CW レーザーアニールによる歪み n 型 Ge の成長

Tensile Strained n-type Ge Grown by Continuous Wave Laser Annealing

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【Introduction】 Germanium (Ge) is one of the promising materials for optoelectronic device integration. It is widely known that Ge is an indirect-band semiconductor like Silicon (Si). However, by introducing tensile strain, the small difference (0.136 eV) between direct and indirect gaps can be reduced. Furthermore, it was mentioned that in 0.2-0.3% tensile strained Ge, n-type doping in the order of 10^{19} cm^{-3} could result in quasi direct-band light emission. [1] Recently, we have successfully crystallized amorphous Ge on quartz substrate by continuous wave laser annealing (CWLA), which also resulted in the introduction of 0.55-0.62% tensile strain. [2] In this study, we applied the similar technique for the Sb-doped n-type Ge film.

【Experimental Procedure】 Poly-crystalline Ge films with ~10^{19} cm^{-3} of Sb concentration were deposited on quartz substrate by molecular beam deposition at 450ºC growth temperature. Then, 300 nm of SiO_2 capping layer was deposited by sputtering at room temperature. The samples are inserted in the CWLA system [2] then annealed at laser scan speed (v_{scan}) of 800 m/min and laser power (E_{laser}) varied from 300 to 1000 mW.

【Results & Discussion】 Change of contrast were seen on the annealed sample surface [Figs. 1(a), 1(b)] due to crystallization. Here, Raman spectra of the Sb-doped Ge samples shows Ge-Ge peak indicating the crystallization of the Ge films and it is largely shifted in high E_{laser} at about -3.6 cm^{-1} [Fig. 1(c)]. This difference could be explained by the liquid phase recrystallization after Ge layer melted by the laser heat. Fig. 1(d) shows the change of peak shift from the as-grown to laser-annealed conditions for the Sb-doped and the undoped Ge. We consider that tensile strain is accumulated during cooling after solidification of Ge layer, due to thermal expansion, since its amount (~0.63% at 1000mW) agreed with the difference of thermal expansion coefficient between solidification temperature (938ºC) and room temperature (-0.6%). [3] These results show the successful growth of tensile strained n-Ge films by the CWLA method. This finding will be useful for the growth of Ge-based films toward the development of Ge-based optoelectronics.

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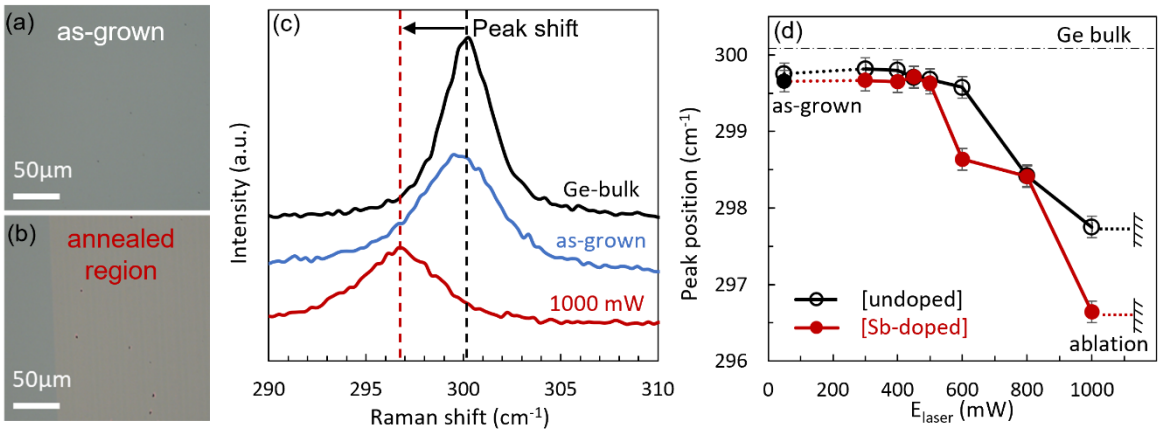

Fig. 1. Sample surface (a) before and (b) after CWLA. (c) Raman spectra of the Sb-doped Ge films and (d) Ge-Ge peak position as a function of E_{laser}.