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Formation and Characteristics of the Fluorocarbonated SiOF Film by O_2/FTES-Helicon Plasma CVD Method

Kyoung-Suk Oh,[1] Min-Sung Kang[1] and Chi-Kyu Choi[1],
Seok-Min Yun,[2] Hong-Young Chang[2]

[1]Department of Physics, Cheju National University,
Cheju 690-756, Korea

[2]Department of Physics, Korea Advanced Institute
of Science and Technoalogy Taejeon 305-701, Korea

Present silicon dioxide (SiO_2) film as intermetal dielectric(IMD) layers will result in high parasitic capacitance and crosstalk interference in high density devices. Low dielectric materials such as fluorinated silicon oxide(SiOF) and fluoropolymer IMD layers have been tried to solve this problem. In the SiOF film, as fluorine concentration increases the dielectric constant of the film decreases but it becomes unstable and water absorptivity increases. The dielectric constant above 3.0 is obtained in these films. Fluoropolymers such as polytetrafluoroethylene(PTFE) are known as low dielectric constant (>2.0) materials. However, their poor thermal stability and low adhesive force have hindered their use as IMD materials.

The concept of a plasma processing apparatus with high density plasma at low pressure has received much attention for deposition because films made in these plasma reactors have many advantages such as good film quality and gap filling profile. High ion flux with low ion energy in the high density plasma make the low contamination and good crosslinked film. Especially the helicon plasma reactor have attractive features for film deposition because of its high density plasma production compared with other conventional type plasma sources.

In this paper, we present the results on the low dielectric constant fluorocarbonated-SiOF film deposited on p-Si(100) 5 inch silicon substrates with 80% of O_2/FTES gas mixture and 20% of Ar gas in a helicon plasma reactor. High density plasma is generated in the conventional helicon plasma source with Nagoya type III antenna, 5~15 MHz and 1 kW RF power, 700 Gauss of magnetic field, and 1.5 mTorr of pressure. The electron density and temperature of the O_2/FTES discharge are measured by Langmuir probe. The relative density of radicals are measured by optical emission spectroscopy(OES). Chemical bonding structure and atomic concentration are characterized using fourier transform infrared(FTIR) spectroscopy and X-ray photonelectron spectroscopy (XPS). Dielectric constant is measured using a metal insulator semiconductor (MIS;Al/0.4 μm thick film/p-Si) structure.

A chemical stoichiometry of the fluorocarbinated-SiOF film deposited at room temperature, which the flow rate of O_2 and FTES gas is 1sccm and 6sccm, respectvely, is formed the $SiO_{1.5}F_{0.36}C_{0.14}$. A dielectric constant of this film is 2.8, but the specimen at annealed 500℃ is obtained 3.24, and the stepcoverage in the 0.4 μm and 0.5 μm pattern are above 92% and 91% without void, respectively.