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Materials challenge for shingled cells interconnection

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Abstract

This paper discusses some challenges that need to be tackled when designing a photovoltaic module using a shingled cells structure. We derive a simple analytical model to determine the conditions needed to avoid interconnection joint failure. It is found that interconnection materials with a low ratio of shear modulus G over shear strength $\tau_{sh.\ str.}$ is preferred for good interconnection joints reliability. As a result, solder joints appear inappropriate for the application, while electrically conductive adhesives (ECA) with low G/ $\tau_{sh.\ str}$ can better fulfill the requirements. An interconnection approach is also proposed which makes use of a combination of adjacent ECA and a non-conductive adhesive materials in a shingled configuration to help achieve string robustness and reliability.

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Keywords: Interconnection ; electrically conductive adhesive ; shingled cells

1. Introduction

The traditional technique to interconnect solar cells in a module is to solder Cu ribbons onto Ag busbars present on the front and the rear of solar cells. This approach has proved to be cheap and, if the soldering process, stringing process and ribbon parameters are well designed and controlled, it is robust and reliable. However, there are several problems associated with this technology. First, the ribbons and front busbars cause substantial shading losses. Moreover, the busbars cover a significant area of the solar cells and are made of almost pure Ag, which is an important cost. Further, as the large cell current is forced into ribbons with a small cross-section, resistive losses are high. Another limitation of ribbon soldering is the differential contraction of the copper ribbons and the silicon,

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which can result in high stress in the metallization and silicon. Moreover soldering local heating and pressure and can contribute to additional stress and micro-cracks in the silicon. As a result soldering interconnection prevents the evolution towards thinner wafers because stress-related yield losses soar when going thinner. Finally, the types of solder materials that are mostly used contain a large amount of Pb, which causes a regulatory concern for the future.

Several new module concepts, which make use of new interconnection technologies and new cell types, are presently being developed and introduced in the market, for instance multiwire interconnection on busbarless cells and conductive backsheet interconnection with back-contact cells. In this paper, we discuss one of these concepts, namely the shingled cells module.

2. Shingled cells module structure

In the shingled cells module structure, the cells that are used are rectangular (Fig.1). The long side usually has the length corresponding the side length of a standard solar wafer, i.e. 15.6 cm. The short side is only a few cm long. Usually, these solar cell strips have been cut out from a processed device with standard size 15.6 x 15.6 cm^2. The cells have busbars or rows of solder pads along the long edge, one on the front and one on the back (opposite edge).

a)

b)

Fig. 1. Schematic drawing of a cell for shingled cells interconnection. (a) top view ; (b) bottom view

To create a cells string, an interconnection material is applied to connect the rear busbar of a cell with the front busbar of the next cell (Fig. 2). The cells overlap each other slightly, so that the front busbars are covered by the edge region of the adjacent cell, just like shingles on a roof (Fig. 3). Because there is no spacing between cells as in conventional modules, because the cell area that is shaded by the front busbar is covered by an active area of another cell, and as there is no ribbon covering the cells' front surface and causing shading, this structure results into modules with extremely high active area to total area ratio, allowing in principle very high module efficiency. One also saves on ribbon cost, but there is the extra cost of cutting the cells into strips. The cell cutting process may cause some cracks and related failures and therefore needs to be well-controlled.