Bistable Hysteresis Physics in radio-frequency inductively coupled plasmas: Theory, Experiment, Modeling

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Abstract

Many different gas discharges and plasmas exhibit bistable states under a given set of conditions, and the history-dependent hysteresis that is manifested by intensive quantities of the system upon variation of an external parameter has been observed in inductively coupled plasmas (ICPs). When the external parameters (such as discharge powers) increase, the plasma density increases suddenly from a low- to high-density mode, whereas decreasing the power maintains the plasma in a relatively high-density mode, resulting in significant hysteresis. To date, a comprehensive description of plasma hysteresis and a physical understanding of the main mechanism underlying their bistability remain elusive, despite the many experimental observations of plasma bistability conducted under radio-frequency ICP excitation. If, in such applications, plasma undergoes a mode transition and hysteresis occurs in response to external perturbations, the process result will be strongly affected. Due to these reasons, this presentation comprehensively reviews the global understanding of the bistability and hysteresis physics in the ICPs [1-3].

[1] H-C Lee, “Review of Inductively Coupled Plasmas: Nano-Applications and Bistable Hysteresis Physics”, Appl. Phys. Rev. in-press (2018).

[2] H-C Lee et al., “Effect of electron energy distribution on the hysteresis of plasma discharge: theory, experiment, and modeling”, Sci. Rep. 5, 15254 (2015).

[3] H-C Lee et al., “Discharge mode transition and hysteresis in inductively coupled plasma”, 102, 234104 (2013).