Soldering Photovoltaic Cells

Increasingly, electronics manufacturing services (EMS) providers specializing in SMT are seeking to diversify and fill capacity. Photovoltaic (PV) solar cell module assembly is becoming a popular choice to meet those goals. 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.

KARL PFLUKE, INDIUM CORPORATION

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), and silicon (Si). CIGS, CdTe, and a-Si are the newest photovoltaic assembly technologies. CIGS is the most promising in terms of reliability (lifecycle), 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 $.80/W. a-Si is a non-crystalline silicon technology made using chemical vapor deposition (CVD) to layer 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) (Figure 1) remain the most traditional and widely used technologies, holding nearly 80% of solar module assembly market. This paper is focused solely on this technology.

Photovoltaics Materials

To navigate the world of PV module assembly, the seasoned SMT practitioner needs to know the

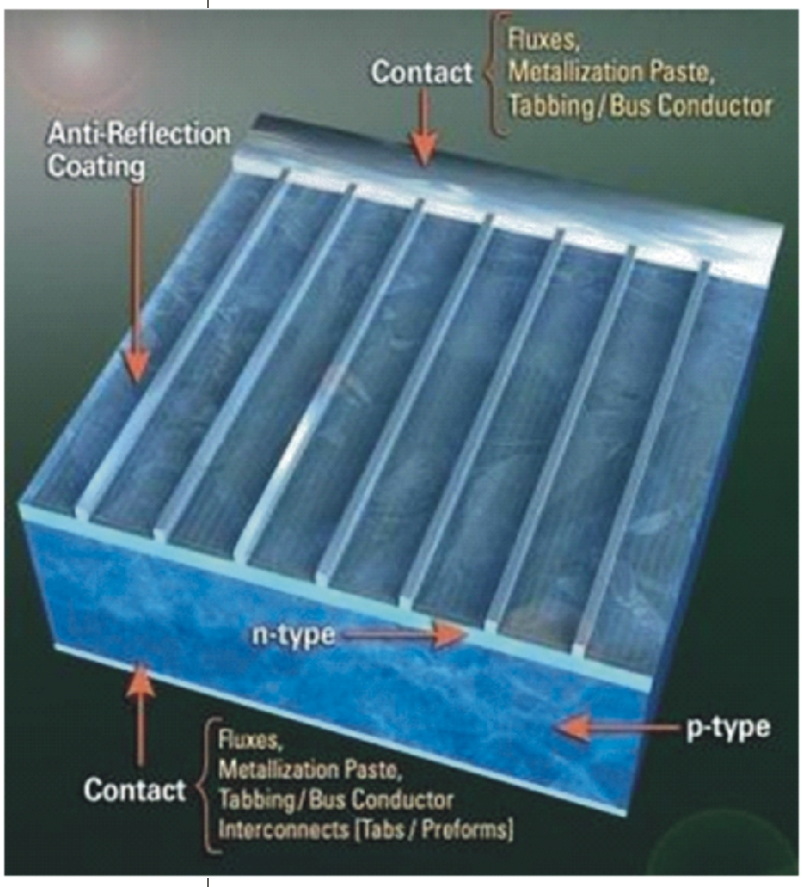

Fig. 1. Crystalline silicon solar cell.

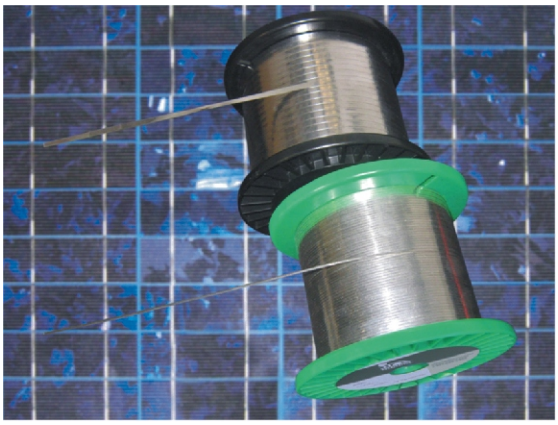

Fig. 2.

following interconnect process steps and materials: For the sake of this article, we divide PV module production into two basic steps (based on interconnects). PV cell interconnect occurs when individual PV cells are joined, usually with 6–10 cells in a cluster. This is frequently referred to as cell stringing. In PV module assembly, these interconnected PV cell clusters are joined together to produce a complete PV module. There are typically 20–80 PV cells in a module. This is frequently referred to as cell bussing. Common SMT assembly materials — 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 tin/lead (Sn/Pb) solder alloys for interconnects, with Sn60 and Sn62 popular choices. Tin/silver (Sn/Ag) alloys are occasionally used, and some manufacturers are exploring the use of tin/silver/copper (Sn/Ag/Cu — SAC) alloys, specifically SAC305. Solder thicknesses can be up to 1 mil (0.001").

