RADIATION INDUCED DEFECTS ON Si-SiO₂ INTERFACE

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The density of surface states at Si-SiO₂ interface is examined for dry and wet oxidization process on <111> silicon substrate. The trivalent silicon centers are probably responsible for thermal and radiation generated surface states at the Si-SiO₂ interface. The dependence of the radiation induced surface state density is compared for various oxide thicknesses and oxidization methods used.

INTRODUCTION

The amorphous silicon dioxide insulating film is widely used in present semiconductor technology. The silicon dioxide is a form of fused silica which has many properties similar to those of crystalline quartz. To the most apparent similarities belong short-range atomic order, the angles between bonds and the ionic and covalent binding forces. Ionizing radiation creates defects in SiO₂ layer, as well as on the Si-SiO₂ interface, which act as trapping centres. These centers are mostly trapping centers for holes produced in SiO₂ by absorption of ionizing...
radiation. The number of structural defects depends on the technological process of oxidization as well as on the radiation dose, and the defects could be removed by thermal annealing process or by ultraviolet radiation.

INTERFACE STATES AND IONIZING RADIATION EFFECTS

The interface states are oxygen deficient centers located within one or two atomic bond distances from the silicon lattice /about 0.5 nm/. It has been shown that the interface states arise at high temperatures in a non-oxidizing ambient /e.g. argon/ atmosphere. The oxygen deficient centers exhibit either full oxygen vacancy denoted as ≥Si . . Si≥ or trivalent silicon centers denoted as ≥Si . . The dot denotes a nonbonding electron and the dash a covalent bond. The trivalent silicon configuration appears more often than the full oxygen vacancy since two silicon atoms in the full oxygen vacancy are more likely to be displaced from each other during the high-temperature process. Electrons and holes from the silicon valence and conduction band can readily make transitions into interface states on the Si-SiO₂ interface /Fig. 1./. The transition rate for the interface states located near the centre of the silicon gap is around 1000 transitions per second at room temperature. During heating at about 1100 °C in argon atmosphere about 10¹³ cm⁻² interface states are produced which originate from incompletely bonded silicon. The majority of these interface states are of trivalent silicon from arising in oxygen deficient argon. In the case of pure oxygen the oxide-silicon interface could exhibit some excess oxygen at the interface resulting in a rare generation of interface states by perturbing the band states. Some trivalent centers could, however, arise