

Surface modification of SiOF films by post plasma treatment

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1. INTRODUCTION

With decreasing device geometry, interlayer dielectric film technology is one of the most important issues for the fabrication of multilevel interconnection in ULSIs.[1-12] In multilevel interconnections, it has been predicted that RC delay of ULSI circuits would limit operating speed of devices as parasitic resistance and capacitance increase. Therefore, it is necessary to reduce this parasitic capacitance to achieve high performance in ULSI circuits. One of the most effective ways to reduce the parasitic capacitance is using low dielectric constant materials for interlayer dielectrics. The SiOF films are one of the realistic solutions for the low dielectric constant films in ULSI multilevel interconnections. However, instability issues related to Si-F bonds still remain for the process integration of multilevel interconnection. Thus the purpose of this research is to study the effect of post plasma treatment on the reliability and dielectric properties of SiOF films.

2. EXPERIMENT

The post plasma treatment of SiOF films were carried out using N_2O and O_2 plasma in-situ at 300 °C with various plasma treatment time after the deposition. The effect of the post plasma treatment on the reliability and dielectric properties of SiOF films was examined in terms of post plasma treatment time. The change of roughness was measured by Atomic force microscopy (AFM). Ellipsometric measurements for determination of deposited film thickness and refractive indexes were made at five points in each sample using a Rudolph AutoEL MS ellipsometer. The chemical bonding structure of the films was evaluated by FTIR, fluorine concentration by XPS. The C-V and I-V characteristics of SiOF films were measured with various plasma treatment time. Specimens for the reliability test were prepared in the form of Cu/TiN/SiOF/Si system. The TiN films were deposited at 400 °C by reactive sputtering using an Ar + N_2 (30%) gas mixture, and Cu films were deposited at room temperature by dc magnetron sputtering system. The reliability test of Cu/TiN/SiOF/Si specimens was carried out in terms of temperature by RTA in N_2 ambient for 30 min. After annealing, the degrees of diffusion and interface reactions taking place in the Cu/TiN/SiOF/Si systems were evaluated from the Auger electron spectroscopy (AES) compositional depth profiles after annealing.

3. CONCLUSIONS

The effect of post plasma treatment on dielectric properties and reliability of fluorine doped silicon oxide (SiOF) films were investigated by measuring their C-V and I-V characteristics and XPS, AFM, AES, etc. The post plasma treatment of SiOF films was carried out in-situ at 300 °C, in deposition chamber. In this research, when the post plasma treatment time increased, we obtained the following. (1) The etch rate of SiOF films decreased from 80 Å/sec to 10 Å/sec (2) Surface roughness of the plasma treated SiOF films were increment due to the ion bombardment effect of post plasma. (3) Refractive index and relative dielectric constant increased from 1.391 to 1.461 and 3.14 to 3.9, respectively. (4) Leakage current density of SiOF films prepared by ECRCVD using SiF₄ and O₂ was less than 1 x 10⁻⁹ A/cm². (5) Breakdown field strength increased from 3.5 MV/cm to 8 MV/cm. (6) The thermal stability of the Cu/TiN/SiOF/Si system was kept upto 600 °C.

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