Research on passivation of semiconductor surfaces by heat treatment in liquid water

°Takayuki Motoki[1], Tomohiko Nakamura[1], Masahiko Hasumi[1], Toshiyuki Sameshima[1], Tomohisa Mizuno[2]
(1. TUAT, 2. Kanagawa Univ.)
E-mail:tsamesim@cc.tuat.ac.jp

1. Introduction

The passivation technology of semiconductor surfaces is important to achieve a high photo-induced minority carrier lifetime τ_{eff} in order to fabricate high performance photo-sensors and photovoltaic devices. The thin passivation layer is necessary for metal-insulator-semiconductor (MIS) type solar cell with a high conversion efficiency [1]. We have developed the thin film passivation technology by heating Si substrates in liquid water at 110°C for 1h. The high τ_{eff} ranging from 8.3×10^{-4} to 3.1×10^{-3} s were achieved [2]. However, the optimum conditions of heating temperature and duration weren't investigated. In this abstract, we report τ_{eff} of the Si substrates heated in liquid water at several temperature conditions.

2. Experimental procedure

500-μm-thick 15 Ωcm n-type single crystalline Si substrates were prepared. Native oxide layers of the Si surfaces were removed by dipping the samples in 5%-diluted hydrofluoric acid. Then, these samples were placed in a pressure proof chamber with a capacity of 2800 cm^3 with 1500 cm^3 of pure water. The Si samples were heated in liquid water at 90, 100, 110, and 120°C for 1.5 h, respectively. We measured the τ_{eff} of the samples under 635 nm light illumination using 9.35 GHz microwave transmittance measurement system to investigate the passivation effect of the present heat treatment [3]. Moreover, we measured change in τ_{eff} with elapsed time for the samples kept in air atmosphere at temperature of 20°C and humidity of 50% after the present heat treatment to investigate the stability of the passivation effect.

3. Results and discussion

Figure 1 shows the τ_{eff} of the samples as a function of heating temperature. The average τ_{eff} of the four initial Si samples is also shown by the arrow in Fig. 1. It was very low value of 3.8×10^{-6} s because substantial defect states were distributed in the Si surfaces. τ_{eff} increased from 1.0×10^{-4} to 2.6×10^{-3} s as the temperature of heat treatment in liquid water increased from 90 to 120°C, as shown in Fig. 1. Liquid water at high temperature probably oxidized the silicon surfaces effectively and passivated them. Figure 2 shows the τ_{eff} of samples as a function of elapsed time after the heat treatment. The τ_{eff} in the cases of the every temperature for heat treatment kept high values for a long time, as shown in Fig. 2. The highest values of τ_{eff} were observed as 3.1×10^{-3} s at 70 h in the cases of after the heat treatment at 120°C. We believe that water molecules adsorbed at the silicon surfaces gradually evaporated during keeping the samples in air atmosphere. In the meeting, we will also report the optimum heating duration of the present heat treatment for silicon surface passivation. Moreover, we will report the application of the present method to the surface passivation of Ge substrates.

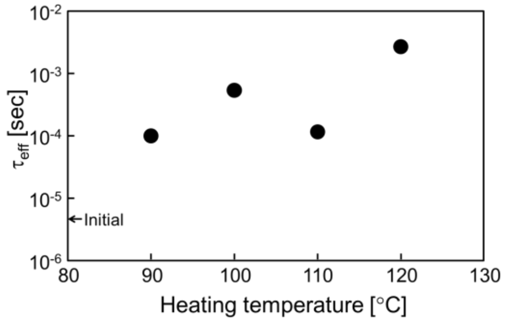

Fig. 1. τ_{eff} of samples as a function of heating temperature.

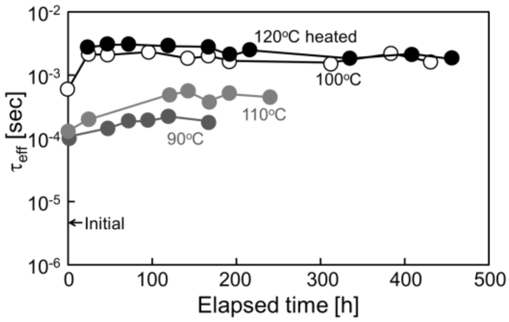

Fig. 2. τ_{eff} of samples as a function of elapsed time after heat treatment in liquid water.

References

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