

Measurement of Helium Metastable Atom Densities in a Plasma-Based Ambient Ionization Source

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1. Representative Helium Emission and Helium Metastable Fluorescence Images

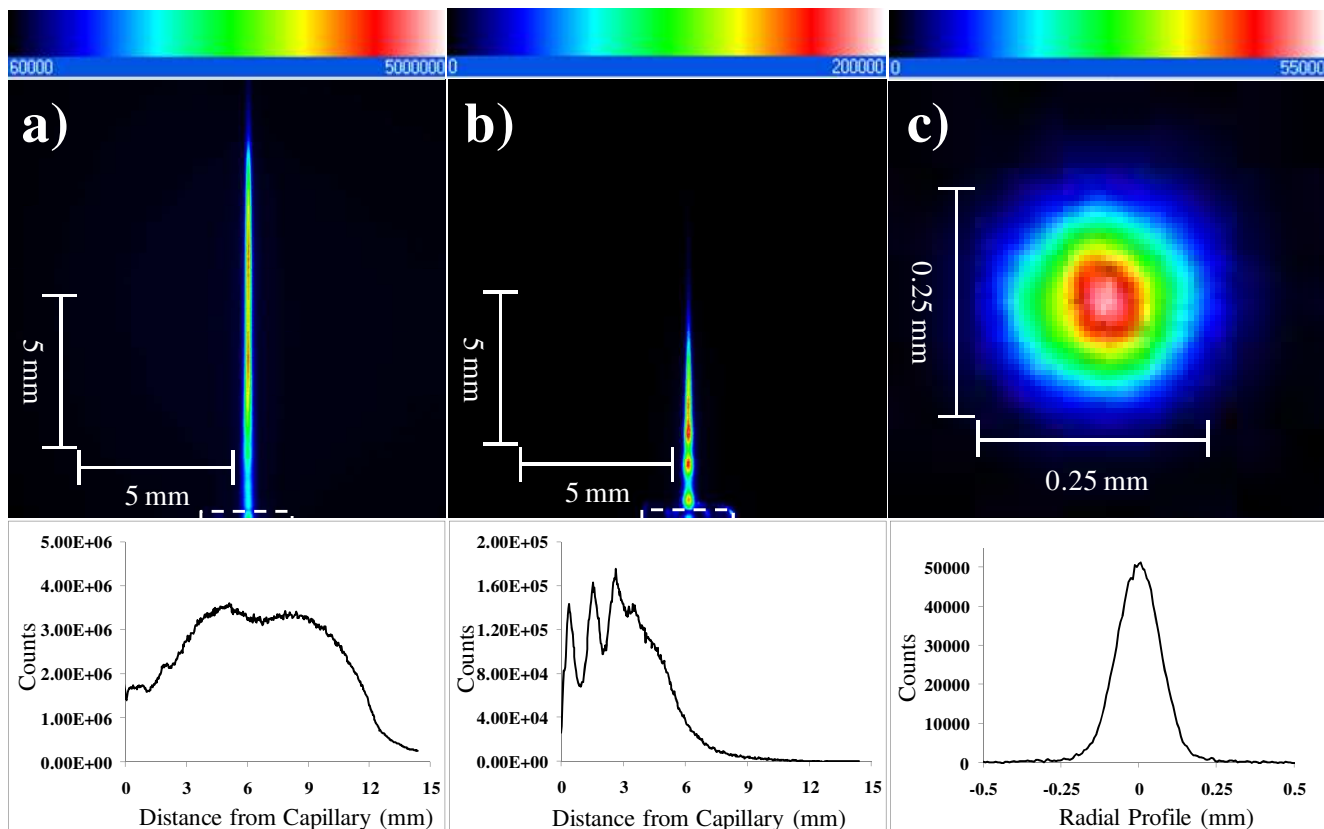


Figure S-1: Side-on images of a) He emission at 587.6 nm, b) He_m fluorescence at 587.6 nm, and c) end-on image of He_m fluorescence at 587.6 nm, and their related cross sections taken at optimal parameters. The radial profile was taken with the laser sheet intersecting the plasma 4 mm downstream from the end of the capillary.

Representative emission and fluorescence images are shown in Figure S-1. The position of the tip of the capillary is shown by a white dashed line in Figures S-1 a) and S-1 b). The capillary is approximately 3mm in diameter. Some residual laser scatter is visible on the tip of the capillary in Figure S-1 b). Cross sections provide axial and radial profiles of the emission and fluorescence images. The false color scales range 60,000 to 5,000,000, 0 to 200,000, and 0 to 50,000 counts for images a, b, and c respectively.

