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Realization of conductive wells for rear side electrical contact of integrated solar cell

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Abstract

The so-called integrated solar cell (i-Cell) consists of several small area sub-cells manufactured by bonding monocrystalline Si (mono-Si) thin foils (20-60µm) onto cost effective insulating substrates on which local conductive wells have been previously integrated. In this paper, we report on the realization of deep recrystallized conductive wells acting as the rear side electrical contact of each sub-cell. These conductive wells have been produced by screen-printing of a thick aluminum (Al) layer followed by a fast-firing process for the formation of the back electrode of each sub-cell. The i-Cell delivers a high voltage and a low current, which reduces the resistive losses in the interconnections of i-cells and modules. The influence of firing temperature profile on the depths and electrical properties of conductive wells are investigated. The feasibility of i-Cell realized on these deep recrystallized conductive wells has been demonstrated. The preliminary results, obtained from 156x156 mm² i-Cell on which four sub-cells are connected in series, show an efficiency over 16%, with a short circuit current of 2.1 A and an open circuit voltage of 2.5 V.

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Keywords: Integrated solar Cell; i-Cell; Conductive wells; Sintered silicon substrate

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1. Introduction

In order to reduce the cost of Si wafers production, and to keep the same level of efficiency as monocrystalline (mono-Si) solar cells, we have developed the mono-equivalent (Mono-EQ®) wafers technology, which combines both the advantages of a cost effective Si substrate obtained by sintering of upgraded metallurgical-grade (uMG) Si powders [1] and the high efficiency of epitaxial mono-Si thin foils on these substrates [2, 3]. This kerfless wafer technology avoids the production of polycrystalline Si (poly-Si), the growth of ingot and the classic wafering by sawing, therefore reducing energy consumption. It also avoids CO_2 emission and the wasting of solar grade Si material during sawing of ingots. A thickness of 20-40µm of mono-Si is enough to achieve high efficiency if the cell structure, its passivation and its optical confinement, are optimized [4, 5]. Based on these Mono-EQ® wafers, solar cells have recently reached a conversion efficiency of 16% by using standard solar cell processes [3]. Moreover, as shown in Fig. 1, we have proposed a new concept of solar cell: the integrated solar cell (i-Cell). The i-Cell consists of several small area sub-cells connected in series by screen-printed finger shape contacts as shown in the photographs presented in Fig. 2. Local conductive wells have been realized by screen printing an industrial aluminum paste, and followed by a fast-firing process. These deep recrystallized local conductive wells act as the rear side electrical contact of each sub-cell. This i-Cell technology allows the production of cells with high voltage levels and low current, which reduce resistive losses. Like a tandem solar cell, the current of an i-Cell corresponds to the minimum of the currents of all sub-cells while the total voltage of an i-Cell is the sum of the voltages of each sub-cell.

In the present work, the realization of conductive wells on insulating hot press sintered Si substrate is studied. The influence of the firing peak temperature on the electrical and microstructural properties of wells has been investigated. The feasibility of the realization of an i-Cell, on which local conductive wells act as a back electrode of each sub-cell, has been demonstrated.

i-Cell structure

One i-Cell structure is shown in Fig. 1. Several, for example four sub-cells, are connected in series on the integrated sintered substrates on which conductive wells have been formed within the insulating sintered substrate. The conductive wells act as the rear side electrical contact of each sub-cell and are spaced relative to each other by a distance of 1 mm. The intermediate layer acts as optical mirror, impurity diffusion barrier, passivation and electrical contact. Ag paste 1 is for front side metallization and firing is needed for this step. Ag paste 2 is for the interconnection of front and rear sides between sub-cells as shown in Fig. 2. For this step, no firing but a simple low temperature annealing is required.

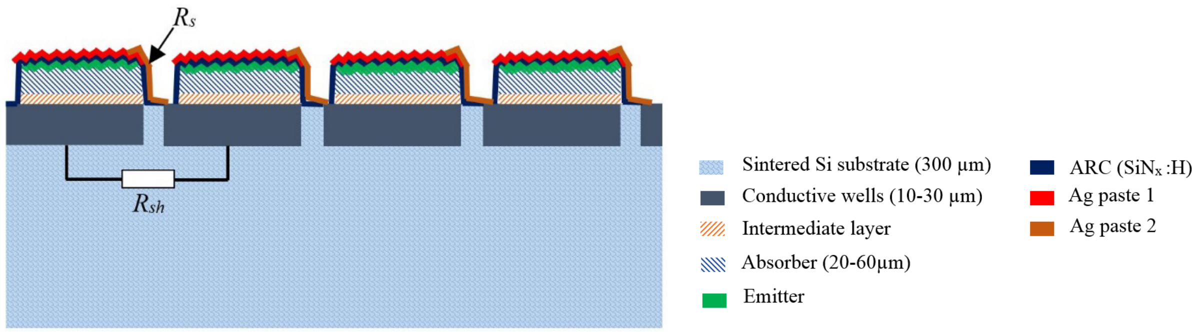

Fig. 1. i-Cell structure