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Fundamentals and Applications of a Plasma Processing System Based on Electron Beam Ionization[1]

DARRIN LEONHARDT, Naval Research Laboratory Plasma Physics Division

Electron beam (e-beam) ionization has been shown to be both efficient at producing plasma and scalable to large area (square meters). NRL has developed a number of advanced research tools culminating in a "Large Area Plasma Processing System" (LAPPS) based on an e-beam sheet geometry. We have demonstrated that the beam ionization process is fairly independent of gas composition and capable of producing low temperature plasma electrons (<0.5 eV in molecular gases) in high densities (10^9-10^{12} cm^{-3}). This system can offer increased control of plasma-to-surface fluxes and the ability to modify materials' surface properties uniformly over large areas. The systems to be discussed consist of continuous and pulsed planar plasma distributions generated by a magnetically collimated sheet of 2-3kV, < 1 mA/cm^2 electrons injected into a neutral gas background (oxygen, nitrogen, sulfur hexafluoride, argon). Typical operating pressures range from 20-150 mTorr with beam-collimating magnetic fields (100-200 Gauss) for plasma localization. The attributes of beam-generated plasmas make them ideal for many materials applications. These systems have been investigated for a broad range of applications, including surface activation, line edge roughening, and anisotropic etching of polymers, electron-ion and ion-ion plasma etching, low-temperature metal nitriding and thin film deposition (reactive sputtering and plasma enhanced chemical vapor deposition). Details of some of these applications will be discussed in terms of the critical plasma physics and chemistry, with complementary time-resolved *in situ* plasma diagnostics (Langmuir probes, microwave transmission, energy-resolved mass spectrometry and laser spectroscopy).

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