

Active Photonic Device - Photo-Detectors

The adoption of all-silicon-based optical receivers has been actively pursued as an attractive alternative to III-V technology for low cost optical communication applications. In particular, germanium-on-silicon (Ge-on-Si) has been extensively explored for near-infrared photo-detection application due to its integration compatibility with existing Si-CMOS technology and large absorption coefficient. Using the selective epitaxy deposition (SEG) of Ge on silicon substrates, *p-i-n* Ge photo-detectors have been demonstrated with good responsivity and quantum efficiency for optical absorption at wavelength λ of 850 nm.

Recently, IME researchers have demonstrated surface illuminated and waveguide-configured *p-i-n* Ge photo-detectors fabricated on silicon-on-insulator (SOI) substrates for even longer wavelength ($\lambda = 1500$ to 1600nm) photo-detection applications. The low temperature Ge epi-film is selectively grown on Si substrate. *Without subsequent high-temperature anneal*, the Epi film quality is excellent in terms of low dislocation defect density and smooth surface morphology. Excellent device performance were achieved in these Ge-on-SOI photo-detectors, leading to a low dark current of ~ 100 nA and a -3 dB bandwidth of ~ 10 -15 GHz for a given applied bias V_A of 1.0 V. Further spectral and frequency response enhancement have also been achieved when such devices are integrated with a Si rib waveguide structure, making these high performance evanescent coupled Ge-on-SOI photo-detectors attractive for high speed optical communication applications.

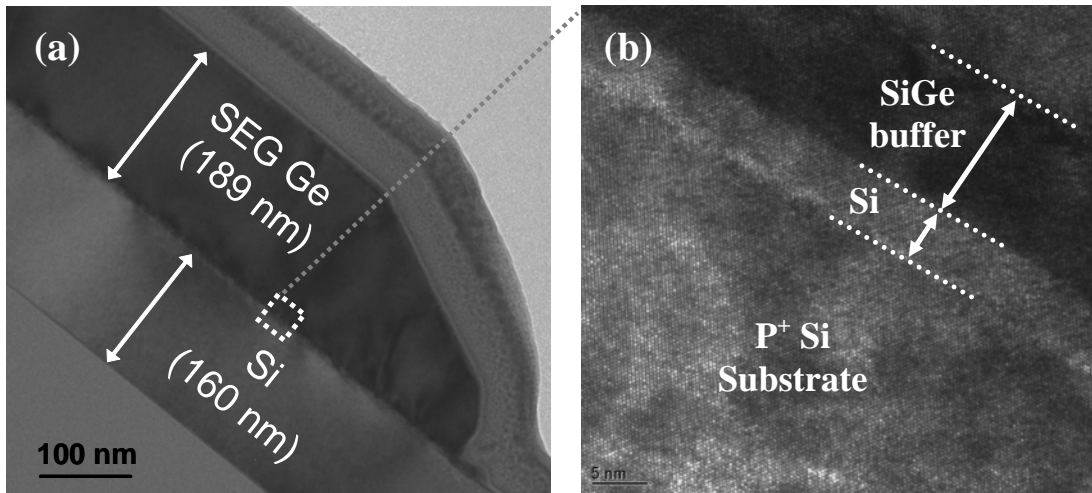
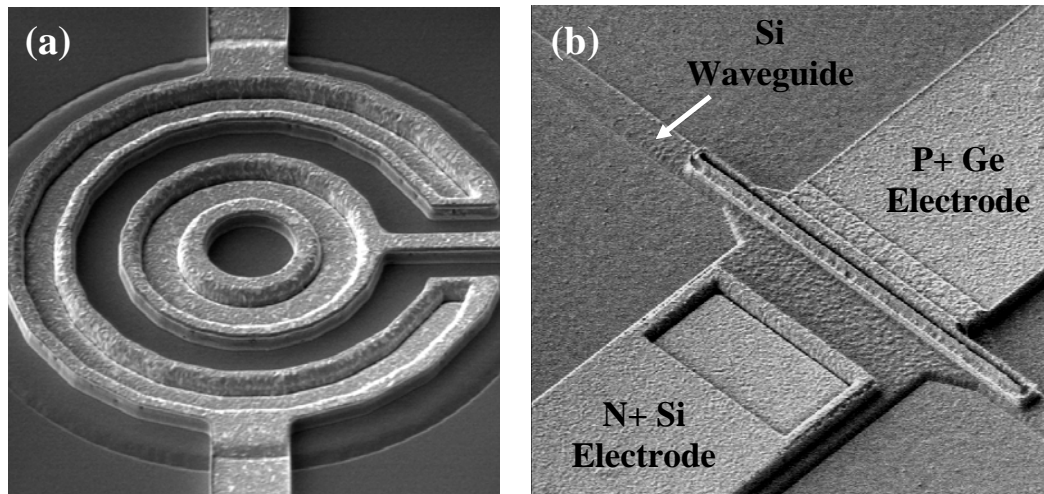


Fig. 1. (a) Transmission electron microscopy (TEM) micrograph of the Ge epitaxial film grown on silicon-on-insulator (SOI) substrate. (b) High resolution TEM micrograph shows the achievement of high interface quality in the Si/SiGe buffer layers.



*Fig. 2. (a) Surface illuminated and (b) Evanescent coupled waveguided *p-i-n* photodetector structures integrated on Ge-on-SOI platform.*

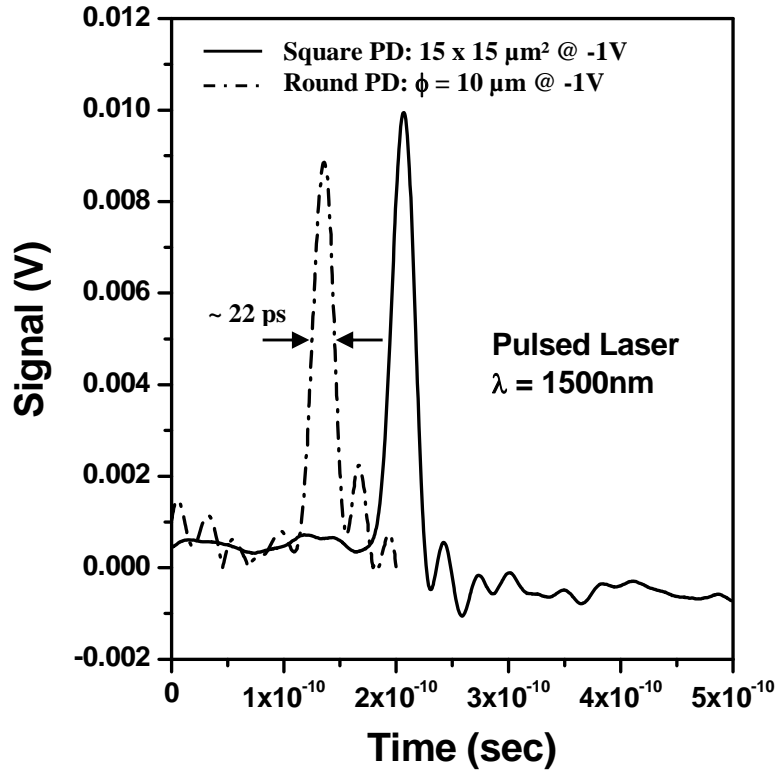


Fig. 3. Temporal impulse response of round-mesa ($\phi=10\mu\text{m}$), and square-mesa (area= $15 \times 15\mu\text{m}^2$) Ge-on-SOI photodetectors at wavelength $\lambda=1500 \text{ nm}$, measured at a reversed bias of 1V.