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ScienceDirect

Energy Procedia 124 (2017) 478–483

Energy Procedia

www.elsevier.com/locate/procedia

7th International Conference on Silicon Photovoltaics, SiliconPV 2017

Ultra-soft wires for direct soldering on finger grids of solar cells

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Abstract

We propose an interconnection concept for solar cells that enables the soldering of solder coated copper wires directly on the contact fingers of the front side metallization without the need of busbars or contact pads. By reshaping the copper wires we realize a wave-shaped stress relief structure. This reduces the yield force, the force value where plastic deformation of the wire starts, up to 90 % compared to straight wires and therefore minimizes mechanical stresses in the joint after the soldering process essentially. Our experimental analysis demonstrates the mechanical long-term stability of the interconnection (ΔP < 2 % after TC 370). The method enables a significant silver reduction by omitting solder pads or busbars on the front side and is especially suitable for the interconnection of exceptionally thin, stress sensitive solar cells or back contact solar cells with a minimized cell bow.

Peer review by the scientific conference committee of SiliconPV 2017 under responsibility of PSE AG.

Keywords: Wire interconnection; wave-shaped wires; reliability; contact fingers; thermomechanical stress; stress relief; Multi Busbar; SmartWire; temperature cycling; electroluminescence

1. Introduction

On the worldwide market, the prices for solar modules have been constantly falling for decades. Therefore, cost reduction is crucial for module manufacturers to remain competitive. One possibility to decrease costs is to reduce the content of silver in a solar module, since silver is comparatively expensive. Omitting busbars or even contact

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1876-6102
Peer review by the scientific conference committee of SiliconPV 2017 under responsibility of PSE AG.
10.1016/j.egypro.2017.09.284

pads is one approach that targets the reduction of the amount of silver for the metallization for silicon solar cells. Unfortunately, it is very challenging to realize a reliable interconnection of a silicon solar cell only with contact fingers due to their low width of < 70 µm. At present, there are three concepts for the interconnection of solar cells without busbars:

Schmid proposes solar cells that are interconnected by infrared soldering of solder-coated copper wires on both sides using a silver-reduced Multi Busbar (MBB) layout [1]. The reliability of solar modules with MBB solar cells has been investigated, where cells feature miniaturized contact pads for solder joints [2].

The SmartWire concept of Meyer Burger enables the interconnection of pad- and busbar-free solar cells during the lamination process by using wires, coated with a low-melting solder and being pre-embedded in polymer foils [3]. This concept requires wires coated with a specific low-melting solder alloy [4].

Schneider et al. and Geipel et al. demonstrated the interconnection of solar cells without pads or busbars by using conductive adhesives (ECA) and ribbons [5, 6] which is especially suited for non-solderable, temperature-sensitive or mechanically fragile cells. The additional cost for the ECA needs to be balanced with the specific module cost (CoO or LCOE) [7].

In this work we introduce a novel concept for a reliable interconnection of solar cells without busbars or pads by soldering copper-based wires, coated with a standard solder (Sn62Pb36Ag2), directly on the finger metallization.

2. Experiments

2.1. Adjusting the wire shape

Changing the shape of copper-based wires potentially leads to a significant change of its mechanical properties. To reshape a wire we developed a method that enables the production of wave-shaped wires with adjustable periods and amplitudes. Figure 1 shows microscopic images of wave-shaped wires with a diameter of 300 µm, a constant period of 3.1 mm and various amplitudes.

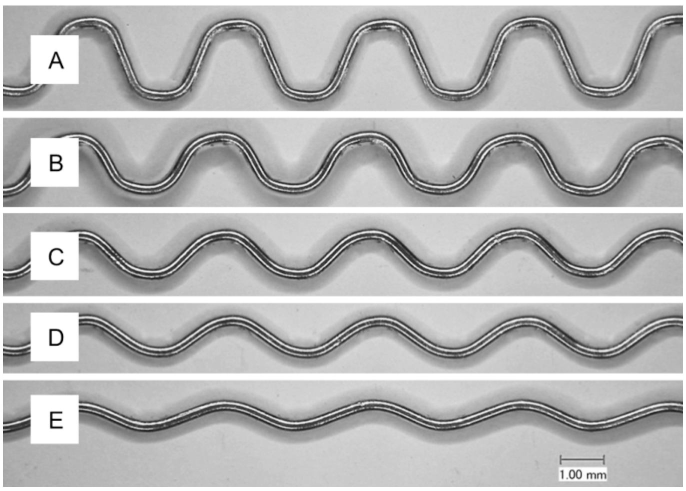

Fig. 1. Microscope images of wave-shaped wire examples with a period of 3.1 mm and various amplitudes (peak-to-peak) between 0.6 and 2.0 mm (A: 1906 µm, B: 1448 µm, C: 1166 µm, D: 1012 µm, E: 779 µm).

We measure the mechanical behavior of a wire interconnector by standard tensile tests according to ISO 6892-1 [8]. By analyzing the stress-strain-curve we obtain the Young's modulus, the yield stress and the ultimate tensile strain. During tensile testing the wave-shaped wire is straightened and the material is stretched. In contrast to the mechanical stress, we analyze the measured force since the force is independent from the geometry. In addition, for wave-shaped wires we denote the elongation level as "effective strain" because both - straightening as well as material stretching - contributes to the total strain.