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Memory effect in Dielectric Barrier Discharge in N_2/O_2 mixture: absolute atom density measurements by Two-photon Absorption Laser-Induced Fluorescence (TALIF) spectroscopy

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This work is aimed to study the memory effect in Atmospheric Pressure Townsend Discharge in N_2/O_2 mixture. As we found that with the presence of few oxidizing gas, the memory effect is more significant which means more production of seed electrons between two successive discharges. This phenomena may be due to an associative ionization. To verify this hypothesis, the absolute density of $N(^4S)$ and $O(^3P)$ will be determined by two-photon absorption laser-induced fluorescence measurement. Furthermore, with the result of concentration of $N_2(A^3\sum_u^+)$ from the literature, we can estimate the seed electron density, then we make the comparison with the experimental measurements.

Dielectric barrier discharge (DBD) is one kind of nonequilibrium discharge, generally working at atmospheric pressure. For most gases and discharge conditions, the DBD consists in a multitude of microdischarges corresponding to the so called filamentary regime. Under certain conditions, the discharge is homogenous along the electrodes surfaces. For example in helium, one can obtain a glow discharge characterized by a bright zone close to the cathode where the electric field is the higher [1]. In case of nitrogen, another homogeneous regime can be observed which is characterized by a uniform light layer located close to the anode [1]. This regime is called Townsend discharge because it exhibits several typical features similar to the dark Townsend discharge at low pressure.

It has been shown that the occurrence of the homogenous DBD is only possible if a memory effect from one discharge to the following one occurs. This mechanism allows to create seed electrons at low electric field [1]. The bombardment of the cathode dielectric surface by the metastable state $N_2(A^3\sum_u^+)$ resulting in the secondary emission of electrons was identified as a contributor to this memory effect [1]. However and counterintuitively we find that the addition of few oxygen (<100ppm) makes the homogenous discharge more stable, despite the high destruction rate of $N_2(A^3\sum_u^+)$ through quenching by oxygen. Due to this phenomenon we propose an additional memory effect occurring in volume and based on the following reactions [2]:

$N(^2P) + O(^3P) \rightarrow NO^+ + e^-$

where $N(^2P)$ is produced by the reaction:

$N(^4S) + N_2(A^3\sum_u^+) \rightarrow N(^2P) + N_2(X^1\sum_g^+)$.

The aim of the present work is to verify this hypothesis. For this purpose we determine the absolute density of $N(^4S)$ and $O(^3P)$ by using measurements Two-photon Absorption Laser-Induced Fluorescence (TALIF) for N_2/O_2 mixtures. The experimental results of Dilecce *et al.* [3] are used together with optical emission spectroscopy measurements to estimate the concentration of $N_2(A^3\sum_u^+)$ in the discharge. Then a simple 0D model is used to estimate the amount of seed electrons produced in the discharge volume through the aforementioned reaction. It allows to estimate the current jump occurring when the polarity reverses, which can be directly compared to experimental measurements. A relatively good agreement is found between them confirming that this mechanism can be considered as a serious candidate involved in memory effect.

In the future, we plan to measure the $N_2(A^3\sum_u^+)$ metastable density through CRDS measurements in order to improve the accuracy of 0D model. Moreover, it is well known that a large amount of NO(X) can be produced in atmospheric pressure discharges in N_2/O_2 mixture [4]. NO molecules being efficient quencher of $N(^2P)$ and $N_2(A^3\sum_u^+)$, LIF measurements of the NO density will be performed in order to include these reactions in the 0D model.

References

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