

Fabrication of ultrathin Ge-on-insulator by direct wafer-bonding

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[Introduction]

Ge and SiGe nanostructured thermoelectric materials have been attracting much attention in recent years to realize high thermoelectric power generator efficiency due to carrier confinement and alloying effect [1-2]. For the fabrication of Ge and SiGe nanostructures by photolithography, an electronic grade ultrathin Ge-(GOI) and SiGe-on-insulator (SGOI) substrates are necessarily required [3-4]. For this purpose, we fabricated p-type GOI substrate by a simple, flexible and scalable method of direct wafer-bonding technique.

[Experimental Procedure]

A 2-inch, ~292- μm -thick p-type Ge(100) wafer and a 3-inch thermally-oxidized ~370- μm -thick p-type Si wafer with an oxide thickness of ~100 nm were used for the fabrication of GOI substrate by direct wafer-bonding technique. Mechanical polishing combined with chemical mechanical polishing (CMP) was performed in order to realize an ultrathin GOI substrate.

[Result and Discussion]

The process flow for the fabrication of ultrathin GOI substrate is shown in Fig. 1(a). We developed an optimized annealing condition for the bonded Ge/SiO₂ pair without any cracks or bond separation and the bonding strength was also strong enough to endure further patterning process. Figure 1(b) shows the cross-sectional SEM image of ultrathin GOI substrate. The resultant layered structure of GOI substrate consists of top Ge layer, buried-oxide (BOX) layer and bottom Si substrate. The layer thickness of the top Ge layer is 156 nm and it has a very flat Ge/SiO₂ interface. This fact confirms that mechanical polishing does not induce any major damage in the fabrication of ultrathin device grade GOI substrate by direct wafer-bonding technique. We performed Raman spectroscopy for both bulk and ultrathin GOI substrates and estimated their strain component to be 0.02 and 0.22, respectively. This shows that the low level tensile strain is induced. To confirm further, we did XRD analysis and determined the lattice mismatch between bulk and ultrathin GOI substrates by evaluating their absolute lattice constant values from the angle of diffraction. In addition, the quality of fabricated GOI substrate were analyzed by surface analysis techniques such as DFM, elemental mapping, chemical analysis etc.

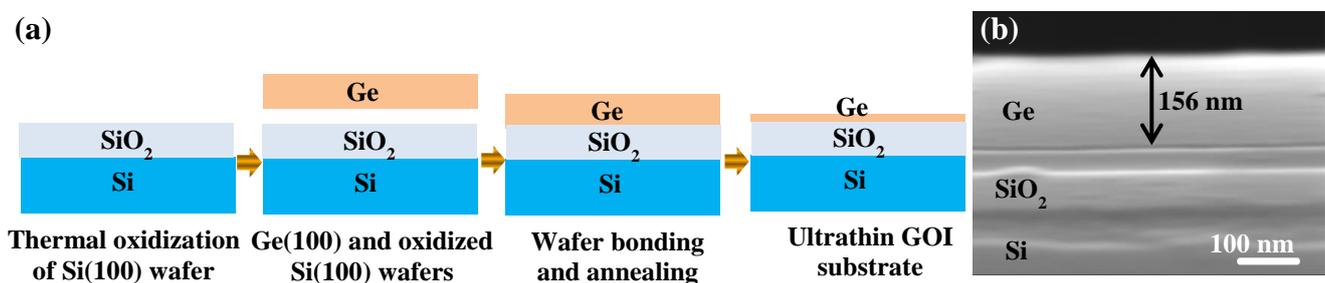


Fig.1 (a) Process flow and (b) SEM image of direct wafer-bonded ultrathin GOI substrate

References

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