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Optimizing the Thermal Stability of Ultrathin GeOx Films by Ti Doping

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Abstract

Thermal stability of the dielectric interfacial layer inside the metal-oxide-semiconductor field-effect transistor (MOSFET) can affect the quality of the final products during the fabrication process of post metallization annealing, especially when the dielectric interfacial layer thickness is reduced to sub-nanometer. One vital problem is whether the size and location of the band gap might be changed by the annealing treatment. Here, we provide a direct measurement of band gap by scanning tunneling spectroscopy (STS) together with the valence band edge determined by ultraviolet photoemission spectroscopy (UPS). The band gap of the ultrathin GeO_x film (about 0.7 nm) grown on Ge substrates by atomic layer deposition (ALD) is clearly revealed. STS spectra show that the band gap of the GeO_x film is significantly modified after the annealing treatment. Meanwhile, UPS spectra also confirm the shift of the valence band edge. The pristine ultrathin GeO_x film behaves sensitive to the annealing treatment. However, for the GeO_x film with Ti doping, the band gap of the film becomes robust to the annealing treatment. Both the band gap and the valence band edge remain unchanged after the annealing treatment. It means that a small amount of Ti can enhance the thermal stability of the ultrathin GeO_x film.