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Several fundamental properties, the electric field, electron density and temperature, are presented for a kHz-driven atmospheric pressure plasma jet. The work focuses on plasma-target interaction where the targets were varied, from low-permittivity dielectrics, to water, to metallic targets. The increasing permittivity of the target causes the behaviour of the plasma on the target to change, as well as the electric field profile in the plasma plume. The increasing permittivity of the target is accompanied by an increasing electron temperature and density in the plasma plume. The work shows that the properties of the target determine the plasma parameters, also in the gas phase.

Atmospheric pressure non-thermal plasmas are researched for many applications. They became popular with plasma medicine, where restrictions on the plasmas are rigorous - they have to be at room temperature and not transfer significant amount of charge to the target, while still providing a mixture of reactive species, charge, field, to be efficient in medical applications. The intended applications soon extended to the treatment of different types of targets, where it is either important to treat them at atmospheric pressure (e.g. water) or with a plasma at room temperature. Atomic layer deposition is a good example of a traditionally low pressure technology being extended into the atmospheric pressure, and so is plasma catalysis. Another family of applications is in food and agriculture, where plasmas present a promising technology applied to a wide range of surfaces, dielectrics of different permittivities, in atmospheric air but also in humid conditions.

The discharges used in these developments very often belong to the family of non-thermal atmospheric pressure plasmas - these are transient discharges, highly non-uniform in both space and time, small-scale (sub-mm), low ionization level, low light output, and most importantly sensitive to their environment. For example, a He plasma jet working in a kHz bullet mode changes its properties when impinging on a target with respect to the case when it expands freely into the ambient atmosphere. This is an important aspect to be kept in mind when bringing non-thermal atmospheric pressure plasmas into applications. It is also the motivation for the research presented in this talk.

This work focuses on the fundamental properties of non-thermal plasmas such as the electric field, charge density and electron temperature. The work was performed on a non-thermal atmospheric pressure He plasma jet working in a kHz-driven mode with one ionization wave produced per voltage period or pulse. These fundamental properties of the discharge were measured in a freely expanding jet as well as when impinging on targets of different types, from low-permittivity dielectrics such as glass, to water, to metal. The measurements were performed in the plasma plume, but also in a target when a high-permittivity dielectric ($\varepsilon_r = 56$) was used.

The results bring one of the first sets of data concerning the E field, electron density and electron temperature, which are relatable to each other through the fact that they were all obtained on the same discharge. The effect of the gas flow speed is significant in the freely expanding jet, showing that the increased flow extends not only the visible length of the plasma plume, but also its electric field profile. In addition, the electron density and temperature were shown to respectively fall and rise within the plasma plume with increasing the distance from the end of the glass capillary.

The presence of the target influences the plasma plume in several different ways. For low-permittivity targets, such as plastic or glass, the presence of the target does not significantly influence the plasma properties in the plume, but it does initiate surface discharges belonging to the family of ionization waves. The electric field induced in the target material by those surface ionization waves were measured, both axially, in the direction through the material, and radially. When the permittivity of the target is increased, the surface ionization waves are replaced by one or several return strokes and a significantly altered electric field profile, along with increased electron density and temperature. In the extreme case of the metallic target, combined with much higher electron densities, the duration of the discharge on the metal surface is extended to a microsecond. The work shows not only that the presence of the target influences the plasma, but that the properties of the target determine the plasma parameters, also in the gas phase.