Characterization of a Helicon Plasma System for Deposition of Thin Film Coatings and for Surface Modification

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Résumé

Abstract
A Helicon Plasma System has been recently developed at Canadian Nuclear Laboratories to perform a variety of plasma processing experiments on nuclear materials, including surface modification, deposition of thin film coatings, and etching. Due to the high ionization efficiency and low temperature, helicon plasmas are well suited for processing materials whose microstructures are susceptible to changes at high temperatures.

Experimental studies focused on the characterization of plasma properties at different plasma conditions will be presented. The Helicon Plasma System includes a quartz plasma chamber, a Nagoya type III antenna powered by a 1.2-kW, 13.5-MHz radio frequency (RF) power supply, a solenoid powered by a 1.5-kW direct current (DC) power supply, and a stainless steel chamber equipped with a sample holder. A Langmuir probe diagnostic system and an optical meter were used to determine the effect of operating parameters on the plasma properties.

Characterization experiments were performed using argon as plasma gas, a plasma chamber pressure of 4.0x10-5 mbar and gas flowrate of 0.60 sccm. Well-defined current-voltage (I-V) curves were obtained at various distances from the plasma aperture, and ion and electron densities, and electron temperature were determined. The electron density at about 1.4 cm from the plasma aperture (substrate location) was also determined using two different plasma operating modes: the helicon and the inductively coupled plasma (ICP) operating modes. In the helicon mode, a 300W RF power was applied to the antenna and 15A direct current was applied to the solenoid to achieve an electron density of about 5.4x108 cm-3. In the ICP mode, 300W RF power was applied to the antenna and no power was applied to the solenoid. An electron density of about 8.7x107 cm-3 was determined in this mode.
The plasma characterization results show that at the same plasma operating conditions, higher ionization efficiencies are achieved in the helicon plasma operating mode than in the ICP operating mode.

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