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Conceptual Design of Electron-Beam Generated Plasma Tools[1]
ANKUR AGARWAL, SHAHID RAUF, LEONID DORF, KEN COLLINS, Applied Materials Inc., DAVID BORIS, SCOTT WALTON, Plasma Physics Division, Naval Research Laboratory — Realization of the next generation of high-density nanostructured devices is predicated on etching features with atomic layer resolution, no damage and high selectivity. High energy electron beams generate plasmas with unique features that make them attractive for applications requiring monolayer precision. In these plasmas, high energy beam electrons ionize the background gas and the resultant daughter electrons cool to low temperatures via collisions with gas molecules and lack of any accelerating fields. For example, an electron temperature of <0.6 eV with densities comparable to conventional plasma sources can be obtained in molecular gases. The chemistry in such plasmas can significantly differ from RF plasmas as the ions/radicals are produced primarily by beam electrons rather than those in the tail of a low energy distribution. In this work, we will discuss the conceptual design of an electron beam based plasma processing system. Plasma properties will be discussed for Ar, Ar/N_2, and O_2 plasmas using a computational plasma model, and comparisons made to experiments. The fluid plasma model is coupled to a Monte Carlo kinetic model for beam electrons which considers gas phase collisions and the effect of electric and magnetic fields on electron motion. The impact of critical operating parameters such as magnetic field, beam energy, and gas pressure on plasma characteristics in electron-beam plasma processing systems will be discussed.

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