Non-conventional plasma and sheath diagnostics

H. Kersten, T. Trottenberg, V. Schneider, S. Gauter, and F. Haase
Institute for Experimental and Applied Physics, University of Kiel,
Leibnizstrasse 19, D-24098 Kiel, Germany

In addition to well-established plasma diagnostic methods (Langmuir probes, optical emission spectroscopy, mass spectrometry etc.) we perform examples of "non-conventional" diagnostics [1] which are applicable in technological plasma processes for particle formation, surface structuring and thin film deposition:
i) The total energy influx from plasma to substrates can be measured by special calorimetric probes based on the determination of the temporal slope of the substrate surface temperature during the plasma process (e.g. magnetron sputtering) [2-4]. By comparison with model assumptions on the involved plasma-surface mechanisms the different contributions to the total energy influx can be separated.
ii) For a variety of thin film applications it is essential to determine the sputtering yield as well as the angular distribution of sputtered atoms. For this purpose we developed a novel and rather simple method, the so-called sputtering-propelled instrument (SPIN) [5]. Comparison of the measurements with simulation yields valuable information on the sputtering mechanisms and support validation of related sputter codes. The angular distribution of sputtered particles has also been measured by a sensitive pendulum which is commonly used for thrust measurements in ion beam sources for space propulsion systems. This method even works for measuring the momentum transport in the sheath of an rf-plasma [6].
iii) The electric field in front of walls has been experimentally determinded by using microscopic test particles which are confined in the plasma sheath and manipulated by an optical tweezer system [7].

[1] T. Trottenberg, A. Spethmann, A. Rutscher, H. Kersten., Plasma Phys. Control Fusion **54** (2012), 124005.
[2] I. Levchenko, M. Keidar, S. Xu, H. Kersten, K. Ostrikov, J. Vac. Sci. Technol. B **31** (2013), 050801.
[3] H. Kersten, H. Deutsch, H. Steffen, G.M.W. Kroesen, R. Hippler, Vacuum **63** (2001), 385-431.
[4] F. Haase, D. Lundin, S. Bornholdt, H. Kersten, Contrib. Plasma Phys. **55** (2015), 701-713.
[5] J. Rutscher T. Trottenberg, H. Kersten, Nucl. Instr. Meth. Phys. Res. B **301** (2013), 47-52.
[6] T. Trottenbrg, T. Richter, H.Kersten, Eur. Phys. J. D **69** (2015), 91.
[7] V. Schneider, H. Kersten, Problems of Atomic Science and Technology **1** (2013), 164-167.