論 文 の 内 容 の 要 旨

論文題目: **Integration of Ge Photodetectors on Si for Optical Clocking**
(光演算のためのSi上に集積したGeフォトディテクター)

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This thesis demonstrated integrated Ge photodetectors on Si waveguides by Ge selective epitaxial growth on Si via ultrahigh vacuum chemical vapor deposition. To that end, we demonstrated selective Ge mesa on oxide-patterned Si substrates. We observed morphological instability of a Ge mesa after *in-situ* annealing at 800^{o}C. This problem can be alleviated by once cooling the sample to room temperature, followed by same annealing process. We fabricated Ge *p-i-n* photodiodes by blanket Ge growth on bare Si substrates. We utilized Si-cap to protect Ge layer from further fabrication processes. By shallow-implantation of phosphorous into Si-cap, we could insert an intrinsic Si (i-Si) layer between n+ Si and Ge layers. The presence of i-Si lowered dark current of the photodiodes using as-grown Ge up to ~10 mA/cm^2, compared with ~400 mA/cm^2 of dark current of photodiodes without i-Si. According to theoretical calculation of absorption coefficient change by tensile strain, we found that biaxial tensile strain resulted in larger absorption enhancement around 1550 nm of wavelength than uniaxial strain. Furthermore, localized strain measurement conclusively proved that a Ge mesa with lateral width larger than 1 μm was under biaxial tensile strain. Using this knowledge, we demonstrated Si-waveguide-integrated Ge photodetector under biaxial tensile strain on the underlying Si multi-mode interferometer structure. For these photodetectors, responsivity reached nearly theoretical maximum ~ 1 A/W when Ge length is longer than 30 μm and 3dB cut-off frequency was over 1-2 GHz. We also demonstrated a prototype of H-tree structure for optical clocking. These techniques and knowledge are crucial to realize optical clocking system in Si microphotonics platform.