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Gas flow simulations of a DBD plasma for deposition processes in pipes

Mariagrazia Troia[1], Andreas Schulz[1], Matthias Walker[1], Sven Boehler[2], Florian Eder[2]

[1]IGVP, University of Stuttgart, Stuttgart, Germany [2]Siemens AG Corporate Technology, Erlangen, Germany

mariagrazia.troia@igvp.uni-stuttgart.de

Dielectric barrier discharges (DBD) at atmospheric pressure are known to be able to create thin layers by means of plasma enhanced chemical vapor deposition (PECVD). Such processes can also be employed to directly deposit thin coatings on the inner sides of pipes and ducts. To this purpose, a DBD electrode for PECVD coatings has been developed.
The experimental setup consists of an inner glass-covered electrode and the metal pipe wall acting as counter electrode. The carrier gas (air) admixed with the film precursor hexamethyldisiloxane (HMDSO) is injected into the gap between the electrodes, where the discharge is located and chemical reactions take place. The inner electrode is moved continuously and steadily through the pipe to achieve a thin and uniform layer along the whole pipe length.
In the current work, a model of the DBD reactor has been replicated by means of an FEM-based model with the aim to investigate the gas flow injected in the reactor: in order to ensure a homogeneous deposition both in thickness and in chemical composition, the monomer-based reactive species must be homogeneously distributed in the plasma phase along the whole deposition volume, with a long enough residence time to attain a higher deposition efficiency. Backflow and stark pressure gradients must also be avoided in order to prevent the formation of dust directly in the plasma phase or in the immediate after-glow. The inner electrode shape, size and conformation have been thus accordingly tuned and optimized.
Subsequently, the simulation model has been refined by taking into account the effects of the heat caused by the plasma itself, the deposition process and the compression/expansion of gas along the pipe. For this purpose, optical emission spectroscopy in the ultraviolet range and thermo-camera analyses have been employed as experimental reference for the FEM-model.

Keywords
Dielectric barrier discharge
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