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Electron power absorption in capacitive RF plasmas based on a moment analysis of the Boltzmann equation

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Low temperature capacitively coupled RF plasma sources (CCPs) are important tools for various industrial applications. Efficient knowledge-based optimisation of these plasma processes requires a detailed understanding of the complete electron power absorption mechanisms. In this work, a spatio-temporally resolved and self-consistent analysis of the electron power absorption dynamics is presented for various gases and discharge conditions. We apply our analysis to unmagnetized electropositive (argon) [1-2] and electronegative (oxygen) [3], as well as to magnetized low pressure CCPs [4]. The analysis is based on a study of the first velocity moment of the Boltzmann-equation using information taken from 1d3v Particle-In-Cell/Monte Carlo Collision simulations. We revisit some of the well known models of electron power absorption in CCPs (e.g. *'collisionless'/'stochastic' heating*, *'Ohmic heating'*, etc.) and show that they do not provide a full and self-consistent understanding, and can lead to misleading results. To obtain a full understanding, the total electron power absorption is divided into four mechanisms: pressure, Ohmic, inertial and magnetic power absorption. Surprisingly, at very low pressure we find *'Ohmic heating'* to be the dominant power absorption mechanism as a consequence of the attenuation of *'Pressure heating'*. The power absorption dynamics of secondary electrons are studied and the effect of externally applied magnetic fields on the acceleration of electrons is also addressed. This work has been conducted in close cooperation with Sebastian Wilczek, Li Wang, Trevor Lafleur, Ralf Peter Brinkmann, Zoltán Donkó and Julian Schulze.

[1] Schulze J et al. 2018 *Plasma Sources Sci. Technol.* **27**(5) 055010
[2] Vass M et al. 2020 submitted to PSST
[3] Vass M et al. 2020 *Plasma Sources Sci. Technol.* **29** 025019
[4] Wang L et al. 2020 submitted to PSST