Radial and temporal density profiles of $Ar(1s_5)$ metastables in a nanosecond pulsed plasma jet impinging on different dielectric surfaces

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We report on the radial-temporal distribution of $Ar(1s_5)$ absolute density in a cold nanosecond pulsed plasma jet impinging on ungrounded flat surfaces of different dielectric constants. The plasma was produced in the form of Guided Streamers (GSs) propagating through the argon gas channel at velocities of some 100s of km/s, reaching the surface in some 10s of ns and spreading on it. The influence of each surface on the $Ar(1s_5)$ absolute density radial and temporal profiles and on the GSs optical characteristics was evaluated for two gas flow rates, 300 and 400 sccm (standard cubic centimetres per minute). At these conditions, a diffuse discharge was established in contrast with the free-jet case (no target). This allowed reliable quantification of the $Ar(1s_5)$ radial density by means of a TDLAS setup and Abel-inverted profiles of the $Ar(1s_5)$ transversal density.

1. Introduction

Atmospheric Pressure Plasma Jets (APPJs) in the form of Guided Streamers (GSs) [1,2] are sources of abundant (re)active species, among which, various metastables. Metastables preserve their energies for relatively long time, contributing this way to the plasma reactivity, which is important for various applications. To map their absolute densities in He APPJs, Tunable Diode Laser Absorption Spectroscopy (TDLAS) has been applied [2]. Nonetheless, for Ar APPJs this technique must be applied wisely due to their filamentary nature in some cases [1]. This work is devoted to the measurement of the spatiotemporal density of $Ar(1s_5)$ metastables in an argon APPJ impinging on dielectric flat surfaces, for conditions which give a diffuse plasma, allowing a precise mapping of the absolute density in both axial and radial coordinates.

2. Experimental setup and results

A coaxial DBD reactor was employed to produce GSs in pure argon (flow rate range: 300−400 sccm) [1]. The reactor was driven by high voltage positive pulses (6±0.06 kV, 224±3 ns FWHM, 20 kHz). The dielectric targets (floating potential) were made of glass ($e_r \approx 4$, see **Figure 1**) and alumina ($e_r \approx 9$), and were placed 5 mm away from the end of the reactor's tube. At these conditions, diffuse discharges were established, allowing reliable application of TDLAS to measure the spatial (i.e., axial−z and transversal−y, see **Figure 1(a)**) and the temporal (over a voltage impulse) distribution of $Ar(1s_5)$. This was achieved by tuning the laser's wavelength to be in resonance with the radiative transition $2p_9{-}1s_5$ of the excited Ar at 811.531 nm. Emission spectroscopy and ICCD imaging were also performed. The reactor−target system was mounted in μm-stages (z and y displacement). The absorption was recorded along the z- and y-axis in steps of 0.5 mm and 10 μm, respectively.

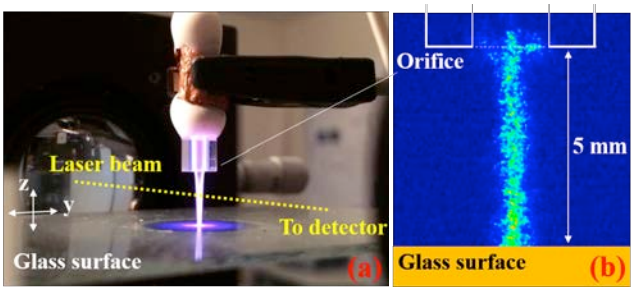

Figure 1. (a) Argon APPJ impinging on a glass surface (the laser beam in the TDLAS setup is illustrated in yellow) (b) ICCD image (3 ns gate) revealing diffuse discharge features.

The presence of the targets allowed the formation of diffuse discharges (see **Figure 1**). The transversal absorption profiles appeared well symmetric and reproducible. Thus, Abel inversion [2] was performed to map radial absolute density profiles at different z positions. Densities of some 10^{14} cm^{-3} were measured, depending on the gas flow rate, axial position and target material. Besides, the effective lifetime of $Ar(1s_5)$ varied between 50 and 400 ns, also depending on the operating condition. These results suggest that this device may be employed for the desorption of organic molecules present in trace amounts on the studied surfaces [1].

3. References

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