DOE Plasma Science Center

Visiting Graduate Student/Post Doctoral Researcher Fellowship Report

Date:	09/06/12	
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Title of Project:	Measurements of the Sheath Surrounding an Electron Emitting Surface	
Dates of Visit:	**Start:** 8/19/12	**End:** 9/1/12

Description of Project and Research Conducted:

The purpose of the collaborative effort between the University of Wisconsin (JP Sheehan) and Sandia National Laboratories (Ed Barnat and Brandon Weatherford) was to make electrostatic probe and Laser-Collisional Induced Fluorescence (LCIF) measurements of the sheath surrounding a planar electron emitting surface to test JP's theory of the emissive sheath potential's dependence on plasma electron temperature. These goals were completed during the two weeks of JP's visit and both parties were exposed new techniques and methodologies.

This interaction brought together two sets of expertise that enabled the testing of JP’s theory in a way that could not have been done without the on-site visit and time spent in the host’s lab. Specifically, the Sandia team utilized a pulse modulated capacitively coupled RF helium plasma to produced to a broad range of electron temperatures during the decay of the plasma in the afterglow. Laser based measurements of electron densities using techniques developed at Sandia were also performed during the visit. This interaction was useful to familiarize JP with practices and procedures used at another Plasma Science Center facility. JP introduced an emissive probe and a Langmuir probe into the plasma environment and measured plasma potential and electron temperature during the decay. The Sandia team was exposed to the workings of the inflection point technique and they plan to make use of it in other experiments.

The first week consisted primarily of building the Langmuir and emissive probe electronics so current-voltage (I-V) characteristic traces could be measured and determining how best to make measurements in the afterglow. The parameters of interest were the floating potential of the Langmuir probe, the floating potential of the planar emitter, the plasma potential, and the electron temperature, all as a function of time. Measurements of the electron temperature were made using the “slow-sweep” Langmuir probe method developed at the University of Wisconsin. For a given bias voltage, the current to the probe was measured as a function of time. When this was done for many bias voltages, the data could be transposed to extract the I-V trace as a function of time. From this information, the electron temperature could be extracted.

To measure the plasma potential, the emissive probe method of the inflection point in the limit of zero emission was used. It had been accepted that this method's weakness was that it could not be used to measure time varying plasma potentials, but by extending the slow-sweep method to emissive probes we were able to make accurate, time-resolved plasma potential measurements for the first time, using this technique.

JP's theory predicts that when the plasma electron temperature is small (within a factor of 10 of the emitted electron temperature), the emissive sheath potential will be smaller by a factor of 2 than that predicted by the commonly used fluid theory. As the electron temperature gets larger, the sheath potential begins to approach that predicted by the fluid theory. The data collected during JP's visit to Sandia provides evidence supporting this theory. Figure 1 shows that the normalized sheath potential depends on the plasma to emitted electron temperature ratio in the same way as predicted by theory.

