OES Diagnostics of HMDSO/O₂/CF₄ Microwave Plasma for SiOCₓFᵧ Films Deposition

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Abstract:
In microelectronic industry, multilevel interconnection technology needs interlayer insulator materials with low dielectric constant to reduce the signal propagation delay induced by the parasitic capacitance at the interconnections. Various materials with low dielectric constant (lower than that of SiO₂) have been investigated. Fluorinated silicon oxide (SiOF) is received much attention due to its low dielectric constant, thermal stability, excellent mechanical properties and to the strong electro-negativity of Si-F bond. In this work, SiOF like thin films have been deposited by microwave electron cyclotron resonance plasma created in a mixture of oxygen-hexamethyldisiloxane (HMDSO) and CF₄. The fluorine contents in the precursor mixture were adjusted by varying the CF₄ gas flow ratio in the range 10% - 70%.

Optical emission spectroscopy (used for the plasma diagnostic) and Fourier transform infrared (FTIR) (used for study of the deposited films) analyses are performed for different values of the dilution ratio R \( [R = \{\text{HMDSO}\} / (\{\text{HMDSO}\} + \{\text{O}_2\})] \) in HMDSO/O₂/CF₄ mixture. Actinometric technique was used to find trends in the concentrations of species present in the plasma. A large number of species have been detected, such as F, Si, O, C and H. These species determine the structures and/or the properties of the as-deposited film.

FTIR spectra revealed the presence of several chemical bonds (such as Si-F and Si-O) depending on the gas flow ratio R. The effect of these bonds on the films refractive index behavior has been studied.

Keywords: Plasma, HMDSO, optical emission spectroscopy, FTIR.