Effect of O_2 or NF_3 plasma treatments on contaminated silicon surface due to CHF_3/C_2F_6 reactive ion etching

한국전자통신연구소 박 형호, 권 광호, 곽 병화, 이 상환, 권 오준, 김 보우

Reactive ion etching (RIE) of SiO_2 on Si in a fluorocarbon plasma is a standard process in the production of very large scale integrated (VLSI) devices. But it can cause damage and contamination effects in exposed materials[1]. And these effects of RIE affect the electrical properties of semiconductor devices[2], such as a degradation of the minority carrier lifetime, changes in the barrier height and of the ideality factor of Schottky barriers formed on dry etched silicon, high contact resistance in contact hole etching and a deterioration of the oxide quality (interface state density, dielectric strength) of thermal SiO_2 films grown on dry-etched substrates. In previous work[3], the two major modifications after RIE using CHF_3/C_2F_6 were found. One is a ~50nm thick silicon layer which contains carbon and fluorine, and the other is a 2~3nm thick residue layer composed entirely of carbon, fluorine, oxygen and hydrogen on the silicon surface.

For removal of silicon surface contaminations resulting from the RIE, heat treatment in dry oxygen or rapid thermal treatments have been studied[4,5]. But through the thermal analysis[6], the removal of surface residue was revealed to be a pre-requisite step for the recovery.

In this work, effects of O_2 or NF_3 plasma treatments on surface residue have been analyzed. About 20min exposure to an O_2 plasma, the chemical bonds of surface fluorocarbon polymer film is changed to F-Si, C-C/H, C-Si, C-O and Si-O bonds. And these bondings can be easily removed by successive wet cleaning

process ($H_2O_2/H_2SO_4=4/1$ and $H_2O/HF=20/1$). With NF_3, we can obtain the same effect only after 10sec exposure. After these removing process of residue, recovery of contaminated silicon surface can be easily achived through thermal treatments.

[1] H.F. Winters, J.Appl.Phys., 49(10),5165(1978)

[2] X.C. Mu, S.J. Fonash et al., Appl.Phys.Lett., 49,67(1986)

[3] H.H. Park, K.H. Kwon et al., Kor.J.of Mat.Res., 1(4),214(1991)

[4] G.S. Oehlein, J.G. Clables et al., J.Electrochem.Soc., 133(5),1002(1986)

[5] S.J. Fonash, R. Singh et al., J.Appl.Phys., 58(2),862(1985)

[6] H.H. Park, K.H. Kwon et al., Kor.J.of Mat.Res., 2(1),35(1992)