maps of energy versus time by the MBMS system following the contours of identical impacting times at the orifice but different arrival times at the detector in the MBMS induced by the energy-dependent time of flight (dashed lines in the right panel). One can see that the IEDFs contain a high-energy tail for the ceramic orifice. This is consistent with simulations of Babaeva and Kushner [3]. In the case of a ceramic orifice, the potential drop from the plasma to the orifice is preserved much longer in the dynamic situation because the high dielectric constant and, thus the higher capacity of the ceramic requires a longer time to charge up the orifice surface, so that the electric field is sustained much longer compared to a metallic surface.

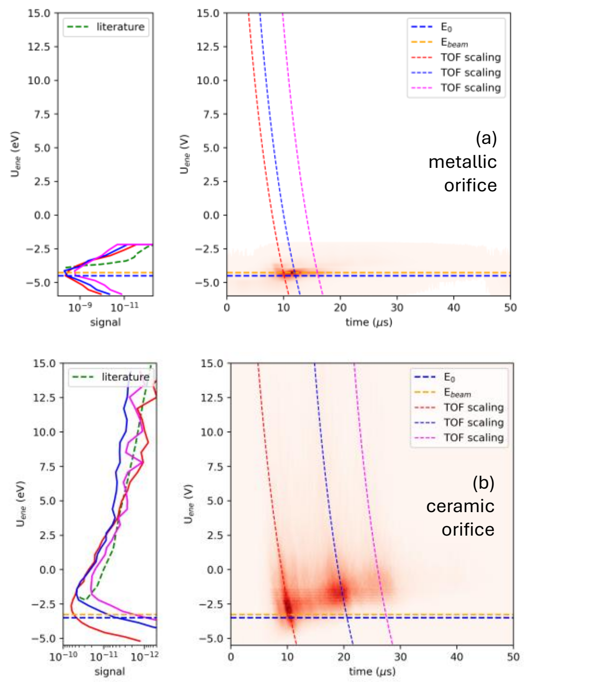

Fig. 1. Time-resolved IEDFs for a metallic (a) and a ceramic (b) orifice. The lines on the right panels indicate the shift due to the energy dependence of the time of flight in the MBMS.

4. Conclusion

The IEDFs of ions from a DBD jet impacting on a surface have been measured by energy-resolved MBMS. In case of a ceramic surface, much higher energies are found.

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References

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