Tabbing ribbon (Figure 2), sometimes called PV ribbon, is the interconnect material used throughout this process. PV ribbon is made from solder-coated oxygen-free high conductivity (OFHC) copper ribbon which is "dead soft." Dead soft copper is easiest to work with in such applications, as it has been annealed so that it is soft and pliable. 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).

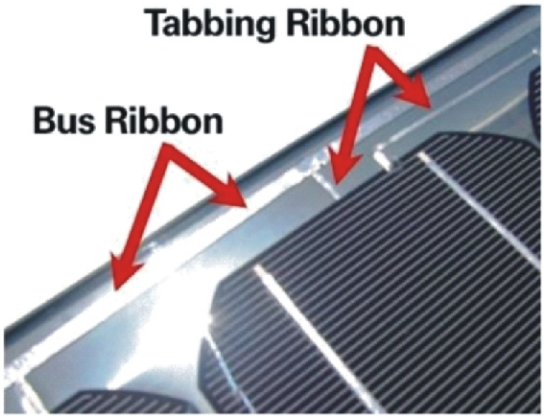

Fig. 3.

There are two types of tabbing ribbon, both shown in Figure 3. Photovoltaic cell interconnect 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 2-mm wide. For PV module assembly, interconnected PV cell clusters are joined together using 5-mm-wide tabbing ribbon, called bussing ribbon (Figure 4). Bussing ribbon delivers current to the module's junction box for final electrical output.

Fig. 4.

PV Module Assembly

There are two basic process steps used to assemble a PV module: photovoltaic cell interconnect by stringing, and PV module assembly by bussing. 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 flux is common 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 delivers the most reliable solder joints. This solder paste printing step is identical to that in the surface mount assembly process. Solder reflow is typically performed 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 (IR) energy. In some cases, automated soldering irons are used. 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 (Figure 5), 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.

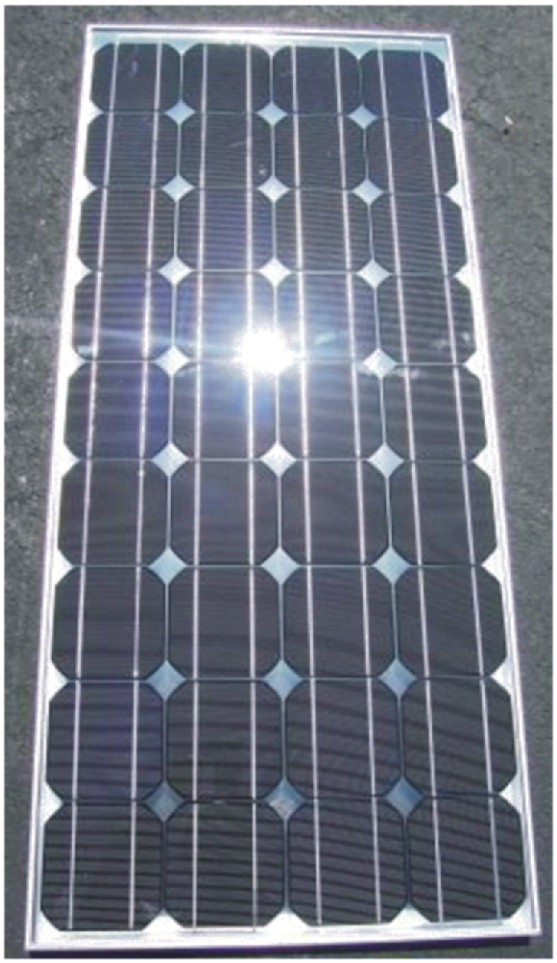

Fig. 5. Complete interconnected solar cells

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

Author Profile

Karl Pfluke

Karl is Business Development and Strategic Account Manager supporting the Solar Business Unit. He can be contacted at solarteam@indium.com. For more information, check out www.indium.com/solar and www.indium.com/blogs/solar-blog.

www.indium.com/blogs/solar-blog.