Microwave Rapid Heating Used for Diffusing Impurities in Silicon

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I. Motivation

We have developed 2.45 GHz microwave rapid heating method using carbon powders as a microwave absorber [1]. A sample is covered by carbon powders. Carbon powders effectively absorb microwave energy and heat sample. In this paper, we report diffusion of boron atoms in crystalline silicon by microwave rapid heating. We demonstrate carrier generation and pn junction formation.

II. Experimental

88 Ωcm n-type 525-μm-thick bare silicon substrates were prepared. 1-μm-thick $B(OH)_3$ layers were formed on the top surface of the samples by an evaporation method. The samples were subsequently covered with 1-g-weight carbon powders and heated with 2.45 GHz microwave irradiation at 1000 W for 14, 17, 20, 23, 26, and 29 s respectively. The sheet resistivity was investigated by the 9.35 GHz microwave transmittance measurement system [2]. The $B(OH)_3$ layers were removed by rinsing with hydrofluoric acid. Comb-type Al electrodes were then formed on the top and rear surfaces by vacuum evaporation. The electrical current were measured by applying bias voltage to the electrodes in the dark field and under light illumination with Air Mass (AM) 1.5 solar simulator at 100 mW/cm^2.

III. Results and discussion

Figure 1 shows the sheet resistivity as a function of microwave heating duration. The sheet resistivity of initial sample was 1676 Ω/sq. It decreased from 1600, to 29 Ω/sq as the microwave heating duration increased from 14 to 29 s, respectively. This result indicates that boron atoms were effectively diffused into silicon from the $B(OH)_3$ layers and well activated by microwave rapid heating. The carrier density was estimated as 7.2×10^{15} cm^{-2} in the case of 29 s heating. Figure 2 shows the electrical current density as a function of bias voltage in the dark field and under AM 1.5 light illumination at 100 mW/cm^2 for 20-s-heated sample. Diode rectified characteristic was observed in the dark field. High photo-induced current and the photovoltaic effect were observed under AM 1.5 light illumination. The short circuit current density, open circuit voltage, fill factor and conversion efficiency were 25.2 mA/cm^2, 0.37 V, 0.31 and 4.37%, respectively. These results indicate that pn junction was formed by boron diffusion induced by microwave rapid heating.

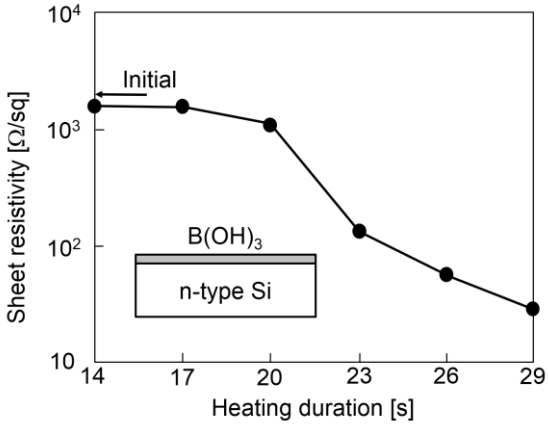

Fig. 1 Sheet resistivity as a function of microwave heating duration.

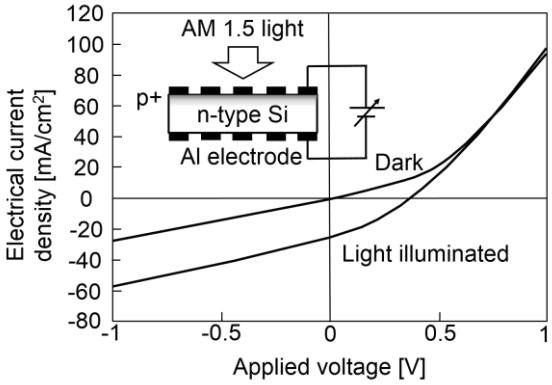

Fig. 2 Electrical current density as a function of bias voltage in the dark field and under AM 1.5 light illumination at 100 mW/cm^2 for 20-s-heated sample.

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References

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