19p-F8-8

Si 上薄膜 Ge pin フォトダイオードにおける成長後アニールの影響
Effect of post-growth annealing on thin-film Ge pin photodiodes on Si

東大院工　○永友翔，石川靖彦
Univ. of Tokyo　○Sho Nagatomo, Yasuhiko Ishikawa
E-mail: y-ishikawa@material.t.u-tokyo.ac.jp

1. Introduction

Epitaxial Ge films on Si have been applied to near-infrared (NIR) photodetectors (PDs) for electronic-photonic convergence on a Si platform [1]. Post-growth annealing of Ge film is effective to reduce threading dislocations in Ge, leading to a reduction of dark leakage current [2]. In this work, effects of post-growth annealing are studied for thin-film (200 nm) Ge PDs on Si. As a result, the dark current is reduced similar to the thicker films (> 500 nm), while the responsivity is degraded for Ge annealed at the temperatures higher than 800°C probably due to the formation of SiGe alloy around the Ge/Si interfaces.

2. Experimental

Epitaxial layers of Ge with the thickness of 200 nm were grown on p^+-Si wafers by ultra-high vacuum chemical deposition (UHV-CVD) with a two-step growth (370/600°C), followed by the growth of Si cap layer. After the growth, the samples were loaded into a furnace and annealed at high temperatures (700, 800, and 900°C) for 30 min in N_2. A phosphorous implantation was performed to form a top n-type layer. Al was deposited for the electrodes. Current-voltage (I-V) characteristics and normal-incidence responsivity spectra were measured at room temperature.

3. Results and Discussions

Figure 1 shows typical I-V characteristics for 200-nm-thick Ge PDs on Si (200 × 200 μm^2) with different post-growth annealing temperatures. The post-growth annealing was found to significantly reduce the dark current: at the reverse bias of 1 V, ~100 mA/cm^2 for as-grown (600°C) and 700°C, ~10 mA/cm^2 for 800°C, and ~2.5 mA/cm^2 for 900°C. This is probably ascribed to the reduction of dislocations in Ge, as in the case for the thicker Ge (> 500 nm) [2,3]. However, the annealing degraded the responsivity of PDs, as in Fig. 2. Although the responsivity spectra were almost the same between as-grown and 700°C Ge, the responsibvity for 800°C was reduced into ~50%, and for 900°C, the responsivity was reduced by two orders of magnitude. The observed degradation is probably due to the diffusion of Si into Ge, forming a SiGe alloy. Although the annealing temperature of 900°C, slightly lower than the melting point of Ge (937°C), was used in the previous studies for thicker Ge films [2], a careful annealing is required in the case of Ge films as thin as 200 nm.

[1] *e.g.,* J. Michel et al., Nature photon. **4**, 527(2010).
[2] H. C. Luan et al., Appl. Phys. Lett. **75**, 2909 (1999).
[3] Y. Ishikawa and K. Wada, Thin Solid Films 518, S83 (2010).

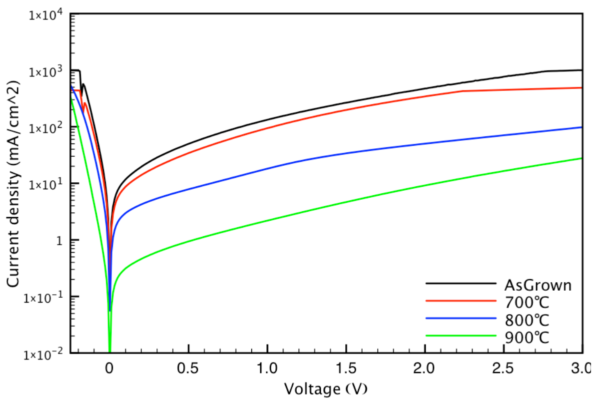

Fig. 1. Current density versus voltage characteristics for PDs (200 × 200 μm^2) with different post-growth annealing temperatures.

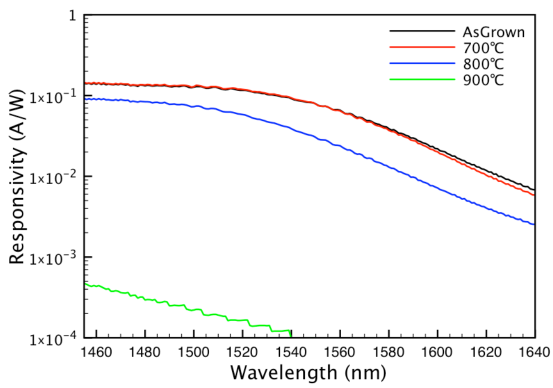

Fig. 2. Responsivity versus wavelength for 200× 200 μm^2 device at 0.5 V.