B-I23 AAPPS-DPP2018

2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

On the importance of determining the momentum transfer from process plasmas to solid surfaces

Thomas Trottenberg, Alexander Spethmann, and Holger Kersten
Institute of Experimental and Applied Physics, University of Kiel
e-mail (speaker): trottenberg@physik.uni-kiel.de

Plasma-wall interactions in low-temperature plasmas are usually considered with respect to electric currents and heat flux to the wall, sputtering, ion implantation, deposition, secondary electron emission and surface reactions, to mention the most important aspects. In contrast, the forces that plasmas exert on walls have never been a major topic.

This contribution shows, that force measurements could provide valuable information about the composition of the impinging particles, in particular about the fast neutral species. Neutral species created by charge-exchange collisions, e.g. [1], are usually not negligible with respect to plasma-wall interactions. In case of electrostatic methods, i.e. Langmuir probes, Faraday cups, and retarding field probes, an *electric* current is measured that results only from the collected (and emitted) *charged particles*. Calorimetric probes have been applied for plasma diagnostics [2], and they are sensitive to the neutral particles; however, additional contributions, for example from chemical reactions, condensation and film deposition, evaporation and sputtering, heat conduction, and radiation, may play important roles and can make the interpretation of the measured data a very puzzling task.

Recently, we reported on simple experiments that allowed measurements of the forces exerted by low-temperature plasmas on boundaries [3,4]. The measured "plasma pressures" were in the order of magnitude of up to a few times the electron pressure close to the sheath edge, i.e. some 10 mPa.

The talk will discuss the forces using a simple model that describes the momentum fluxes across the sheath edge. It is concluded that ion-neutral collisions in the presheath can enhance the force caused by electron pressure and ion flux by a larger accelerated mass consisting of ions and fast neutral atoms.

The force probe consists basically of an elastic cantilever and a test surface attached to its free end (see Fig. 1). The displacement of a few microns is measured interferometrically and translated into the causing force by calibration. The probe with its small test surface (a few cm²) is integrated into a bigger plane surface, which could be a solid boundary or an electrode. A detailed description of the force measuring technique can be found in [5].

Measurements in capacitively coupled radio-frequency plasmas and microwave generated plasmas are discussed in the light of simple models, e.g. [6].

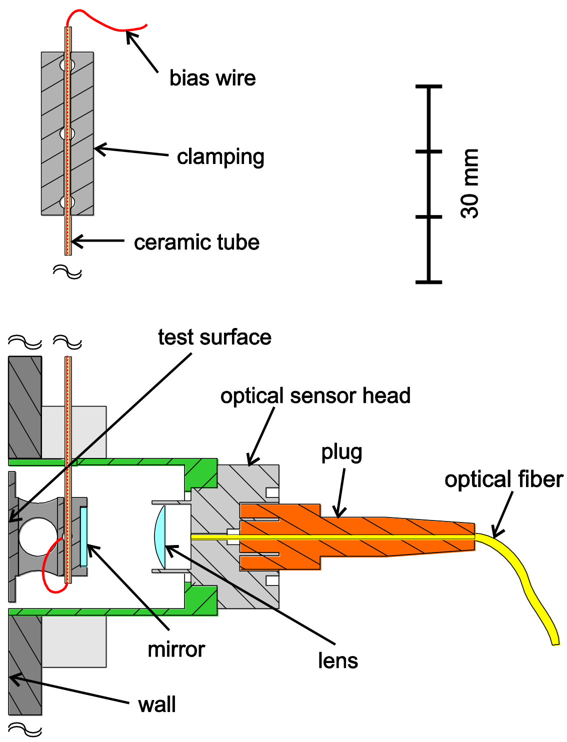

Figure 1. Schematic of the solid boundary (wall or grounded electrode) with integrated force probe. The ceramic tube serves as elastic cantilever; it has one fixed end at the clamping cylinder; the free end is at the test surface facing the plasma and the mirror at the back.

References
[1] G. Makrinich, A. Fruchtman, D. Zoler, and R. L. Boxman. J. Appl. Phys. 123, 173302 (2018).
[2] S. Gauter, M. Fröhlich, W. Garkas, M. Polak, H. Kersten. Plasma Sources Sci. Technol. 26, 065013 (2017).
[3] T. Trottenberg, T. Richter, and H. Kersten. Eur. Phys. J. D 69, 91 (2015).
[4] T. Trottenberg and H. Kersten. Plasma Sources Sci. Technol. 26, 055011 (2017).
[5] T. Trottenberg, A. Spethmann, and H. Kersten. EPJ Techn. Instrum. 5, 3 (2018).
[6] U. Czarnetzki and T. V. Tsankov, Eur. Phys. J. D 69, 236 (2015).