Deduction of a novel electron energy equation in fluid model and its applications in predicting the electron temperature behavior of inductivecoupled plasmas

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The fluid model is widely used inpredicting the behavior of both capacitively and inductively coupled plasmas inthe case that the discharges are sustained by the Ohm\'s heating mechanism[1,2].Continuity and energy conservation equations, together with the drift anddiffusion approximation of momentum equation, comprise the electron equations. Theelectron energy equation is well known to describe the transport of electronenergy density, i.e., product of density and temperature, and this bringsdifficulties in explaining the electron temperature behavior that the Langmuirprobe produces. In this presentation, a novel electron energy equation that eliminatesthe electron density influence via its continuity equation and describes only theelectron temperature behavior, is deduced. This novel equation is used toexplain the electron temperature behaviors in argon inductively coupled plasma,such as non-monotonic trend with applied power [3] and the monotonicallyincreasing trend with inlet velocity at incompressible flow of background gas. Itis concluded that the temperature behaviors are determined actually by new typeof collisional energy loss process and skin effect, cooperatively. The correlationof skin effect with electron temperature is discovered via one importantparameter, power density divided by electron density, which is first introducedby the novel electron energy equation. Still, the ability of this equation inpredicting electron temperature behavior is testified via the ionizing reactionsof metastables.

Reference

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