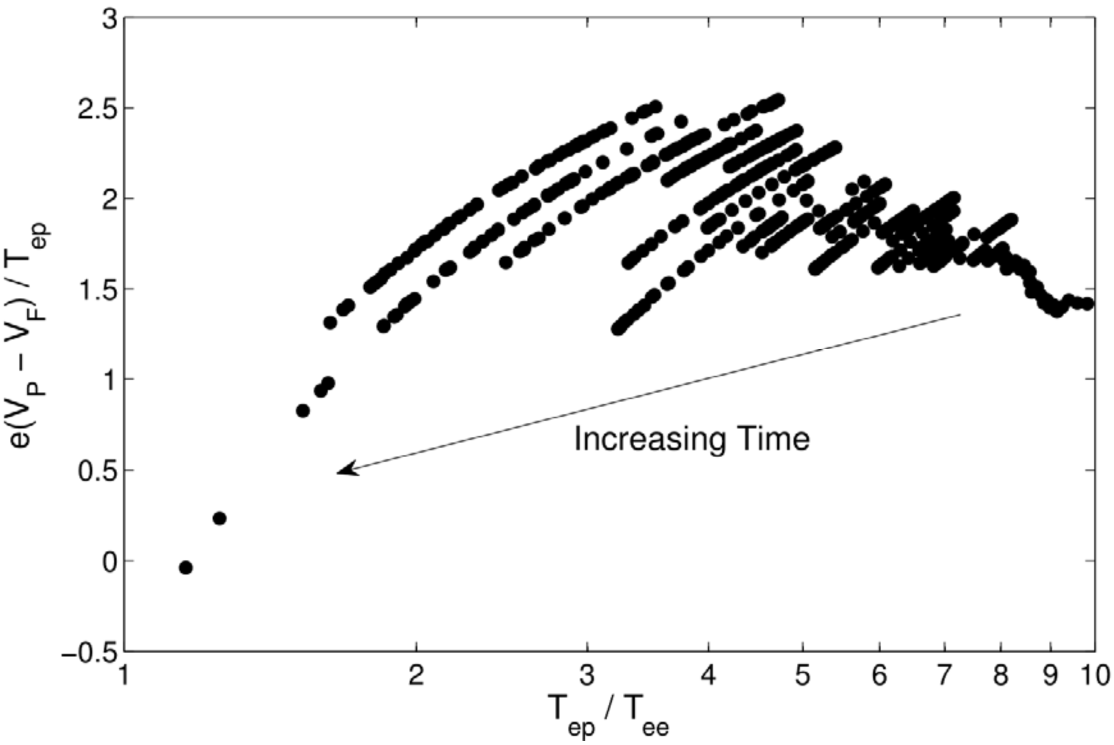

Figure 1: Normalized sheath potential versus plasma to emitted electron temperature ratio

Some preliminary LCIF measurements were made in this system as well, though low densities made resolving the sheath structure difficult. However, the data indicates that the presheath of an emitting surface is much less pronounced than that of a collecting sheath (see Fig. 2). This may suggest that ion behavior in the emissive sheath is not what is expected, though a more rigorous investigation into this phenomenon is needed.

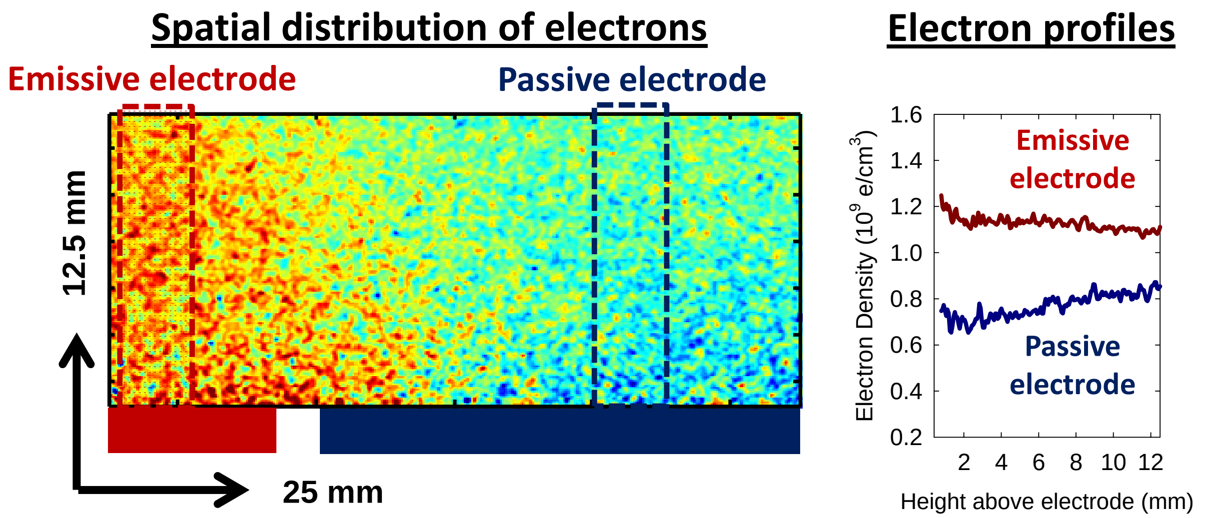

Figure 2: (Left) Two-dimensional profile of electron densities around the emitter surface and (Right) profiles of electron densities above the two electrodes. Measurements were made 50 μs after the RF power was turned off.