Simulation Study of Microwave Microplasmas Based on Microstrip Technology

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Abstract

The generation of stable plasmas can be easily done using microwave generators. A large number of chemical processes make use of such plasma sources. The microstrip technology can provide a low-power electrodeless microwave-excited plasma source [1]. Based on the technology, microwave powers can be directed to the target area precisely, so as to allow the generation of high-density plasmas and reduce the contamination of the plasma source by sputtering electrodes. However, until now although many experimental results have been reported [2-4], the theoretical numerical researches are still limited to 1D plasma fluid model [3] or 2D electromagnetic field model [4]. This could be deduced to a fact that the microstrip technology uses a metallic wave-guiding structure on the substrate surface to transmit microwave powers to the underlying gas channel, thus a three-dimensional modeling will be needed, which would be extremely computationally intensive.

In this work, a three-dimensional model is developed based on COMSOL Multiphysics@. The simulations are performed for a 2.45 GHz microwave-excited argon plasma source operated at an input power of 2 W. The gas pressures are 50 and 100 Torr and the gas temperature is assumed to be 300 K. The species taken into account are electrons, atomic argon ions (Ar+), molecular argon ions (Ar2+), electronically excited atoms (Ar*), electronically excited molecules (Ar2*), and the background argon atoms (Ar). Dimer species are included because of the relatively high operating pressures. 15 kinds of chemical reactions comprised of electron elastic scattering, electron impact ionization and excitation reactions, Penning ionization reactions, three-body reactions for dimer excited species and ion formation, quenching and de-excitation reactions are considered.

The present work reveals the electric field induced by the electromagnetic wave is concentrated in the neighborhood of the inner surface of gas channel under the microstrip line in microwave-excited microstrip plasma sources. The governed ions are atomic argon ions (Ar+) and molecular argon ions (Ar2+) and the latter has a wider distribution. The resonance zone at which the electron density is equal to the critical density is examined.

Keywords: Microwave plasma, Microstrip technology, Critical plasma density, COMSOL Multiphysics

Reference

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Figures used in the abstract

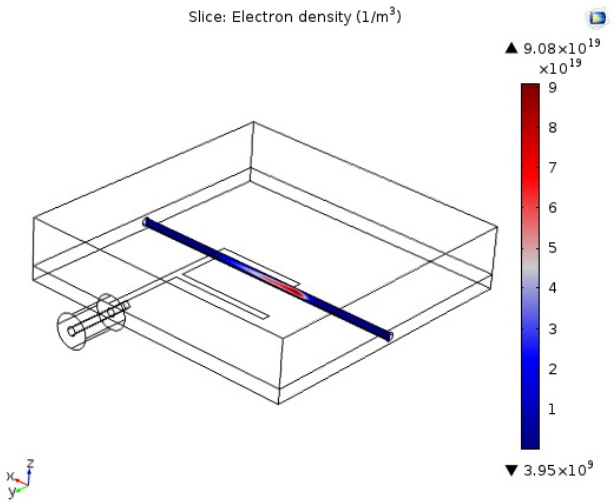

Figure 1: Electron density in an argon microwave microplasma based on microstrip technology

Figure 2

Figure 3

Figure 4