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Chemical and electrical characterization of high-k ultra-thin films on Ge substrates.

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Microelectronic engineering trends concern the replacement of SiO_2, as gate insulator in MOS devices, with high-k dielectrics and the possible substitution of Si with high-mobility substrates such as Ge [1,2].For thermodynamic stability reasons, the choice of dielectrics is restricted to the oxides of Hf, La, Y, Zr and Al [3].

In this study, high-k ultra-thin films were grown by Atomic Layer Deposition (ALD) technique. ALD is one of the most known techniques in microelectronics field, which provides ultra-thin films with absolute control of thickness. Ultra-thin films of Al_2O_3 and HfO_2 were grown on Ge (100) substrates, at various deposition temperatures, from 80°C to 300°C, with nominal thickness of 5nm and 10nm. Furthermore, gate stacks of HfO_2/Al_2O_3/p-Ge were grown at different thicknesses.

The purpose of the present work is to investigate theinfluence ofthe ALD deposition temperature on the chemical composition andthickness of the deposited oxides. Furthermore,the possible formation of Ge oxide at the Al_2O_3/Ge and HfO_2/Ge interfaces, the oxide intermixing at ultra-thin layer HfO_2/Al_2O_3/Ge stacks as well as the electrical characteristics are also examined. All samples were studied by X-Ray Photoelectron Spectroscopy (XPS).

The experimental results revealed that the deposited films at higher temperatures (150 °C - 300 °C) are homogeneous and stoichiometric[4] while the ones deposited at 80°C are non-uniform. No chemical interaction, degradation or diffusion between the layers and the substrate were observed. The calculated equivalent film thickness of XPSwas found in good agreement with the nominal one, estimated by the ALD recipes. The electrical measurements showed that the dielectric constant has a smaller value for the ultra-thin films compared to the bulk one and it is independent of the deposition temperature. The presence of ultra-thin Al_2O_3 layers, acting as passivation layer in the stacks, produced superior quality Ge-based MOS structures with negligible leakage currents and low density of interfacial traps (D_{it}) compared to the Al_2O_3/Ge and HfO_2/Ge structures.

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