

Abstract Submitted
for the GEC15 Meeting of
The American Physical Society

Modeling of Microplasmas with Nano-Engineered Electrodes

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Purdue University — Microplasmas can potentially be used as unique tunable dielectrics for reconfigurable radio-frequency systems, if electron densities of 10^{10} - 10^{12} cm^{-3} can be sustained in cavities smaller than 100 micron. However, for low loss tangent, gas pressures below 10 mTorr would be required, whereas the physics of electron impact ionization dictates the pd scaling so that microplasmas must operate at high gas pressures, hundreds of Torr, and also high voltages. We analyze a new principle of plasma generation that goes well beyond the pd scaling by eliminating electron impact ionization. In the new concept, electrons are generated at the cathode by field emission from nanotubes, and ions are independently produced in field ionization at atomically-sharp tips on the anode. The electrons and ions then move in the opposite directions, mix, and create a plasma. The low pressure results in collisionless motion with no electron-impact ionization. One-dimensional PIC/MCC calculations show that emitters such as carbon nanotubes placed sparsely on the cathode, combined with field ionization nanorods at the anode, can indeed ensure steady-state electron densities of up to 10^{12} cm^{-3} at gas pressure lower than 10 mTorr with only 50-100 Volts applied across a 40-50 μm gap.

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Date submitted: 17 Jun 2015

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