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A—5—3 Suppression of Oxidation-Induced Stacking Faults Formation in Silicon by High Pressure Steam Oxidation

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The presence of oxidation-induced stacking faults (OSF) is known to have a deleterious effect on device performance. In this study, suppression of OSF formation in silicon by the high pressure oxidation is described compared with the conventional wet oxidation at normal atmospheric pressure.

The high pressure steam oxidation accelerates the oxidation rate of silicon[1] and it can reduce the thermal oxidation time considerably. Therefore, the density and length of OSF would be expected to be reduced for a thick oxide compared with the conventional wet oxidation for a long time.

The high pressure steam oxidation was carried out in O_2 and H_2 mixture by using a new oxidation apparatus.[2] The flow rates of O_2 and H_2 were maintained at 1 SLM and 1.77 SLM. The partial pressure of H_2O which was generated by H_2/O_2 reaction was 6.57 kg/cm^2 throughout the whole high pressure steam oxidation experiments.

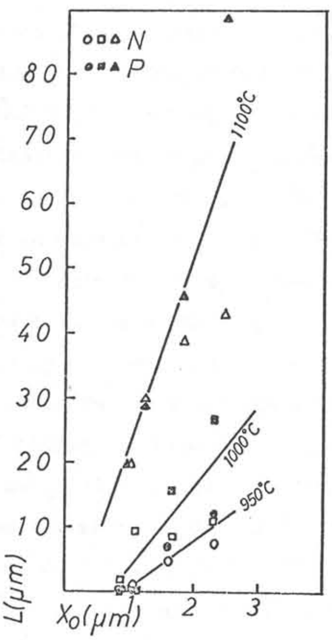

Fig. 1. The length of OSF (L) vs. oxide thickness(X_0) for wet oxidation.

The conventional wet oxidation at normal atmospheric pressure was performed in the wet oxygen (oxygen bubbled through water at 95°C).

The oxidations were carried out at temperatures between 950°C and 1100°C. After oxidation, the oxide was etched off in 6 : 1 H_2O : HF mixture and the wafers were rinsed in deionized water. To reveal the OSF features, wafers were etched for 30 sec in a Secco etch[3] by ultrasonic agitation. The density and size of OSF were measured by using a calibrated microscope.

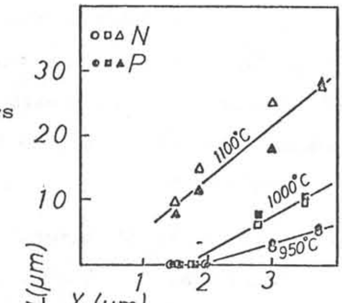

Fig. 2. The lengh of OSF (L) vs. oxide thickness (X_0) for high pressure steam oxidation.

The silicon wafers used in this study were <100> oriented, Czochralski grown, in the form of circular slices 2" in diameter and chem-mechanically polished to 270-290 μm thickness. The resistivity was 6-9 ohm-cm (p-type boron doped) and 10-20 ohm-cm (n-type phosphorous doped).

Figs. 1 and 2 show the length of OSF(L) as a function of oxide thickness (X_o) for conventional wet oxidation and high pressure steam oxidation, respectively. Straight lines have been drawn through a least-squares fit of the experimental results. The length of OSF can be described by the following equation:

$$L = a_o X_o - a_1$$

where a_o and a_1 are constants at a given temperature.

The length of OSF for the same oxide thickness could be reduced considerably by the high pressure steam oxidation compared with the wet oxidation at normal atmospheric pressure. In Fig. 3, the logarithm of the linear rate constant a_o is plotted against the reciprocal of the absolute temperature. The activation energy of a_o was 1.07eV for high pressure oxidation and 1.29eV for wet oxidation, respectively.

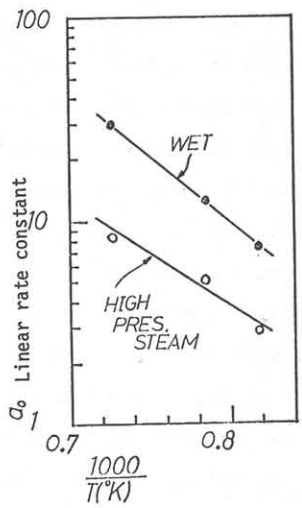

Fig. 3. The effect of temperature on the linear rate constant (a_o).

Fig. 4 shows etched patterns of OSF formed on two halves of the same silicon wafer which were oxidized by different oxidation methods. One half (right side in Fig. 4) was oxidized in the wet oxygen at 1050°C for 500 minutes. The other half was oxidized in high pressure steam at 1050°C for 60 minutes. Oxide thickness were 1.60 μm and 1.50 μm, respectively. This figure shows that the density of OSF formed by high pressure steam oxidation could be reduced significantly compared with the wet oxidation for the same oxide thickness.

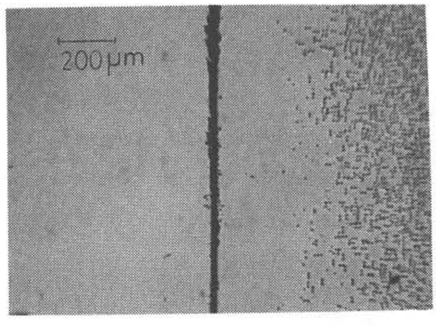

Fig. 4. OSF formed by high pressure steam oxidation (left side) and that by wet oxidation (right side).

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