Activation of Silicon by Ion Implantation under Heating Sample

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1. Introduction

The activation of semiconductor materials ion-implanted with dopant atoms is a mandatory step to fabricate electronic devices. Reduction in thermal budget is simultaneously required for low cost fabrication. We discuss activation behavior in the case of heating silicon substrate during phosphorus-implantation [1]. We report marked reduction in disordered amorphous state by heating sample between 200 and 400°C. We also report decrease in the sheet resistivity and increase in the photo-induced minority carrier effective lifetime τ_{eff}.

2. Experimental

N-type bare silicon substrates with a high resistivity of 1505 Ωcm and a thickness of 500 μm were prepared. Ion implantation of phosphorus atoms with a dose of 1.0×10^{15} cm^{-2} was conducted. Sample substrates were coincidently heated at 200, 300, and 400°C by rapid thermal heating during ion implantation for 4 min. Phosphorus ion implantation at 1.0×10^{15} cm^{-2} was also conducted at room temperature (RT), Samples phosphorus-implanted at RT were then heated at 200, 300, and 400°C for 10 min for comparison. Optical reflectivity spectra were measured to analyze the effective amorphized thickness A_{eff} at the surface region. The sheet resistivity and τ_{eff} were measured by 9.35 GHz microwave transmittance measurement system [2,3].

3. Results and discussion

Figure 1 shows A_{eff} as a function of heating temperature. Although A_{eff} was high of 65 nm in the case of implantation at RT, it markedly decreased to 2.0 nm at 200°C implantation. It further decreased to 0.56 nm as the implantation temperature increased to 400°C, while it was high of 48 nm in the case of implantation at RT followed by heating at 400°C.

Figure 2 shows the sheet resistivity as a function of heating temperature. The sheet resistivity decreased from 30105 to 1422 Ω/sq as the implantation temperature increased from RT to 400°C, while it was still high of 8200 Ω/sq in the case of implantation at RT followed by heating at 400°C.

Figure 3 shows τ_{eff} as a function of heating temperature. The value of τ_{eff} increased from 3.4×10^{-6} to 4.6×10^{-5} s as the implantation temperature increased from RT to 400°C, while it was still low of 1.5×10^{-5} s in the case of implantation at RT followed by heating at 400°C.

References

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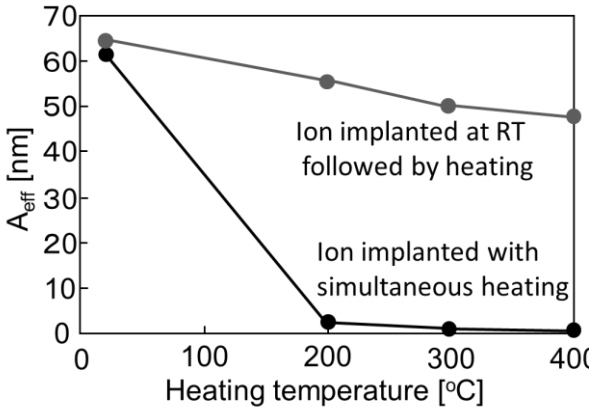

Fig.1. Changes in A_{eff} for samples implanted with simultaneous heating and implanted at RT followed by heating as a function of heating temperature.

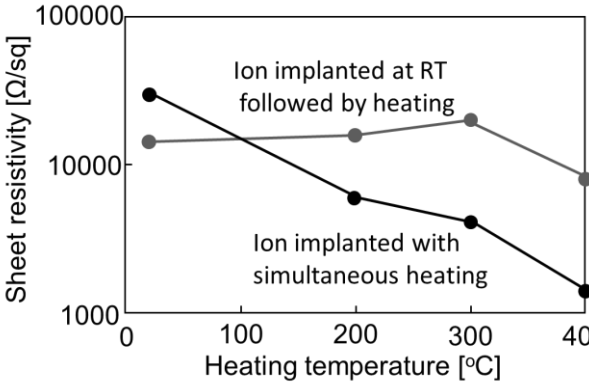

Fig.2. Sheet resistivity of samples implanted with simultaneous heating and implanted at RT followed by heating as a function of heating temperature.

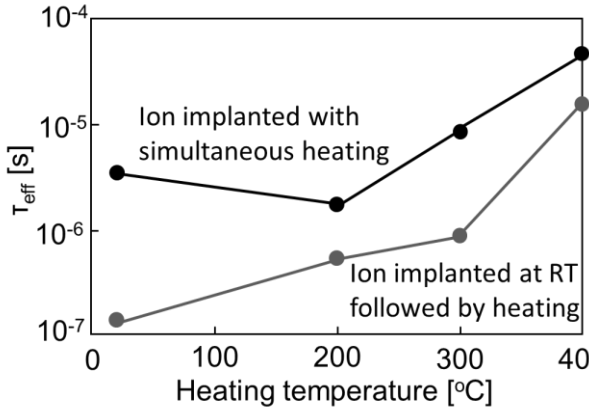

Fig.3. τ_{eff} as a function of heating temperature for samples implanted with simultaneous heating and implanted at RT followed by heating in the case of 635 nm light illumination.