アルゴンイオン注入援用によるシリコンにイオン注入したボロン原子の低温活性化
Ar+ ion implantation used to reduce temperature for activating B atoms implanted in silicon

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Introduction

Activation of implanted dopant atoms at low temperatures is necessary to develop the low-temperature fabrication technology for semiconductor devices such as thin film transistors (TFT) [1]. We have investigated activation of dopant atoms at low temperature by forming crystal defects before implantation of dopant atoms. In this paper, we report the carrier generation by Ar ion implantation followed by B ion implantation to form crystal defects.

Experimental procedure

We prepared n-type Si substrates with a thickness of 500 μm and a resistivity of higher than 1500 Ωcm. Ar ions were implanted to the top and rear both surfaces of the Si substrates at an acceleration energy of 70 keV with doses ranging from $1x10^{13}$ to $5x10^{14}$ cm^{-2} at room temperature (RT), as shown in Fig. 1. B ions were then implanted to the top and rear both surfaces of the Si substrates at 20 keV with $1x10^{15}$ cm^{-2} at RT. We heated the samples at 200, 250, and 300^{o}C in stepwise for 30 min each temperature and investigated change in the sheet resistivity. The sample was irradiated 9.35 GHz microwave at 1 mW to measure the microwave transmissivity determined by free carrier absorption. The experimentally transmissivity was numerically analyzed to estimate the sheet resistivity [2].

Result and discussion

Figure 2 shows the sheet resistivity as a function of the dose of Ar ions at the top surface for as-implanted samples and samples heated at 300^{o}C. The sheet resistivity of initial sample was $3.1x10^{4}$ Ω/sq. The sheet resistivity of Ar-as-implanted followed by and B-as-implanted samples distributed from 3.2 $x10^{4}$ to $2.7x10^{5}$ Ω/sq. The sheet resistivity was decreased to 5.9 $x10^{3}$ Ω/sq by heating 300^{o}C a sample implanted with only B atoms. It monotonously decreased as the dose of Ar increased. When a dose of Ar was $1x10^{14}$ cm^{-2}, the sheet resistivity had the minimum value of 890Ω/sq. These results suggest that Ar ion implantation with $1x10^{14}$ cm^{-2} induced crystalline defects in the Si surface region, and decreased the activation energy of B ions for moving from the interstitial to lattice site of Si.

Conclusion

We researched the Ar+ ion implantation to reduce the temperature for activating B atoms implanted in silicon with $1x10^{15}$ cm^{-2} for each surface. The sheet resistivity had the minimum value of 890 Ω/sq for the sample implanted with Ar ions at $1x10^{14}$ cm^{-2} followed by post-annealing at 300^{o}C, while it was a high value of 5.9 $x10^{3}$Ω/sq for only B implantation.

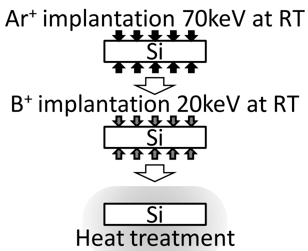

Fig. 1. Schematic processing steps of Ar^{+} followed by $1x10^{15}$ cm^{-2} B^{+} ion implantation and post heating

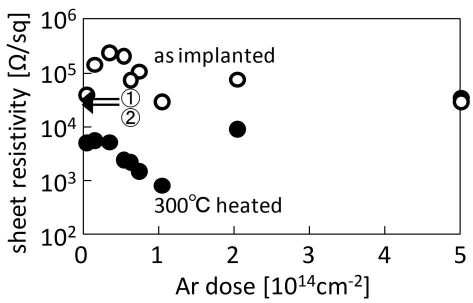

Fig. 2. Sheet resistivity as a function of dose of Ar^{+} ions at the top surface for as-implanted samples and samples heated at 300^{o}C. The arrow①is no implanted or heated sample, arrow② is no implanted and 300^{o}C heated sample.

References

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[2] T. Sameshima, T. Motoki, K. Yasuda, T. Nakamura, M. Hasumi, and T. Mizuno, Jpn. J. Appl. Phys. 54. 081302-1-6 (2015).