

Photovoltaic Module Assembly Using SMT Assembly Materials and Processes

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Increasingly, SMT electronics manufacturing service providers (EMSs) are seeking to diversify and fill capacity. Photovoltaic (PV) solar cell module assembly is becoming a popular choice to meet those goals. Commonly referred to, in the solar industry, as the “back-end process”, PV solar cell module assembly has similarities to the SMT assembly process.

Introduction

The increasing demand for clean energy has caused photovoltaic (PV) module production to nearly double, year on year, in recent times. There are four types of PV modules being produced:

- copper-indium-gallium-selenium (CIGS)
- cadmium-telluride (CdTe)
- amorphous silicon (a-Si)
- silicon (Si)

CIGS, CdTe, and a-Si are the newest photovoltaic assembly technologies. CIGS is the most promising in terms of reliability (life cycle), efficiency, and cost. Numerous start-up companies in the U.S., and established companies in Europe, have embraced this technology. CdTe is a proven solution for cost-effective thin-film PV technology and has been on the market for years. Modules made using this material deliver power for as little as US\$1/watt.

a-Si is a non-crystalline silicon technology that uses chemical vapor deposition (CVD) to deposit optical coatings over a large area at low temperatures. This enables deposition on polymer substrates to produce flexible thin-film solar cells.

Si and crystalline silicon (c-Si) remain the most traditional and widely-used technologies, holding nearly 80% of solar module assembly market. This paper will discuss this technology exclusively.

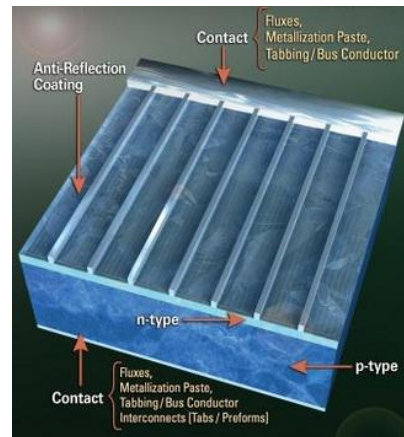


Figure 1 Crystalline silicon solar cell.

TERMINOLOGY:

Similar to the SMT industry, the PV module assembly industry is rife with jargon. To navigate the world of PV module assembly, the seasoned SMT practitioner needs to know the following interconnect process steps and materials:

Interconnect Steps:

For the sake of this article, we divide PV module production into two basic steps (based on interconnects):

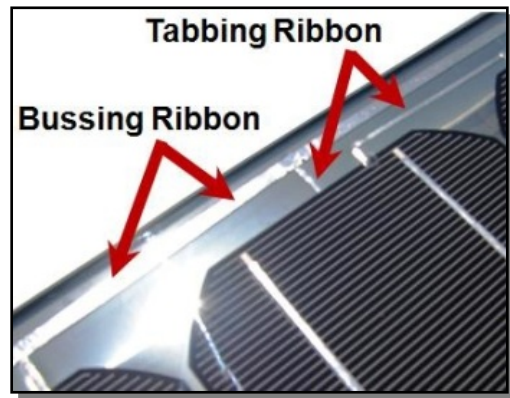
- PV Cell interconnect: individual PV cells are joined, usually with 6-10 cells in a cluster. This is frequently referred to as “cell stringing”.
- PV module assembly: interconnected PV cell “clusters” are joined together to produce a complete PV module. There are typically from 20 to 80 PV cells in a module. This is frequently referred to as “cell bussing”.

Interconnect Materials:

Common SMT assembly materials, such as solder pastes, solder wire, solder preforms, and fluxes, are used to make interconnects during photovoltaic solar cell module assembly.

Since the RoHS and WEEE initiatives do not apply to the solar industry, many manufacturers use Sn/Pb solder alloys for interconnects, with Sn60 and Sn62 being most popular. Sn/Ag alloys are occasionally used, and some manufacturers are exploring the use of SAC alloys (Sn/Ag/Cu), specifically SAC305. Solder thicknesses can be up to 1 mil (0.001 inch).

“Tabbing ribbon” (sometimes called “PV ribbon”) is the term used to describe the interconnect material used throughout this process. PV ribbon is made from solder-coated OFHC (oxygen-free high conductivity) copper ribbon which is “dead soft”. This ribbon carries the current from each PV cell to a “bus”, a larger tabbing ribbon that carries power from the PV cell clusters to the module’s junction box (power output). There are two types of tabbing ribbon:



- Photovoltaic Cell interconnect: this tabbing ribbon, called “stringing ribbon”, connects individual PV cells to one another in a cluster and delivers current to the bussing ribbon. Stringing ribbon is typically 2mm wide.

- PV module assembly: interconnected PV cell “clusters” are joined together using 5mm-wide tabbing ribbon, called “bussing ribbon”. Bussing ribbon delivers current to the module’s junction box for final output.

ASSEMBLING A PV MODULE

There are two basic process steps used to assemble a PV module:

Photovoltaic Cell Interconnect: Stringing

Connecting individual PV cells into a PV module is called solar cell tabbing or solar cell interconnect stringing. In this process, the cells are electrically connected using stringing ribbon.

The solder-coated tabbing ribbon is dipped into, or sprayed with, flux. Alcohol-based fluxes are widely used for this application, although VOC-free fluxes are also used. An air knife is often used to eliminate excess flux. As in the SMT assembly process, there is also the option of printing flux or solder paste onto the PV cell itself. A no-clean paste with little or no flux residue is best as it reduces process steps and addresses reliability issues. This solder paste printing step is identical to that of the surface mount assembly process.

Solder reflow is typically conducted at the tabbing machine. The ribbon is placed on the collector grid (the substrate). Since the collector grid is metalized with silver, a silver-containing solder is used to make the interconnect. Soldering is frequently performed via radiant infrared energy. In some cases automated soldering irons are used.

PV Module Assembly: Bussing

After the PV cells have been strung together through reflow, they are placed on a substrate, typically glass. Six to ten rows of cells are then “bussed” together (via soldering) to create the collector grid. This process step is typically performed using a soldering iron.

Once all the PV cell stringing and bussing is complete, another layer of glass is placed on top of the cells. An anti-reflective coating is then applied to the top glass surface. Next, the module is sealed and tested for efficiency. After the module passes inspection, it moves to the framing stage, then to a sun simulator to determine if the module is generating sufficient power.

Conclusion

PV cell stringing in solar module assembly is achieved using many common SMT materials and processes. Solders, fluxes, and common reflow technologies produce

electrical interconnects in both a-Si, and c-Si photovoltaic technology. This, together with the growing demand for clean energy, has an increasing number of SMT EMSs diversifying into solar module assembly.