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Atmospheric pressure plasma treatments inside meander-like cavities

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Atmospheric pressure non-equilibrium plasma jets are used in a variety of applications related to surface treatment. An important advantage of plasma jets is its ability to penetrate into small structures, such like cavities, gaps, crevices, and tubes. But, plasma-induced functionalization, cross-linking, and etching processes on plasma-exposed substrates leads to physico chemical changes in the surface properties, which in turn influence the performance characteristics. For this purpose, a three-dimensional polycarbonate module was used to demonstrate the capability of jet plasmas, driven at atmospheric pressure, to penetrate into small cavities accompanied by a detailed surface analysis applying X-ray photoelectron spectroscopy (XPS). Therefore, a 3D module, composed of 24 perforated polycarbonate (PC) slices was generated. The perforations of the PC slices are interconnected in a vertical direction producing meander-like channel configuration. Each slice was 0.5mm in height, and a stack of 24 slices generates pore channels of an overall longitude of around 1.2cm. However, in this study the impact of operating gas, namely Ar and Ar/O_2, and the influence of plasma treatment time on the surface properties of the end-layer is studied. Hence, the elemental composition was analyzed to gain insights in the extent of surface functionalization. Indeed, differences could be observed between the operating gases and the treatment times. For instance, no surface functionalization of the end-layer was observed after 30s Ar plasma whereas a significant increase in the O/C ratio was determined as well as an incorporation of nitrogen into the surface with an N/C ratio of 8% after 300s Ar plasma exposure. Moreover, an amino group density of approximately 1% was estimated. Summarizing, the plasma assisted creation of oxygen- and/or nitrogen-containing functionalities in small cavities in complex 3D geometries revealed the possibility to enhance the field of applications for plasma jets. Consequently, a careful choice of plasma parameters allows a user-defined tailoring of the surface properties.

Keywords
atmospheric pressure
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