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Multi-wire interconnection of busbar-free solar cells

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Abstract

The interconnection of busbar-free solar cells by multiple wires is a simple and evolutionary concept to lower the cost of PV modules by reducing silver consumption for the front side metallization and to increase the module efficiency by lower series resistance and improved light harvesting. A 0.33 % absolute higher performance of MBB against the established H-pattern solar cell has already been demonstrated by Braun [1]. This work focuses on the interconnection of Multi Busbar cells (MBB) by infrared soldering and the optimization of the front metallization design in order to achieve reliable solder joints. We find the following factors to be crucial for the MBB-interconnection process: a homogeneous radiation field, a process-adapted down-holder device, a homogeneous wire coating, a precise wire positioning and a method to absorb the wire expansion caused by the elevated solder temperatures. We measure peel forces up to 5.7 N/mm as the average peel force value of five pad rows from the center of two MBB cells containing 160 soldered pads. Furthermore a one-cell MBB-module shows a more homogeneous series resistance with an approximately 0.3 Ωcm² lower series resistance compared to a one-cell 3-busbar module, which we determine by C-DCR (coupled determination of the dark saturation current and the series resistance). Finally two 20-cell MBB modules manufactured with an automated MBB-stringer pass the TC-200 test without significant changes in IV, EL and module optical appearance.

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Keywords: solar cell; multi busbar; interconnection; PV module; wire interconnection

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1. Introduction

In order to reduce the amount of silver for the metallization of crystalline silicon solar cells and to improve the module efficiency the current trend in interconnection technology is to move from three busbars to four or five busbars [2]. Continuing the idea of increasing the number of busbars and reducing the finger cross sections results in the interconnection of busbar free solar cells.

Meyer Burger's SmartWire Connection Technology (SWCT) concept [3] is based on the Day4Energy technology [4] which was commercialized between 2007 and 2011. It favours 38 wires and interconnects during the lamination process at 160 °C using a low melting-temperature alloy. The main idea of SCHMID's Multi Busbar concept (MBB) is to solder the wires onto the cells before lamination. This concept currently favors 15 solder coated copper wires and uses infrared soldering.

The benefit of wire interconnection compared to the three-busbar (3BB) design has been published by Braun confirming an efficiency gain of 0.33 % absolute and a lower silver consumption of 50 % [1, 5-7]. Braun attributes the efficiency gain to improved module optics, due to the round shaped wires, and the shorter current paths in the finger metallization. Schindler investigates the influence of the copper wire diameter of 250 µm and 300 µm on the peel force, observing no considerable differences in terms of peel force and fracture mode [8]. However, increasing the wire diameter enables a lower series resistance along with higher shadowing of the active cell area.

2. Interconnection of multi busbar cells

2.1. Soldering tests

We perform preliminary soldering tests on Gen 2 cells in order to compare infrared, contact, hot air, laser and induction soldering. Due to the larger pads on the cell, higher adhesive forces can be observed at the beginning and the end of the curve. In figure 1 representative peel results of the inner pads are shown, to compare the different soldering methods. Soldering by infrared, contact soldering and hot air results in a higher number of connected solder pads, compared to soldering by laser or induction.

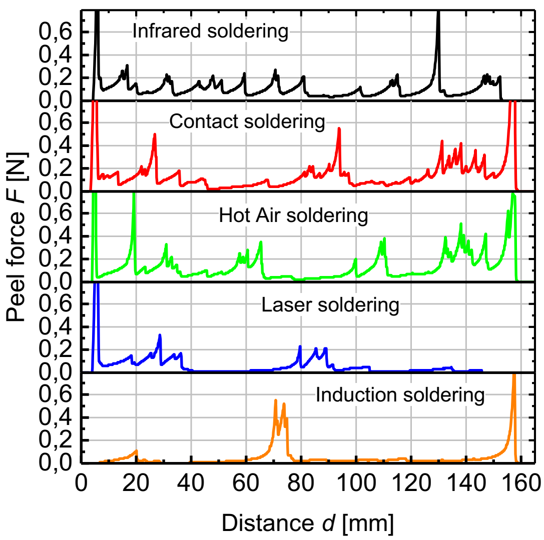

Fig. 1. Adhesive force measurements of different soldering methods.

We analyse the solder joints with X-Ray to investigate the solder distribution on the pad and to inspect the joints for either voids or any non-uniformity. Table 1 shows the X-Ray images of the different solder methods. We found no