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Tunability and Scalability of Low-temperature Microplasmas[1]

YANGYANG FU, JOHN P. VERBONCOEUR, Michigan State University — Low-temperature microplasma, with emerging importance in device and sensor miniaturization, has received growing attention from both academia and industry in recent decades. Understanding the discharge characteristics is of fundamental importance for engineering devices across microplasma parameter regimes. In this work, the tunability of microplasma ignition and scaling laws are investigated with theoretical and computational models. Firstly, with engineered electrode surface morphology, Paschen's curve for the microgap can be flattened in either left or right branch, enabling control of the breakdown voltage and current characteristics across a wide range of gas pressure [Appl. Phys. Lett. 113, 054102 (2018)]. Secondly, classical similarity laws are found to be valid into the microplasma regime, with small scaling factors. At high ionization degree a transition from low to high density scaling characteristics is observed. The breakdown scaling is also examined based on the transition of microplasma voltage-current characteristics, including Townsend discharge, subnormal glow, normal glow, and abnormal glow discharge regimes [Appl. Phys. Lett. 114, 014102 (2019)]. Thirdly, using a hybrid plasma hydrodynamics model with electron Monte Carlo collisions, atmospheric pressure microplasmas with multiple electric field-enhanced thermionic emitters, and their scaling with temperature, are investigated. Finally, challenges for the tunability and scalability of low-temperature microplasmas are discussed in different discharge regimes.

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