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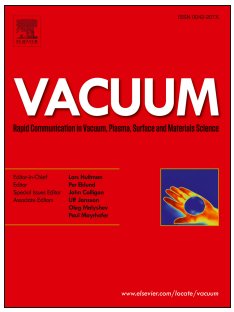

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Optical and mass spectroscopic properties of microwave $CH_4/H_2/Ar$ plasma for diamond deposition in a resonance cavity

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Abstract

The properties of microwave $CH_4/H_2/Ar$ plasma for diamond deposition in a resonant cavity have been investigated by optical emission spectroscopy (OES) and quadrupole mass spectroscopy (QMS). Ar emission intensity decreases monotonically with gas pressure, where electron impact excitation plays an important role. H_α. CH and C_2 intensities exhibit the different pressure dependences, which decrease at first and then rise with the further increasing of gas pressure, suggesting the change of electron activation mechanism to thermally driven chemistry for the formation of excited reactive hydrocarbon species at high gas pressures. The addition of small amounts of CH_4 to the H_2/Ar plasma causes increases in emissions of H_α and CH generated from the CH_4 dissociation. With further increase of CH_4 flow rate, both emissions and abundances of 2-carbon species enhance, while a reduced intensity of CH emission is observed, reflecting the complex dissociation and dimerization reactions of hydrocarbon species. The dissociation of CH_4 is enhanced in plasma under higher power condition. A slight change can be observed in both emission and abundance of hydrocarbon species with increasing Ar flow rate.

Keywords: Microwave cavity-resonance plasma, Optical emission spectroscopy, Mass spectroscopy

Introduction

Microwave plasma chemical vapor deposition (MPCVD) has been the most promising method to synthesize diamond films with high purity by using hydrocarbon reactive gases [1-4], which possesses various discharging modes in wide gas pressure ranges, including electron cyclotron resonance, surface wave, and cavity-resonance discharging. Compared with other methods, microwave cavity-resonance plasmas can operate under higher gas pressure, where an electromagnetic cavity is excited at its resonant frequency with much higher electric field. In this case, it is possible to obtain higher deposition rates due to the denser active precursors in cavity-resonance plasmas under higher pressure and power density.

With increasing gas pressure, the vapor reactions in the plasmas become also more complicated. There exist a lot of active hydrocarbon groups in the hydrocarbon plasma through the vapor reactions, which develop to eventually subnano-/nano-sized particles through a series of complicated reactions in this typical reactive system. These groups and particles play an important role in the