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Comprehensive study of material dependency for silver based conductive glues

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Abstract

This work is related to a comprehensive study on the material dependency for solar cell interconnection by means of epoxy based silver conductive glue (CG) and its effect on module reliability. The effect of power degradation for samples exceeding DH1000 was studied for various ribbon coatings, rear side AlAg silver pad pastes, amount of CG and for different encapsulation materials. We show that the choice of cell and module materials play a significant role in terms of electro-chemical corrosion. Cheap ribbon materials as non-coated copper ribbon were identified which lead to very positive damp heat results if used in combination with the right encapsulation materials. Special $R_{contact}$ samples did undergo more than 3000 hours of damp heat and proved that pure Cu ribbons without any coating performed almost the same as Ag coated ribbon and significantly better compared to Sn coated ribbon which typically fails for more than 1200 hours of DH. The speed of moisture ingress strongly impacts the corrosion process, hence specifically the rear contact is prone to degradation. We show that this process is even accelerated for larger amounts of dispensed CG. A study on various encapsulant materials showed that non coated Cu ribbon showed excellent results for TPO, TPO with embedded Al and Ionomer materials and acceptable results for Tectosil and EVA whereas Sn coated ribbon requires a TPO based material. DH testing proved that the choice of AlAg paste has a measurable effect on the electro-chemical corrosion and a minor impact on the CTM losses. Finally results for a new CG product development with superior peel strength and contact behavior are presented.

Peer-review under responsibility of the scientific committee of the SiliconPV 2014 conference

Keywords: Solar modules; conductive glue; ribbon; climatic testing; peel testing

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1. Introduction

Conductive glues offer major advantages in solar cell interconnection compared to the soldering process: Bow reduction due to reduced process temperature, contacting of solar cells without front busbars hence offering big saving potential in Ag metallization paste and the application of lead-free ribbons which are currently rarely used due to the by 50 Kelvin increased soldering temperature leading to increased cell breakage. Another major disadvantage of soldering is the incompatibility with cell interconnection of certain high efficiency cell designs as IBC cells. Currently stringer equipment suppliers are already or on its way to offer new stringers or modification for existing equipment to adapt for the glue application (dispensing or printing) and curing process. Specifically with new cell designs as IBC cells are on the rise to enter mass production this technique promises great advantages compared to soldering. This development comes along with strong price reductions for CG due to recent developments with less Ag filling. On the other hand only little or no information is available on how epoxy based silver CG reacts if combined with various materials as AlAg pastes, encapsulation materials and ribbon coatings. For this reason a vast material study was conducted under extended IEC testing conditions to help understanding and controlling the electrical corrosion effect which can only be seen once exceeding DH1000 hence being insensitive to IEC testing in certain respects [1, 2]. Furthermore was a new CG product with superior properties in terms of peel strength and cell to module losses evaluated. Both adhesives, SB1227 respective SB1242, are a product line which is distributed by Polytec PT GmbH and manufactured by Germany based SoltaBond GmbH.

2. Design of experiment

The material investigation should cover the main materials, which are responsible for electro-chemical corrosion or promoting the effect of degradation by water ingress and was performed partly on special contact resistance samples and on one-cell mini-modules. The study was divided into four parts:

- *Study of the $R_{contact}$ change during damp heat for Ag front busbar, AlAg rear pad and various ribbon coatings*
  To understand the effect and root causes of electro-chemical corrosion during damp heat in more detail $R_{contact}$ samples as shown in Fig. 1 were prepared: various ribbon (pure Cu ribbon, Cu ribbon with 100% Ag coating and Cu ribbon with 100% Sn coating), Ag front busbar as well as AlAg rear pad stripes were interconnected by CG (SB1227) and the total resistance change monitored during damp heat twice per week. In total 12 contact points between CG and sample material was established to increase the overall series resistance and allow for less measurement errors due to the small contact resistance of CG to material. The sample/glue interconnection was placed on a substrate (silicon wafer isolated by PET foil) and embedded between standard module glass and backsheet by EVA hence showing a standard module setup. Since the backside will see accelerated moisture ingress due to the large backsheet area the ribbon/glue interconnection was divided into two groups: facing the glass side (front side) and facing the backsheet (rear side). Several samples were processed for each material combination and exposed to 3000 hours of damp heat (85 degrees Celsius and 85% relative humidity).

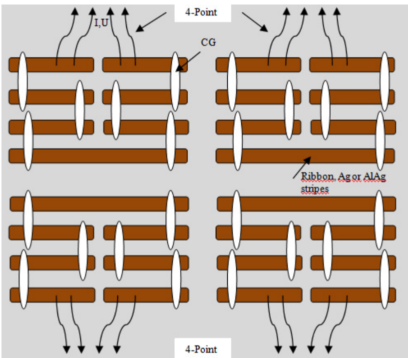

Fig. 1. $R_{contact}$ setup of samples used for the electro-chemical corrosion study.