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Hiden ESPion plasma probe measurements on a hollow-cathode based large-volume plasma source

Vacuum-based surface engineering and coating processes require plasma sources generating a high charge carrier density in order to achieve enhanced sputter and activation effects. Fraunhofer FEP is providing a hollow-cathode based plasma source, which produces homogeneous large-volume plasmas of up to 1 m^3 with maximum plasma densities of more than 10^{12} cm^{-3} at chamber pressures between 0.1 and 10 Pa. The cathode tube is flown through by the working gas such as argon with flow rates between 8 and 100 sccm. A diffuse arc discharge with currents up to 200 A between the inner cathode tube surface and the surrounding annular anode is ignited and amplified by an axial magnetic field with field strengths up to 100 mT.

In order to characterize the plasma plume and to study the discharge mechanisms of the hollow cathode, extensive measurements with the Hiden ESPion plasma probe have been carried out. The probe tip was moved by a linear Z-motion drive up to 60 cm into the chamber at three axial distances from the hollow cathode device (30 cm, 70 cm, and 125 cm) yielding spatial distribution of plasma parameters. It was found that reducing the gas flow through the cathode tube results in drastically increased plasma density and range. Furthermore, the measurements show the pressure dependence of the axial plasma density decay and of the electron temperature. At high gas pressures, the plasma is more concentrated near to the hollow cathode, and the Maxwell-distributed electrons have lower energies. On the other hand, low gas pressures lead to a beam-like character in the vicinity of the hollow cathode and to a low axial and lateral density decay, exhibiting pronounced homogeneity. Comparable results have been found in nitrogen and oxygen atmosphere, where additional optical and mass-spectrometric analysis revealed strong excitation and dissociation of the reactive gas molecules.

The high efficiency of the plasma source was already shown in various applications such as high rate plasma etching for substrate pretreatment, plasma-activated evaporation of metal and oxide layers for corrosion protection, plasma-assisted reactive magnetron sputtering of hard and wear-resistant coatings, and plasma-enhanced chemical vapor deposition. The Hiden ESPion plasma probe has been shown to be an excellent tool for the quantification of plasma effects and the development of new plasma processes.

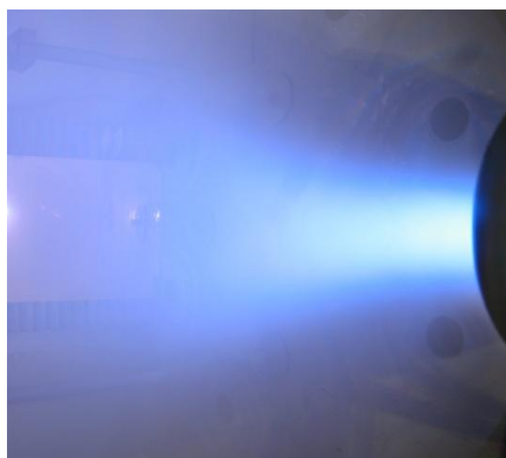

Fig. 1: Hollow cathode plasma plume

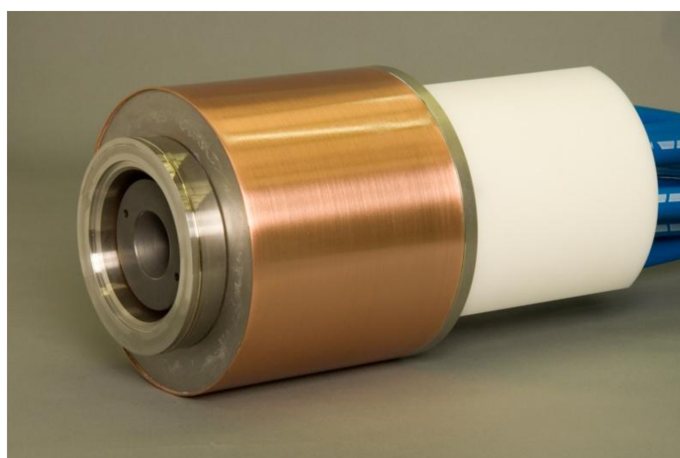

Fig. 2: The hollow-cathode based plasma source

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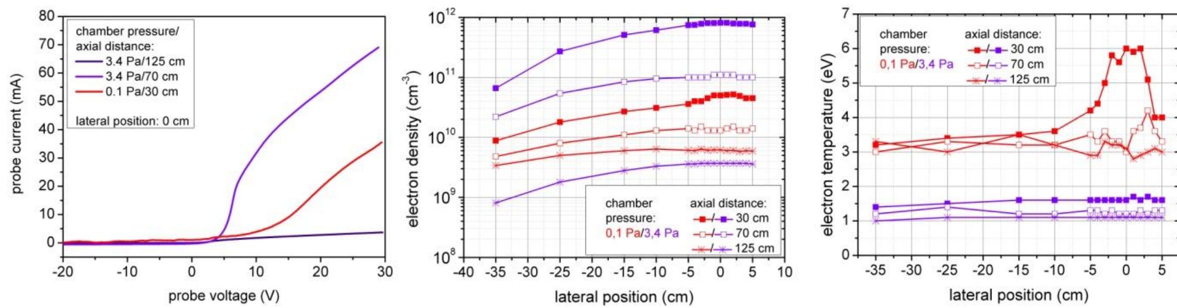

Fig. 4: Plasma probe measurement results

(a) Probe characteristics
(b) and (c) Lateral density and electron temperature distribution at different axial positions and chamber pressures (discharge current: 50 A, cathode gas flow: 10 sccm)

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B. Zimmermann, F. Fietzke, W. Möller: "*Spatially resolved Langmuir probe measurements of a magnetically enhanced hollow cathode arc plasma*" Surface and Coatings Technology, Volume 205 Supplement 2 (2011), Pages S393-S396

Hiden Product:
ESPion Langmuir Probe
Follow the link to the product catalogue on our website for further information:
http://www.hidenanalytical.com/index.php/en/product-catalog/51-plasma-characterisation/80-hiden-espion-advanced-langmuir-probe-for-plasma-diagnostics