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Michigan Institute for Plasma Science and Engineering

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Room 1005 EECS

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Electron-beam Generated Plasmas and Their Applications - from Materials Processing to Space Propulsion

There is growing interest in electron beam (e-beam) generated low temperature plasmas (LTPs) for materials processing at atomic scales for microelectronics and quantum systems. For these applications, the plasma ([e] ~ 10^{9}-10^{12} cm^{-3} , T_e ~ 0.1-10 eV) is typically generated by injecting an energetic (10^{2} – 10^{4} eV) e-beam into a low pressure (10^{-1}-10^{2} mTorr) gas along an applied magnetic field (10-10^{3} Gauss). The B-field helps confine the e-beam propagating through the reactor. An applied electric field across the B-field enables control of the ion flux to the substrate (wafer) at the periphery of the plasma. The ability of e-beam plasma sources with crossed electric and magnetic (ExB) fields to selectively produce ions and reactive species with a uniform flux of low energy particles to the wafer makes them attractive for low damage processing of materials. Since e-beams efficiently ionize molecular gases at sub-mTorr pressures, they were recently proposed for airbreathing plasma thrusters at very Low Earth Orbits (70-200 km). In this talk, I will review concepts for e-beam generated LTP systems and their applications. I will outline key plasma processes, including plasma generation, cross-field diffusion and beam-plasma interactions. I will discuss challenges in control of characteristic instabilities, fluxes and energy distribution functions of electrons and ions in e-beam generated ExB plasmas.

About the Speaker: Yevgeny Raitses is a Principal Research Physicist at the Princeton Plasma Physics Laboratory (PPPL) with expertise in experimental plasma physics. His more than 200 publications are on physics of crossed-field plasma devices, plasma-surface interactions, low temperature plasma and its applications to synthesis and processing of nanomaterials, and plasma diagnostics. Raitses received his PhD in Aerospace Engineering from Technion-Israel Institute of Technology in 1997. He joined PPPL in 1998. His current research interests include e-beam generated magnetized plasmas, advanced plasma propulsion, and plasma diagnostics for semiconductor manufacturing. Dr. Raitses leads several projects and initiatives at PPPL including the DOE-Princeton Collaborative Low Temperature Plasma Research Facility (PCRF, https://pcrf.pppl.gov), advanced plasma propulsion physics (https://htx.pppl.gov), plasma-based nanosynthesis and nanofabrication of materials (https://nano.pppl.gov). Raitses is an associate fellow of the American Institute of Aeronautics and Astronauts and Fellow of the American Physical Society. Among many honors, Raitses received PPPL's Kaul Foundation Prize for Excellence in Plasma Physics Research and Technology Development in 2019.