Space resolved ozone detection in the effluent of a cold atmospheric pressure plasma jet

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The ozone concentration and production rate of an atmospheric-pressure plasma jet operated with argon and small admixtures of dry oxygen and wet argon were investigated by UV absorption measurements. This study shows the wavelength dependency of the line of sight optical depth τ. Comparison of the results with literature shows a good agreement with the spectral absorption profile of ozone. To conclude this fact the absorption signal is mainly due to ozone molecules. From the measurements of the optical depth result a high spatial resolution three dimensional map of the ozone densities.

In this study an atmospheric plasma jet with argon as a feed gas and small amount of oxygen admixtures (< 2 %) is investigated regarding its ozone production rate.

The applied method is UV absorption spectroscopy in the Hartley band which determines high space resolved distribution of the ozone concentration in the plasma jet effluent. A schematic setup of the UV absorption measurements of ozone is shown in figure 1. A deuterium lamp (DH2000, Ocean Optics) as the light source with a continuum in the UV range was used.

For the measurement of the line of sight optical depth as a function of a wavelength between 225 nm and 300 nm a monochromator with a holographic grating (1200 lines/mm) at the beginning of the optical path was installed. The wavelength resolution of the monochromator was 5nm (FWHM).

With the imaging spectrometer (Shamrock 500i, grating: 2400 lines/mm, blazed at 300 nm, Andor) the two dimensional line of sight optical depth was measured. The advantage of using an imaging spectrometer is that a space resolved measurement with a high spatial resolution (radial direction: 0,33mm, axial direction: 0,04mm) becomes possible without moving the plasma jet. Hence, the measurement time for one fully spatial resolved accumulation is minimized. This is analogue to an increased accuracy since more accumulations can be performed in the same time duration. The investigated area was 20 x 20 mm^2. As detector an iCCD camera (iStar, Andor) was connected to the spectrometer.

In order to proof that only ozone and no other molecules like NO is responsible for the measured absorption signal the plasma jet was additionally investigated in a controlled environment. Therefore a vacuum chamber filled with pure oxygen (99,995%), pure nitrogen (99,999%), or synthetic air (80% nitrogen and 20% oxygen) was used. In the case of oxygen as purge gas no N_xO_y molecules from inside the chamber influence the absorption signal. Since the absorption signal in case of oxygen purge gas is identical to the other investigated purge gases namely nitrogen and synthetic air, the measured signal is not influenced by nitrogen species. Furthermore, the wavelength depended absorption signal measured in our experiment resembles the ozone absorption curve found in literature remarkably well. Hence, only ozone is responsible for the measured absorption signal.

From the measured optical depth a three dimensional distribution of ozone density is calculated via Abel transformation. Because of the noise sensitivity of the Abel transformation the measurements were fitted by a Gaussian function. Accordingly, this function was Abel transformed.

In figure 2 the axial and radial ozone density distribution is displayed. It decreases rapidly with the distance in axial and radial direction from the nozzle. Not only the spatial ozone distribution was investigated but also the impact of changing oxygen and water vapour admixture to the argon gas. A significant influence on the ozone density distribution and production rate was observed. Furthermore the ozone production rate was compared to production rates deduced from infrared absorption measurements of the same plasma jet [1].

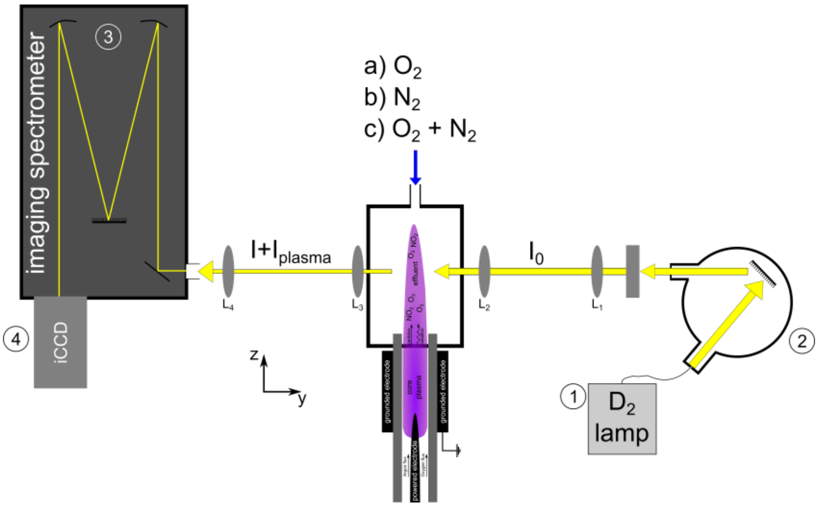

Fig. 1: Schematic setup of the ozone measurements with the deuterium lamp (1), a UV sensitive monochromator (2), an imaging spectrometer (3) and an iCCD detector.

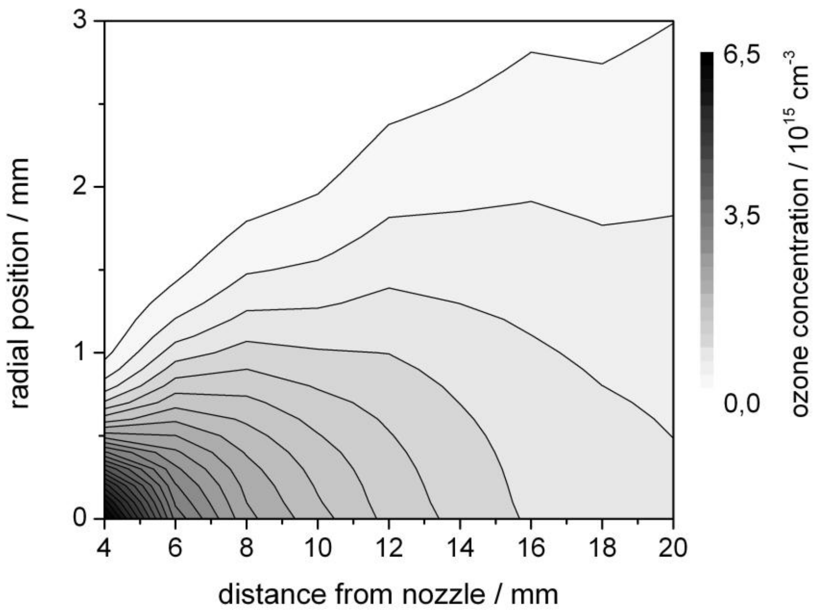

Fig. 2: Map of the space resolved ozone density distribution. The plasma jet nozzle is located at 0 mm distance from nozzle [1].

References

[1] S. Reuter et al., *"Detection of Ozone in a MHz Argon Plasma Bullet Jet"*, PSST Special Issue Plasma Jets and Bullets (submitted)