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

Influence of the electron extraction voltage on plasma parameters in a low pressure microwave microplasma as an electron source for a miniaturized mass spectrometer*

Patrick Hermanns[1], Stephan Westerdick[2], Benedikt Janssen[3], Simon Boeddeker[1] and Peter Awakowicz[1]

[1] Institute of Electrical Engineering and Plasma Technology, Ruhr-University Bochum, [2] Institute of Electronic Circuits, Ruhr-University Bochum, [3] Chair for Embedded Systems of Information Technology, Ruhr-University Bochum

e-mail (speaker): hermanns@aept.rub.de

Miniaturization of sensors and actuators is an important field of ongoing research with many applications. Devices on a micrometer- to millimeter-scale are often based on MEMS technology. The authors present a micro-fabricated mass spectrometer with integrated plasma source [1-2]. Doped electrically conducting silicon is etched and connected to borosilicate glass by anodic bonding. A membrane pump and a turbomolecular pump reduce the pressure to 10^{-5} mbar outside of the mass spectrometer chip. A hot filament is not suitable for the application as an electron source due to the relatively high gas pressure. Instead, an antenna creates a plasma (f = 2.45 GHz) inside a cylindrical volume of 300 µm in height and 250 µm in radius. Electrons inside the plasma chamber can be extracted into the mass spectrometer by applying a positive voltage opposite of an entrance slit. The aim of this work is to investigate the influence of an electron extraction on a small plasma volume.

Absolutely calibrated, space- and time-averaged optical emission spectroscopy (OES) is used to measure gas temperature, electron temperature and electron density in noble gas atmosphere with small additions of nitrogen [3]. Plasma parameters are measured under variation of forward generator power and electron extraction voltage.

Results show a rising gas temperature with higher forward generator power. Without electron extraction the electron temperature rises with increasing forward generator power from 3.58 eV to 4 eV. An electron extraction voltage of 70 V increases the electron temperature to 4.2 eV. Electron density measurements show a decrease in electron density with electron extraction turned on. This effect is reduced with increasing forward generator power. The electron extraction acts as a loss term in the electron particle balance with a constant generation term, which results in a lower electron number density. The outflow and acceleration of electrons explains the increase in electron temperature.

* The authors would like to thank the financial support by the Bundesministerium fuer Wirtschaft und Energie (BMWi, FKZ: 03ET1314B)

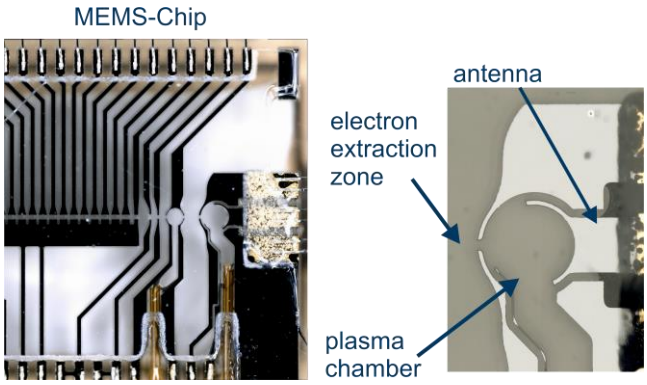

Figure 1: Microscopic image of the MEMS based mass spectrometer-chip (left) and image of the plasma chamber (right)

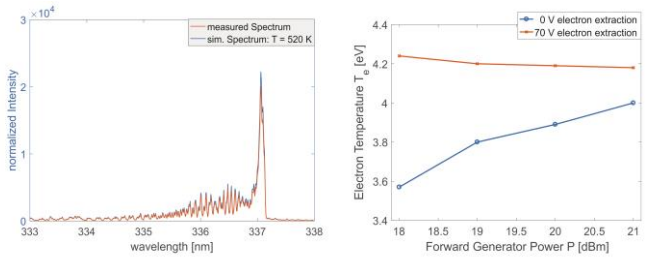

Figure 2: a) Measured and simulated spectra of N_2(C-B,0-0) in Ne/N_2 gas-mixture b) Electron temperature in the plasma chamber under variation of forward generator power and electron extraction voltage

References

[1] Wapelhorst et al, Sens. Actuators, A 138 (2007) 22-27
[2] Hauschild et al, J. Mass. Spectrom. 44 (2009) 1330-1337
[3] Bibinov et al, Meas. Sci. Technol. 18 (2007) 1327-1337