Increasing electron density with increasing oxygen admixture? Competing reaction and recombination processes in an atmospheric N$_2$/O$_2$ dielectric barrier discharge

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— A DBD is investigated for various N$_2$/O$_2$ mixtures in controlled atmosphere by OES in combination with numerical simulations and I/V-measurements. Surprisingly, an increasing electron density was found for increasing O$_2$ content. Due to the higher electron affinity of O$_2$, the opposite would be expected. Furthermore, the spatial electron distribution in the discharge volume differs comparing synthetic air with pure N$_2$ as process gases. While the synthetic air discharge shows a homogeneous electron distribution in the center of the discharge, the pure N$_2$ discharge appears to be more confined to the electrode. The rate constants, reaction rates, and life times of the positive ions of O$_2^+$ and N$_2^+$ are calculated and compared. The recombination rate of N$_2^+$ is more than an order of magnitude lower than the recombination rate of O$_2^+$. Calculating the N$_4^+$ production and recombination rates, we found that they are several orders of magnitude larger than both, O$_2^+$ and N$_2^+$ recombination rates. Since N$_4^+$ occurs in significant densities with higher N$_2$ fraction in the gas mixture, electrons are consumed in recombination with N$_4^+$ efficiently. Thus, the electron density decreases with higher N$_2$ content.

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