Area: 1. Crystalline and Thin Film Silicon PV.

DEVELOPMENT OF PASSIVATION FILMS FOR N-TYPE CRYSTALLINE SILICON SOLAR CELLS

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The n-type crystalline Si solar cell using fire-through electrode has received attention as a cost-effective and high efficiency solar cell. We have developed the n-type crystalline Si solar cell with PERT (Passivated Emitter Rear Totally diffused) structure which has a deeply diffused emitter, a negative charged passivation layer, such as Al_2O_3, and a BSF (Back Surface Field) layer.[1] Although a BSF layer is effective to improve Voc in a PERT structure cell, it is difficult to improve both Voc and rear contact resistance simultaneously. Therefore, we have developed a novel rear passivation layer for n-type Si solar cell.

A phosphorous doped poly-crystalline Si layer is applied as a rear passivation layer. In the case of using a fire-thorough electrode, a passivation layer needs to possess sufficient durability for high temperature firing process. Therefore we have studied the condition of post-deposition annealing for a passivation layer. Figure 1 shows implied Voc measured by QSSPC (Quasi-Steady-State Photoconductance) technique of four passivation structures fabricated with different deposition conditions. The optimum temperature to obtain the highest Voc varies with deposition conditions. The implied Voc of condition B is up to 0.700 V at an annealing temperature at 800 °C. This result suggests that the passivation layer possesses durability for high temperature process. Furthermore, a non-doped Si layer (condition D) shows very low implied Voc for any temperature.

Figure 2 shows the schematic structure of a novel solar cell passivated by a poly-crystalline Si layer on rear side. Table I shows the comparison of solar cell parameters of a novel n-type cell and a conventional n-type PERT cell. In a novel cell, both Voc and FF are enhanced simultaneously and conversion efficiency is improved from 21.5% to 21.9%. It is well known that increasing doping density of a BSF layer leads to improvement of series resistance and of FF, and the degradation of Voc is caused by carrier recombination at a BSF layer. Compared to the conventional cell, simultaneous enhancement of Voc and FF of a novel cell suggests that the passivation structure can suppress the carrier recombination and reduce the contact resistance for a fire-through electrode.

[1] S. Nishimura, et.al., IEEE Journal of Photovoltaics, vol. 6, No.4, 2016,. pp. 846-851.

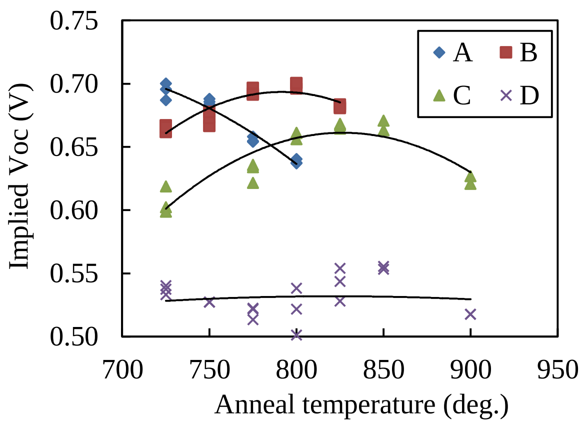

Figure 1: Temperature dependence of implied Voc for various passivation films.

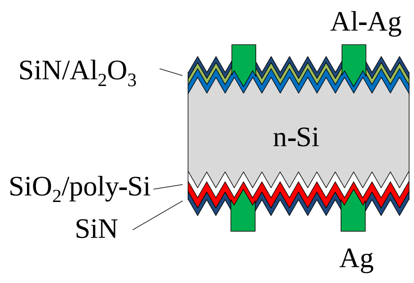

Figure 2: Schematic structure of a rear passivated solar cell by poly-crystalline Si layer.

Table I: Comparison of solar cell parameters.

	Jsc (mA/cm^2)	Voc (V)	FF	C.E. (%)
Novel n-type cell	39.6	0.686	0.807	21.9
Conventional n-type cell	39.5	0.683	0.797	21.5

In-house measurements.