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Solder joint stability study of wire-based interconnection compared to ribbon interconnection

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Abstract

For the comparative study with focus on mechanical long-term stability, we perform a temperature cycle (TC) test-to-failure for 1250 cycles according to IEC 61215 with laminated solar cell strings. The strings were produced with Multi Busbar (MBB) solar cells interconnected by wires and with solar cells with 3 busbars (3BB) interconnected by ribbons. One module sample comprises two electrically isolated 3-cell strings, one for each technology. The 3BB string displays a power loss of more than 5 % after 850 cycles, while the MBB string only exceeds 5% loss after 1250 cycles. After TC 1250 the 3BB string shows a degradation of -8.2 % in FF and -8.0 % in power, while the MBB string shows a degradation of -6.2 % in FF and of -5.3 % in power.
In the second comprehensive comparative study we use for each interconnection technology 15 cells for isothermal storage (up to 130 °C, 42.8h) and 10 modules for TC (up to 400 cycles). Each reliability analysis includes IV and EL characterization as well as adhesion force measurements and microsection analysis. After TC 400 the MBB interconnection shows less than 1 % degradation in efficiency compared to 4-5 % degradation for 3BB ribbon interconnection in a common module setup. The cells and modules show that most of the electrical contacts are still intact with respect to the EL image after 42.8 h isothermal storage and TC 400, although the average peel forces degraded from about 2 N/mm to less than 0.5 N/mm.
Both studies indicate a superior mechanical long-term stability for Multi Busbar technology compared to ribbon interconnection.

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Keywords: Multi Busbar; 3 busbar; solar cell; solar module; electroluminescence; IV measurement; microsection; peel test; test-to-failure; wire; ribbon; temperature cycling; mechanical analysis;

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1. Introduction

Nowadays the solar cell interconnection technology for PV modules is dominated by ribbon-based interconnection [1] with 3-5 busbars per cell [2] and ribbon dimensions of 0.9 mm to 1.5 mm width and a thickness of around 200 µm. The market share of modules with strings interconnected by multi wire technologies is expected to grow in the coming years [3]. For standard front and rear contact solar cells there are two prominent approaches for multi wire interconnection on the market using only fingers and/or contact pads interconnected by wires instead of ribbons.

Schmid's Multi Busbar technology (MBB) favors 12-15 wires [4] and Meyer Burger's SmartWire Connection Technology (SWCT) can use up to 38 wires [5, 6]. Schmid uses infrared light for soldering whereas the Meyer Burger approach performs the soldering during module lamination at temperatures below 160 °C enabled by low melting temperature solder. For this concept the wire positioning on the cell is realized by a foil containing these wires which has to be additionally fabricated whereas Schmid directly solders the wires onto the cell. Typical wire diameters are between 200 µm and 400 µm, strongly dependent on the number of wires used for the interconnection. There are several upsides to multi wire interconnection technology:

- lower optical interconnector shading [7, 8]
- lower silver consumption [6, 8–11]
- reduced current per finger enables small finger width [11, 12]
- shorter effective current paths in fingers enables an increased homogeneous series resistance distribution [4, 10]
- higher power on module level [8, 10, 11]
- enhanced reliability in pressure cooker test and improved contact redundancy [13]

This work focuses on the mechanical long-term stability of 3 busbar modules and Multi Busbar modules.

2. TC test-to-failure with 3-cell strings

2.1. Experimental approach

We laminate two 3-cell-strings with MBB and 3BB interconnection in one module (Fig. 1) according to a common module setup (Fig. 7), thereby eliminating effects caused by differences in material or lamination process.

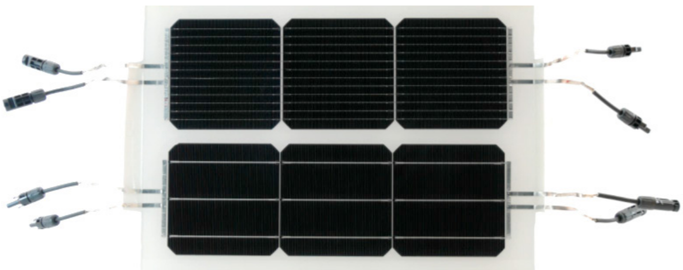

Fig. 1. Test-to-failure module setup consists of two electrically separated 3-cell-strings in one module – 3BB on the bottom, MBB on the top.

The 3-cell-configuration simulates more realistic loading modes for intercellular effects, which occur in common modules including 60 solar cells. The two strings are electrically isolated.

The interconnected bifacial MBB cells (156 mm, mono, psq, n-type, $Ø_{wire}$ = 390 µm) are provided by Schmid. The interconnection of the reference, 3 busbar PERC solar cells (156 mm, mono, psq, p-type, 1.5 x 0.2 mm² ribbon), is done by an industrial tabber-stringer from Somont at Fraunhofer ISE after determining the best solder parameters on about 300 cells.

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