# Influence of hydrogen ion implantation dose on characteristics of Ge-on-insulator substrates fabricated by smart-cut technology

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**【Background】** A Ge-on-insulator (GOI) structure is effective for realizing CMOS in further scaled technology nodes [1]. For GOI fabrication, the smart-cut technology is considered as a promising method because of the cost effectiveness and the high film quality on a Si wafer. Although many research groups have studied the smart-cut technology for GOI substrates [2], there is no report on the effect of the hydrogen ion implantation (I/I) dose on electrical characteristics of the GOI layers fabricated by the smart-cut process. In this work, we examine the effect of the I/I dose on the physical and electrical properties of the GOI films.

**【Experiments】** Fig. 1 shows the fabrication process using smart cut. (100) and (111) GOI substrates were fabricated with two hydrogen I/I dose conditions, $1\times10^{17}$ cm$^{-2}$ and $4\times10^{16}$ cm$^{-2}$. The fabricated GOI samples were annealed at various temperatures to improve the film quality [3]. Raman analyses were performed to examine the Ge crystallinity and the physical characteristics. In addition, Hall bar devices were fabricated on the GOI substrates to evaluate the electrical characteristics of the GOI films.

**【Results and discussion】** Fig. 2 shows the Raman spectra of the (100) and (111) GOI substrates with the high and low I/I dose conditions before and after annealing at 550 °C. The high dose GOI samples before annealing show the broader spectra than the low dose ones, suggesting the higher damages with the high dose. On the other hand, the annealed samples indicate the similar Raman spectra to those of bulk Ge, indicating the significant improvement of the crystallinity by annealing. Fig. 3 and 4 show the carrier density and the Hall mobility, determined from Hall measurements. The samples annealed at 550 °C show the minimum hole density and the maximum hole mobility. The carrier density for GOI with the high and low dose is the similar doping level to in the initial bulk Ge, meaning that the carriers generated by I/I is recovered after annealing. However, the annealed GOI samples with the low dose exhibit higher mobility, which is close to the Hall mobility of bulk Ge with the similar hole concentrations [4], than those with the high dose, attributed to any damages in the high dose.

**【Conclusion】** The effect of the hydrogen ion implantation dose on the physical and electrical characteristics of the GOI layers fabricated the smart-cut process was experimentally investigated. The high I/I dose ($1\times10^{17}$ cm$^{-2}$) condition has been found to cause more damages resulting in the degradation of the hole mobility than the low I/I dose ($4\times10^{16}$ cm$^{-2}$) condition.

**【References】** [1] X. Yu et al, Microelectron. Eng. **147**, 196 (2015) [2] M. Kim et al, Semicond. Sci. Technol. **33**, 015017 (2017) [3] J. Kang et al, Mat. Sci. Semicon. Proc. **42**, 259 (2016) [4] O. A. Golikova et al, Sov. Phys. Solid State **3**, 10 (1961).

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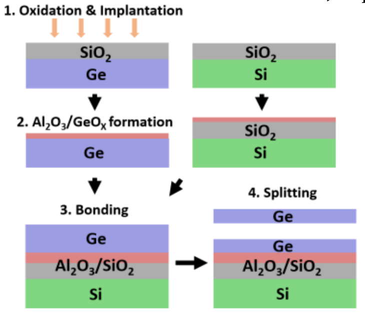


Fig. 1 Smart-cut process flow for the GOI substrate.

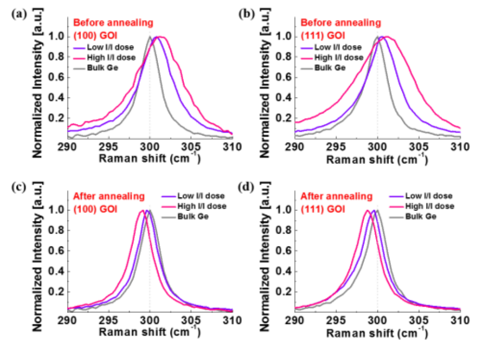


Fig. 2 Raman spectra of SC (100) and (111) GOI substrates before and after annealing.

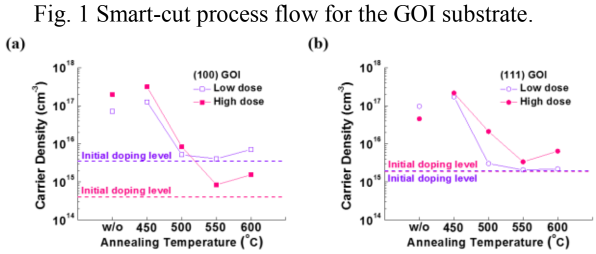


Fig. 3 Hole density depending on different I/I dose conditions for (a) (100) and (b) (111) GOI substrates.

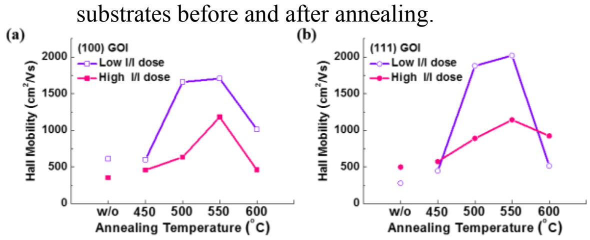


Fig. 4 Hall hole mobility depending on different I/I dose conditions for (100) and (111) GOI substrates.