Detection of Two-Temperature Distributions of Argon ICP Using Collisional-Radiative Model and Tomographic Optical Emission Spectroscopy

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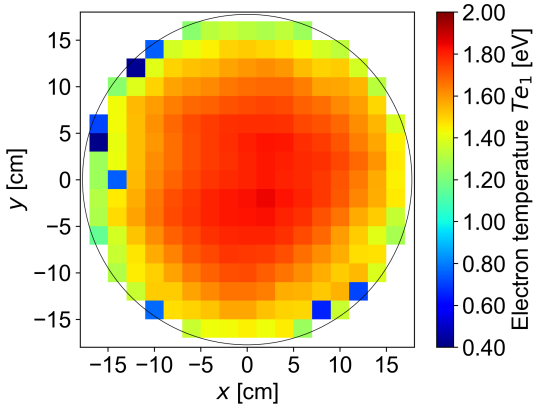
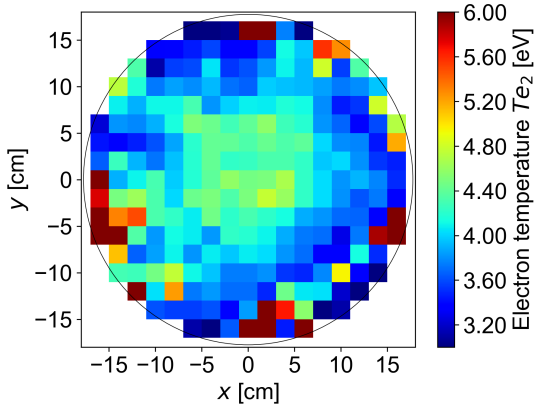
Non-Maxwellian electron energy distributions have been reported in low-pressure plasmas in previous studies. These deviations are particularly prominent in ICP, where the electron energy probability functions (EEPFs) often show characteristics of two-temperature distributions. Specifically, the low-energy range often approximates a classical Maxwellian distribution, while the high-energy tail is significantly depleted[1]. However, accurately determining these two-temperature distributions remains a significant challenge, especially when relying on optical emission spectroscopy (OES) and collisional-radiative model (CRM). Limitations in optimization methods and computational resources further complicate precise characterization of electron kinetics.

In our study, argon ICP was analyzed using experimental data through a Maxwellian-based method as a simplified approach to determining two-temperature distributions which were estimated by fitting rate equations derived from the CRM. The results obtained from the Maxwellian-based method were compared to those derived using a generalized two-temperature model, as developed in our previous study[2].

As a next step, we reconstructed spatially resolved mappings of electron temperature, density, and EEPF within a two-dimensional horizontal plane using tomographic OES. The figures a and b below show the electron two-temperature distributions in 1 Pa argon ICP with 600 W ICP power and 0 W bias power, respectively. The presentation will focus on the effects of ICP power and bias power on plasma parameters. Detailed discussions and analysis will be presented in the talk.



(a) Mapping of low electron Temperature



(b) Mapping of high electron temperature

References

[1] Godyak *et al.*, *J. Appl. Phys.*, vol. 73, no. 8, 1993, pp. 3657 – 63.

[2] Kikuchi *et al.*, *J. Phys. D*, vol. 57, no. 33, 2024, p. 335202.