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Germanium MOS Technology for Infra-Red Detectors

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There are a number of position sensitive detector applications where there is a requirement for an imaging device which has enhanced response in the near infra-red spectrum ($0.77\mu\text{m}$ to $1.5\mu\text{m}$). Although infra-red detectors are fabricated using III-V and HgCdTe materials, integration with silicon readout circuitry is not easily achievable, often relying on bump-bonding technology. Germanium (Ge) is compatible with silicon device technology, and is once again becoming a mainstream semiconductor material. A Ge detector will exhibit a high quantum efficiency at all wavelengths from ultra-violet up to near infra-red, and is thus highly desirable for multi-spectral imaging and image fusion applications.

Fabrication of an electrically stable dielectric is a key enabling technology in the production of a Ge detector. This work investigates the use of atmospheric pressure CVD (APCVD) silicon dioxide (SiO_2) deposited on Ge at 400°C using SiH_4 , O_2 and N_2 source gases. After deposition the SiO_2 layers were densified at 800°C for 10 minutes in N_2 . To study the electrical properties of the Ge- SiO_2 interface MOS capacitors have been fabricated on p-type $2\Omega\text{-cm}$ Ge substrates, using a dielectric thickness of 170nm. Analysis of these characteristics reveals a satisfactory oxide surface-state charge (Q_{ss}) of $1.7 \times 10^{11} \text{cm}^{-2}$, a flat-band voltage (V_{fb}) of -1.77V , and a threshold voltage (V_{th}) of -0.60V . The DC leakage current density through the Ge MOS capacitors is less than $2 \times 10^{-11} \text{Acm}^{-2}$ for applied voltages between -5V and $+5\text{V}$, thus verifying the insulating properties of the dielectric.

At a frequency of 10kHz the capacitance measured in strong inversion approaches that of the dielectric alone. This 'low frequency' mode of operation occurs at a frequency approximately three orders of magnitude higher than would be observed for a Si MOS capacitor, and is due to the increased charge generation rate in the narrower bandgap Ge substrate. SIMS analysis of the APCVD SiO_2 after densification at 800°C shows that significant Ge outdiffusion from the substrate into the dielectric layer has occurred. For comparison, results from Ge MOS capacitors incorporating APCVD SiO_2 layers densified at 600°C , and dielectrics deposited using plasma enhanced CVD (PECVD) will be presented. The effect of 450°C forming gas (H_2/N_2) post-metal anneals on the capacitor characteristics will also be discussed.

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