Ignition behaviour of atmospheric-pressure dielectric barrier discharges in argon with admixtures of hexamethyldisiloxane and tetramethylsilane

M. M. Becker[1], J. Philipp[2], A. K. Czerny[2], C.-P. Klages[2], and D. Loffhagen[1]

[1] *INP Greifswald, Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany*
[2] *TU Braunschweig, Institut für Oberflächentechnik, Bienroder Weg 54 E, 38108 Braunschweig, Germany*

The impact of small admixtures of the precursors hexamethyldisiloxane and tetramethylsilane on the ignition behaviour of dielectric barrier discharges in argon at atmospheric pressure has been analysed by means of a time-dependent, spatially one-dimensional fluid model and measurements. A drop of the ignition voltage by about 60 % is found when adding up to 200 ppm of precursor gas to argon. Very good agreement between measured data and modelling results is obtained when assuming that 30 % of the collisions between excited argon atoms and precursor gas lead to Penning ionization.

Dielectric barrier discharges (DBD) represent the main approach for plasma-enhanced chemical vapour deposition (PECVD) processes and facilitate the scale-up for industrial processing. Silicon-organic coatings can be achieved by mixing precursors like hexamethyldisiloxane (HMDSO) or tetramethylsilane (TMS) to the carrier gas used by the DBD [1]. A detailed understanding of the impact of the precursor admixtures on the discharge properties like ignition voltage and energy consumption is highly important for DBD-based PECVD processing. Here, a fluid modelling approach is combined with measurements to analyse the impact of small admixtures of HMDSO and TMS to argon on the ignition behaviour of the DBD.

The investigations were performed by means of the time-dependent, spatially one-dimensional fluid-Poisson model for argon DBD reported in [2], which was extended by an appropriate reaction kinetics for HMDSO and TMS, respectively. The numerical studies are based on the experimental conditions described in [1]. A symmetric plane-parallel electrode configuration was used with a thickness of the dielectrics of 2 mm and a gap width of 1 mm. The discharge is driven by a sinusoidal voltage supply at 86.2 kHz. The ignition voltage was determined by a stepwise increase of the applied voltage until the discharge was ignited and covered the entire electrode area of 8 cm^2.

Results of the ignition voltage in dependence on the precursor concentration x are shown in figure 1. It has been found experimentally that the ignition voltage U_i of the considered argon DBD decreases by about 60 % with the admixture of HMDSO and TMS, respectively, in the range from 0 to 200 ppm. The modelling-based analysis of the ionization budget shows that the impact of Penning ionization processes mainly causes the observed decrease of U_i. Very good agreement between measurements and numerical results was obtained using rate coefficients for the collisions of precursor gas with excited argon atoms based on the works of Jauberteau *et al.* [3,4] and a fraction of 30 % of these collision processes leading to Penning ionization.

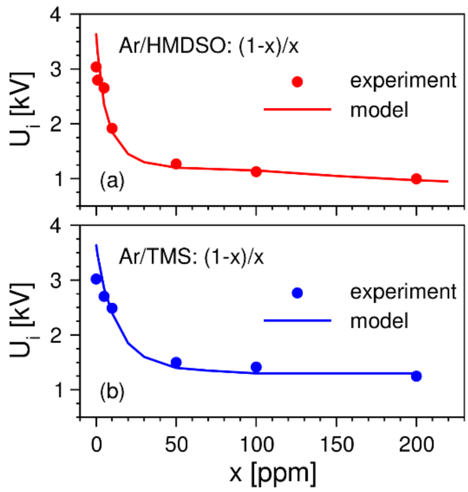

Figure 1: Ignition voltage in atmospheric-pressure argon DBD with admixtures of HMDSO (a) and TMS (b).

Acknowledgment

The work was supported by the German Research Foundation under grants LO 623/3-1 and KL 1096/23-1 as well as in the framework of the Collaborative Research Centre Transregio 24 “Fundamentals of Complex Plasmas”.

References

[1] J. Philipp *et al.*, Plasma Process. Polym. **13** (2016) 509–520.

[2] M. M. Becker *et al.*, J. Phys. D: Appl. Phys. **46** (2013) 355203.

[3] J. L. Jauberteau *et al.*, J. Phys. Chem. A **116** (2012) 8840–8850.

[4] J. L. Jauberteau *et al.*, Chem. Phys. Lett. **327** (2000) 351–358.