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Multi-Diagnostic Approach to Energy Transport in Atmospheric Pressure Plasma Discharges[1]

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Many applications in plasma processing science rely on the non-equilibrium properties of cold plasmas. Transport is a consequence of physical non-equilibrium systems as temperature and pressure gradients drive energy and mass transport. The energy that is selectively pumped into the electrons couples via different physical processes to other species present in the plasma on diverging time-scales, e.g. via drift, diffusion, elastic and inelastic collisions. As a consequence, theoretical description of these plasmas is challenging and requires complex models including kinetic description via Boltzmann equation or particle in cell simulations. However, to tailor non-equilibrium plasmas to the desired properties, e.g. for CO_2 splitting, a fundamental understanding of these processes is necessary. Here, we present a multi-diagnostic approach to experimentally and quantitatively study the energy transport in an atmospheric pressure plasma discharge. We exemplary investigated an RF-driven helium-oxygen discharge. The electrical energy input was calculated from voltage and current waveform measurements. We used optical emission spectroscopy to measure the atomic oxygen density as a scale for the chemical energy and thermocouple measurements to study the neutral gas temperature as a scale for thermal energy. Using an absolutely calibrated echelle spectrometer, we also measured the radiation energy emitted in the visible wavelength range. We demonstrate that these diagnostics allow to trace the major energy transport mechanisms in the plasma discharge. A parameter study on the control parameters power, frequency, and oxygen admixture revealed only limited control over the final energy distribution in the physical system.

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