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Letter

Thin crystalline silicon solar cell bonded to sintered substrate with aluminum paste

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Abstract

Making thinner wafers is a simple way to reduce the production cost of silicon solar cells. However, thin wafers need to be supported mechanically in order to avoid the problem of breakage. Among the several possible supporting materials, silicon substrate made from the sintering of silicon powder, which is produced during the slicing process is the most favorable one because of its abundance and its similar thermal expansion coefficient with silicon wafers. For the bonding of the substrate and thin silicon wafers, aluminum paste is selected because of its compatibility with silicon and the possible BSF effect. Silicon solar cells of 150 μm with the sintered substrate on the back show 5.42% in solar cell conversion efficiency. Compared to commercial silicon cells, lower J_{sc} is obtained. This might be due to the poor conduction in the back layer of aluminum, which is absorbed into the supporting substrate during the annealing process.

Keywords: Bonding; Aluminum; Solar cell

1. Introduction

The enhancement of conversion efficiency and reduction of production costs are the two main research areas in the production of silicon solar cells. The cost of

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silicon wafers constitutes more than 65% of the total production cost of silicon solar cells [1]. In order to make silicon a commercially viable material for solar cell production, lowering the wafer cost is highly desirable. One way of lowering the wafer cost is by reducing the thickness of the silicon wafers [2]. Currently, wafers thicker than 350 μm are used for producing solar cells. Including 250 μm of kerf loss, 600 μm of silicon needs to be used in order to make a wafer of 350 μm. Recently, slicing technology improvements have allowed for the cutting of 150 μm thick wafers. With this trial, a 47% yield increase is expected. However, thin wafers are easily broken during the fabrication process. To avoid this breakage problem, careful handling of wafers is vitally important. A non-contact fabrication process can be one solution. Another solution is to support the thin solar cells with a cheap substrate. This supporting substrate should not only be strong, but also have a similar thermal expansion coefficient as the silicon wafers [3]. If there is a big difference in the thermal expansion coefficient between these two materials, then another breakage problem can occur. The breakage may occur during fabrication, or the solar cell may fail in the field. One way to make the supporting substrate cheaper is to use cheaper raw materials. Fortunately, during the slicing process of the silicon wafers, silicon sawing dust is collected in the form of sludge. This sludge is composed of silicon powder of 6 μm in diameter. If properly treated, this material can be a good raw material for the cheap substrate. In this investigation, the cheap substrate is attached with aluminum paste to a 150 μm solar cell. The purpose of this investigation is to determine if this method can be used to reduce the production cost of solar cells.

2. Experiments

For the thin silicon solar cell structure as in Fig. 1, silicon wafers of p-type (1 0 0) are etched to be 150 μm with KOH solution. And then, emitter is formed on this wafer by annealing it at 950 °C for 30 min with $POCl_3$. TiO_2 layer on the top of the emitter layer is formed with APCVD. With screen printing techniques, the aluminum layer is printed on the back of the wafer. The whole fabrication process is shown in Fig. 2. Due to its abundance, silicon sludge produced during the slicing process has been selected as the material for a back supporting substrate. The average size of the

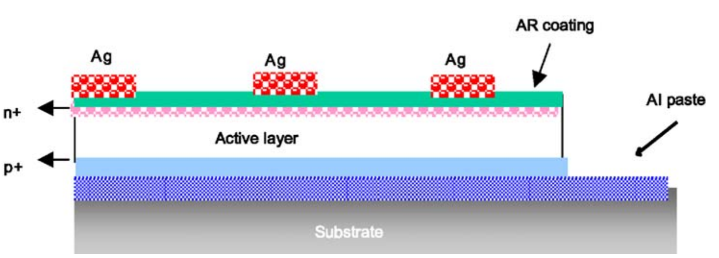

Fig. 1. Schematic solar cell structure employed in the experiment.