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STOCHASTIC HEATING IN ASYMMETRIC CAPACITIVELY COUPLED RF DISCHARGES AND THE PSR EFFECT

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Abstract. Electron dynamics in asymmetric capacitively coupled radio frequency (RF) discharges is investigated experimentally and by developing basically simple models and simulations. The investigations focus on two closely related physical effects: Stochastic heating of electrons by the oscillating sheath in front of the electrode and the occurrence of high frequency oscillations of the current and the sheath in asymmetric discharges. Both effects become important only at low pressures. High frequency oscillations are caused by an effective series oscillator resulting from the sheath capacitance and the electron inertia in the plasma bulk, giving the effect its name: Plasma Series Resonance (PSR). The non-linear charge-voltage relation of the RF sheath is essential for the effect and makes asymmetric discharges quite distinct from symmetric discharges. The PSR effect leads to current and sheath oscillations at about one order of magnitude higher frequencies than the applied sinusoidal RF voltage, thus enhancing substantially stochastic heating. In the experiment a combination of various diagnostics is applied: Laser electric field measurements for the sheath, phase resolved optical emission spectroscopy for collisional excitation of atoms by energetic electrons, Langmuir probe measurements for the EEDF and electron density in the bulk, a SEERS sensor for current measurements and a high voltage probe for monitoring the applied RF voltage. Data from these diagnostics are correlated, compared, and further analyzed by analytical models and a hybrid fluid dynamic-kinetic simulation incorporating the Brinkmann sheath model. This integrated approach results in a unique insight into the underlying physics and provides a coherent picture of the discharge mechanism.

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