Propagation of a nanosecond pulsed discharge in ambient air at atmospheric pressure along thin film and nanostructured surface

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Abstract

In this work, we have studied the plasma propagation in surface dielectric barrier discharge (SDBD) configuration in ambient air with specific multilayer materials. A silicon wafer covered by a silica layer (1µm thick) is first used as a propagation surface. The plasma is generated on the dielectric part of the surface, with a tungsten electrode touching the silica layer. Positive nanosecond voltage pulses with a low repetition rate (50 Hz) are used. The plasma is studied with fast ICCD imaging (PIMAX 4), time and space-resolved emission spectroscopy and current measurements. The surfaces are analyzed by space resolved Raman spectroscopy before and after plasma exposure. Single discharge events are visualized using a dedicated UV microscopy bench. Compared to a bulk material surface (glass) in exactly the same operating conditions, it first appears that this multilayer material has a strong influence on the plasma features. Instead of transient filaments more and less randomly distributed on the glass surface (fig.1a), the plasma exhibits a well-defined symmetric ring pattern, without any filaments (fig.1b). The ring pattern gradually expands on the surface during the positive voltage pulse and demonstrates high pulse-to-pulse reproducibility and stability.

When additional layers are deposited on the silica layer, the plasma still propagates with this stable ring structure. With an additional layer of a nanodiamond (300 nm thick), the plasma propagation distance and velocity are increased. Furthermore, the high pulse-to-pulse reproducibility of the ring plasma pattern results in local surface modification.

The generation of the stable ring plasma in ambient air at atmospheric pressure could be of interest for advanced plasma-surface interaction studies.

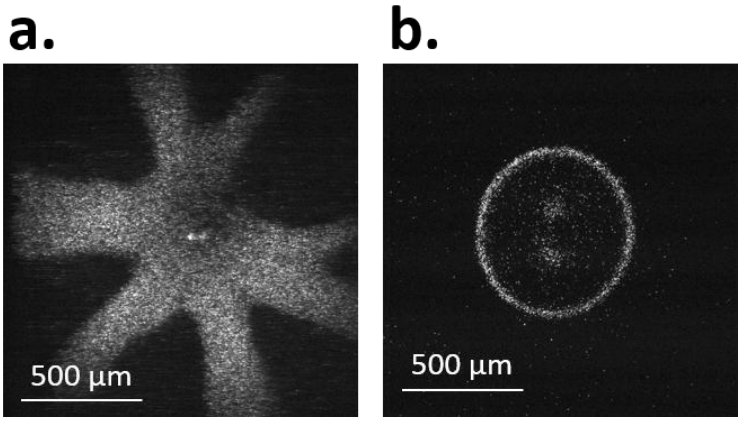

Figure 1: ICCD imaging of the plasma propagation on a glass plate (a.) and on a multilayer with a Si wafer covered by 1 µm of SiO_2 (b.). The images are taken in single shot and integrated 4 ns, in the same operating conditions.