EXTREMELY HIGH-FREQUENCY IMPEDANCE ANALYSIS ON PASSIVATION FILM WITH LARGE LEAKAGE CURRENT FOR PASSIVATED CONTACTS

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Carrier recombination at the contact-silicon interface is becoming apparent as a limiting factor due to the maturation of surface passivation technology. Thus, the passivated contact structure has been attracting attention, in which an ultrathin dielectric film is inserted right under metal contact. Characteristics such as the interface state density $D_{it}$ and the fixed charge $Q_f$ have conventionally been evaluated by capacitance-voltage measurement. However, it is difficult to determine the thin film capacitance in a structure with large leakage current. We have conducted impedance analysis in the high frequency region of 1 MHz - 3 GHz and are trying to analyze a highly leaky passivation film. In this study, we report on the results of characterization of a-Si/c-Si interface.

An i-a-Si film of 20 nm was deposited on n-type c-Si, and aluminum with 0.1 mm in diameter was vacuum deposited as an electrode. To reduce parasitic components on the back surface, an n⁺ layer was formed and then silver was deposited. Frequency sweep measurement was performed with a direct current bias of 0 - 8 V using an impedance analyzer (Keysight E4991B).

The Cole-Cole plot at DC bias 1 V is shown in Figure 1. Good fitting results were obtained by an equivalent circuit (inserted diagram in Figure 1) consisting of two RC and a series resistance elements. The fitting results of the two capacitive elements C1 and C2 are shown in Figure 2. In the DC voltage sweep, the capacitance C2 has a constant value, while C1 is largely changed. The bias dependence of C1 is attributed to the combined capacitance of the depletion layer and the thin film. From the comparison of the ideal capacity curve by the Terman method [1] for the CV curve obtained by the voltage $V_{ROI}$ at C1 from the three resistance elements, $D_{it} \sim 10^{12} - 10^{13}$ cm$^{-2}$eV$^{-1}$ and $Q_f < 0$ were subtracted (Figure 3).


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Figure 1: Cole-cole plots under DC voltages of 1 V. Black dots indicate experimental values, and a red line indicates fitted curve. The inserted figure shows the estimated equivalent circuit.

Figure 2: C-V curves of fitted C1 and C2.

Figure 3: C1 in Figure 2 vs. calculated voltage curve. The black line indicates the ideal C-V curve derived from Terman method.