Investigation of atomic oxygen density distributions in the free effluent of a micro-scaled atmospheric pressure plasma jet in front of a surface

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Reactive oxygen species such as atomic oxygen or ozone found in the post discharge effluent of a micro-scaled Atmospheric Pressure Plasma Jet (µ-APPJ) operated at a helium base gas flow with a minor admixture of molecular oxygen are supposed to be of major importance for bio-medical tissue treatment and for surface modifications such as wettability. Since the reactive mechanisms are still discussed detailed knowledge on the distribution of the reactive species close to the surface is of great importance. Models and numerical simulations proposed to understand the plasma-chemical processes in- and outside the discharge have to be cross-checked.

We report on measurements of the spatial distribution and its development of atomic oxygen from the discharge exit nozzle through the free effluent up to distances of about 250 µm in front of planar surfaces. Investigations were carried under variation of gas mixture, gas velocity and applied power. The effect of the effluent on various substrates (PET, glass, stainless steel, gold) and vice versa was investigated. Atomic oxygen was detected by means of two-photon laser induced fluorescence spectroscopy. In parallel, ozone density development has been investigated by UV absorption spectroscopy from the discharge core into the effluent. Surface analysis have been carried out with XPS.

The discharge is operated at a frequency of 13,56 MHz at sender powers of about 12 Watt. The gas flow is composed of 1.5 slm Helium and 9 sccm molecular oxygen. This mixture has been determined to be optimum for atomic oxygen production [1].

The local densities fall of from up to some 10^{156} cm^{-3} to about 10 % typically within the first few millimetres. The corresponding reaction time of ~50µs is independent of the operation parameters meaning stationary chemical processes in the effluent. PET and gold are discussed exemplarily for the interaction with the effluent. While PET behaves as an efficient drain for the atomic oxygen yielding extremely constricted interaction areas (Fig. 1) gold seems to provide a source of atomic oxygen and by this enlarges the reaction zone.

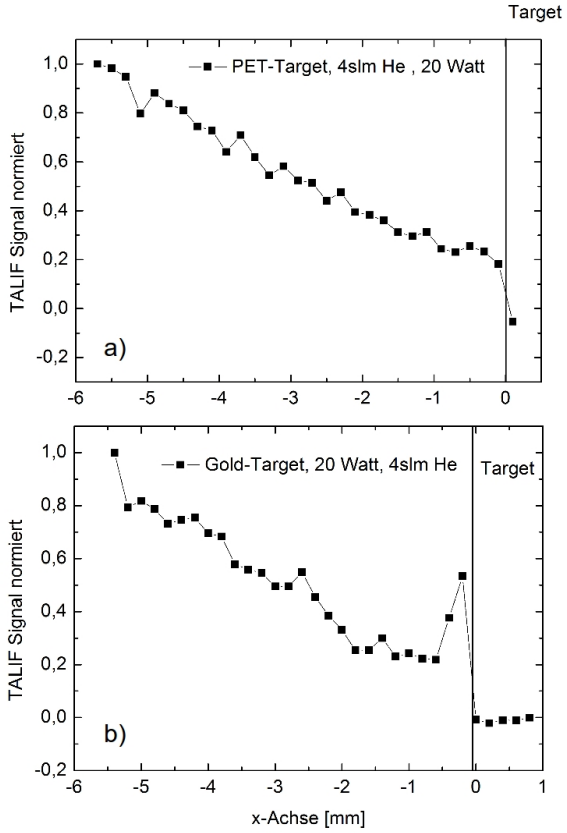

Fig.1: Oxygen concentration in front of a) a PET and b) a gold substrate

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[1] Nikolas Knake, Kari Niemi, Stephan Reuter, Volker Schulz-von der Gathen, and Jörg Winter, Appl. Phys. Lett. 93, (2008) 131503