FOWLER – NORDHEIM TUNNELING IN STRUCTURES WITH ULTRATHIN DIELECTRICS

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Currents through ultrathin dielectric films SiO_2 are used for storage and erase charge in electrically programmable memory elements and are very important for reliability of ultra-large integral circuits (IC). The influence of different parameters such as the doping level and type of a substrate, oxide thickness, and post-metallization annealings is investigated in detail. MOS structures with aluminum gate were used for study. The doping level in substrates influences the Fowler – Nordheim current significantly, and this influence is decreased with a growth of the oxide thickness. The annealings in hydrogen and in H_2O reduce the Fowler – Nordheim current. The influence of H_2O is stronger. To explain the observed experimental results, the influence of the charge in SiO_2 on experimental current-voltage $I(V)$ characteristics and the corresponding Fowler – Nordheim curves of MOS structures is considered. The charge at the $Si–SiO_2$ interface and in SiO_2 was determined by step-by-step etching of silicon dioxide and measurements of capacitance-voltage $C(V)$ characteristics. The influence of the charge built-up in SiO_2 on the $I(V)$ characteristics of a MOS structure is based on the oxide charge induced tunnel transparency modification. The Fowler – Nordheim currents in MOS structures were theoretically calculated in the Wenzel – Kramers – Brillouin energy barrier transparency approximation.