Spectroscopic studies of MW plasma containing HMDSO, O_2 and N_2

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1. Introduction

The deposition of SiO_x thin layers based on organosilicon plasmas is used to implement advantageous mechanical, electrical, and/or optical properties on various substrates. The development of such coating processes resulting in a wide range of chemical and physical film properties, using hexamethyldisiloxane (HMDSO) as a precursor, has been in the center of interest of various studies in the past years. In plasma, the dissociation of HMDSO into a large amount of different fragments is a rather complex chemical phenomenon. The monitoring of the precursor and of formed radicals and of stable species is very valuable to understand the chemistry of these plasmas.

2. Experiment

The experiments were performed in a cylindrical plasma reactor which is described in more detailed elsewhere [1]. In the plasma reactor, the ground state concentrations of HMDSO, and of the reaction products CH_4, C_2H_2, C_2H_4, C_2H_6, CO, CO_2 and CH_3 as a function of the HMDSO/O_2 mixture ratio, and the applied power at various pressure values has been monitored using infrared absorption spectroscopy (IR-AS) [2] based on lead salt lasers and External Cavity Quantum Cascade Laser [3, 4]. Optical emission spectroscopy has been applied as complementary diagnostics in order to evaluate electron density and electron temperature.

3. Results

Figure 1 shows an example the evolution of the concentration of the precursor HMDSO, and of six stable molecules and of the methyl radical depending on the power, which ranges over five orders of magnitude. The total added amount of HMDSO, the available concentration of C atoms, deduced from the degree of dissociation of the HMDSO precursor, found to be between 30 and 90 %, and information on the carbon mass balance are given. Figure 2 shows the evolution of the electron density as a function of the power at p = 25, 35 and 50 Pa. The gas temperature was calculated by measuring the Doppler broadening of the CH_3 absorption lines and was found in the range 500 to 1000 K. Electron density and temperature were found in between 10^{10} to 10^{12} cm^{-3} and 1.2 to 1.5 eV.

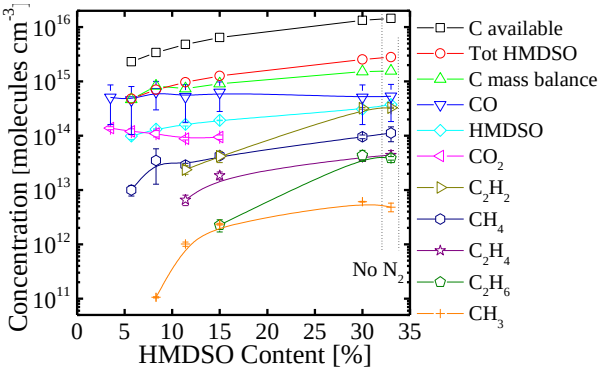

Fig. 1: *Concentration of HMDSO, CO, C_2H_2, CH_4, C_2H_6, C_2H_4 and CH_3 depending on the HMDSO content. The total added amount of HMDSO, the available amount of C atoms and the carbon mass balance are given in addition. (P=1.5 kW, p= 35 Pa)*

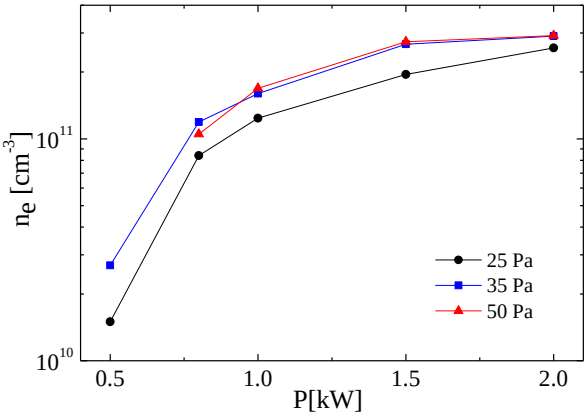

Fig. 2: *Electron density as a function of the power at p = 25, 35 and 50 Pa (Φ = 100 sccm O_2 + 50 sccm HMDSO + 15 sccm N_2)*

References

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