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Modeling of an inductively coupled plasma of argon-oxygen mixture at low pressure

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Low pressure inductively coupled plasma (ICP) operating at radio-frequency (RF) has found various applications in industrial materials processing. ICP is a source operating at low pressures (below 50 mTorr) to improve uniformity and reduce contamination, and high plasma densities (greater than 10^{12} cm^{-3}) to produce high ion fluxes at the surface of the substrate resulting in high etch rates and moderate bombardment energies (1-200 eV). In general, many reactive gases and inert gas are widely used in the creation of the plasma. Argon, for instance, is a main gas component in plasma processing. For the molecular gases, oxygen discharges are applied in etching of photoresist and growth of oxide thin films. RF discharges in argon - oxygen mixture with inductive coupling are clearly finding increasing interest. We considered in this study a two-dimensional (2D) model of argon - oxygen plasma created with an RF frequency of 13.56 MHz, a pressure of 20 mTorr and a gas temperature of 500 K, in a planar geometry ICP reactor using a flat coil of three turns, we have modeled an industrial reactor, respecting its geometry, its dimensions and the characteristics of the materials composing it. The model couples the Maxwell electromagnetic equations and the transport equations of the particles present in the plasma. It is developed using commercial software COMSOL Multiphysics. We are interested in three fundamental points: the spatial variation of electron density, electron temperature and electric potential in the center of the discharge, the effect of pressure on ratio of negative ion density to plasma density and the effect of the applied power on ratio of negative ion density to plasma density of a mixture of 70% Ar-30% O_2.

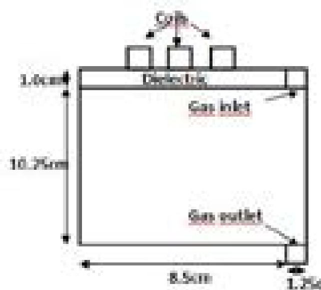

Figure 1: Design and dimensions of the inductively coupled plasma reactor studied.

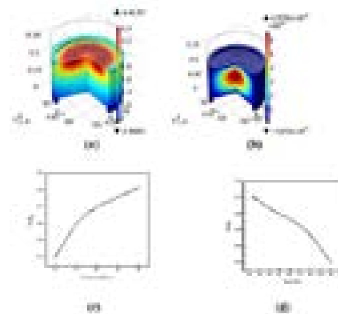

Figure 2: Variation of :a) Electron density b) Electron temperature c) The effect of the pressure on ratio of negative ion density to plasma density of a mixture of 70 %Ar-30 % O2 d) The effect of the applied power on ratio of negative ion density to plasma density of a mixture of 70 %Ar-30 % O_2.

Recent Publications:

1. Debnath Raha and Debajyoti Das (2013) Nanocrystalline silicon thin films prepared by low pressure planar inductively coupled plasma. Applied Surface Science 276:249-257.
2. Mark W Kiehlbauch and David B Graves (2003) Inductively coupled plasmas in oxygen: Modeling and experiment. Journal of Vacuum Science and Technology 21(3):660-670.
3. H M Katsch T, C Manthey, J A Wagner and H F Dfbele (2005) Negative ions in argon–oxygen discharges. Surface & Coatings Technology 200(1-4):831-834.
4. C Jia, J Linhong, W Kesheng, H Chuankun and S Yixiang (2013) Two-dimensional simulation of inductively coupled plasma based on COMSOL and comparison with experimental data. Journal of Semiconductors 34(6):7.
5. G J M Hagelaar, G Fubiani and J P Boeuf (2011) Model of an inductively coupled negative ion source: I. General model description. Plasma Sources Science and Technology 20(1):16.

Biography

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