2. Time Resolved Helium Emission Images

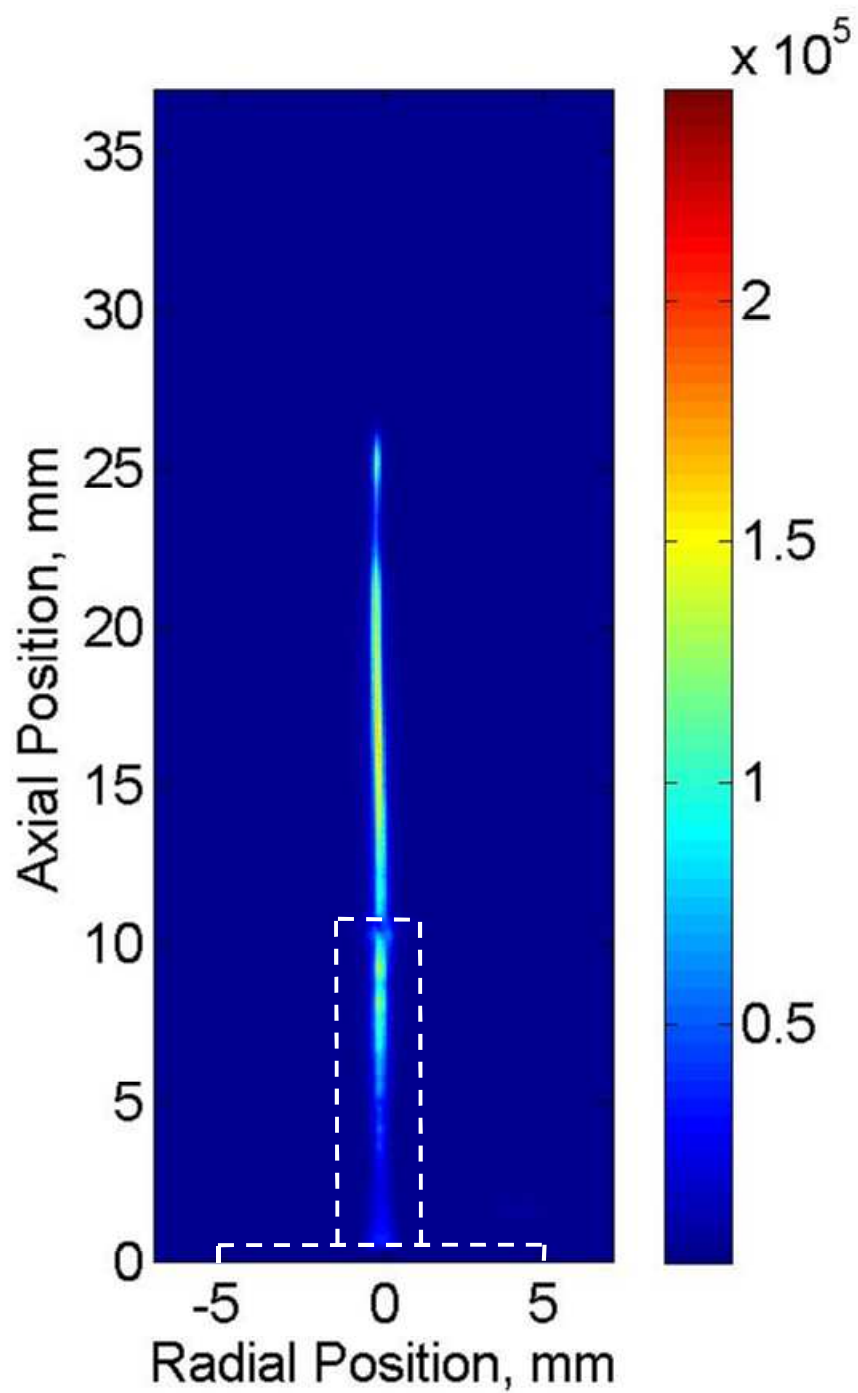


Figure S-2: Representative He emission images at 587.6 nm, taken from the time resolved imaging data at 1 to 3 imaging. Vertical and horizontal scales are given. The position of the tip of the capillary and ring electrode is shown by a dashed line.

For 1:3 imaging of the plasma, emission was collected with a pair of matched achromatic doublets having focal lengths of 100 mm and 300 mm. A Semrock FF01-588/21-25 bandpass filter was placed between the achromatic doublets for spectral filtering of the emission. The emission was focused onto a PI-MAX iCCD. The emission images were collected in gate mode with images consisting of 35,000 gates/exposure and 5 software accumulations. The 20 ns gate was triggered externally by a delay generator with a delay of 250 μ sec which was triggered by the waveform of the rf power supply. The 250 μ sec delay was necessary in order to image 1 of every 88 cycles at a frequency tolerated by the iCCD. 100 images were accumulated at increments of about 30 nanoseconds across a single cycle of the voltage waveform, with delays of 25 to 3000 ns. Because of the method used to reduce the sampling frequency, frequency drift during the course of the experiment is expressed as a drift in the gate with respect to the calculated delay. There is an uncertainty in the position of the gate indicated in the video of about 150 ns.

Several interesting features of the time-resolved data merit comment. The region of bright emission moves from just above the ring electrode to near the top of the image in approximately 1 μ s. This corresponds to a rise velocity of about 30,000 m/s, far too fast for it to be indicative of material transport. Rather, it appears to be direct reheating of the partially ionized helium by the applied voltage. The plasma above the tip of the capillary is never completely quenched. Most of the excitation of the helium occurs during the rising half of the voltage waveform, but there is clearly some excitation occurring during the falling portion as well. The separation of a small, excited region near the top of the voltage waveform may, given the uncertainty in the gate position, be associated with the voltage peak. These phenomena are similar to those reported in published, time-resolved studies of dielectric barrier discharges.^{1, 2}

- (1) Teschke, M.; Kedzierski, J.; Finantu-Dinu, E. G.; Korzec, D.; Engemann, J. *Plasma Science, IEEE Transactions on* **2005**, *33*, 310-311.
- (2) Shi, J.; Zhong, F.; Zhang, J.; Liu, D. W.; Kong, M. G. *Physics of Plasmas* **2008**, *15*, 013504-013505.