SOLDER VERSION OF 8 INCH BACK-CONTACTED SOLAR CELLS

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Abstract: Back-contacted solar cells have the potential to fulfill an important role in present and future solar markets. In order to enhance market introduction of back contacted cells, proven interconnection technology must be applied. Therefore, a solderable version for 8-inch back contacted cells has been developed, comprising an insulation pad between base and back contact emitter. Screen- printed UV-curable systems are used successfully. These systems cure within a few seconds due to photoinitiator technology. A 28-cells module consisting of 8-inch back-contact cells equipped with insulation pads has passed several IEC related climate chamber tests.

Key Words: Multi crystalline solar cells, Back contact cells, module technology

1 Introduction

In order to facilitate market introduction of back-contact solar cells, proven interconnection technology should be anticipated for. The innovative single-step interconnection and lamination concept results in intrinsically lower module costs due to the ability of using large wafer sizes in combination with reduced wafer thickness [1]. Other significant advantages of back-contact cells are reduction of shadow losses on the front side with respect to standard H-pattern cells and the ability to place cells very close together in a module. Both advantages allow back-contact cell modules to be at least 5% more efficient than their H-pattern counterparts.

A novelty addressing interconnection technology of such back-contact cells is bonding to an electrically conducting material integrated in the rear-side foil of a module. This rear-side foil combines two functions, namely electrical interconnection and environmental protection. Furthermore, electrical resistance losses are 3 times less with a conductive foil compared to tabbing. Bonding of the cells onto the conductive sheet is carried out with the aid of electrically conducting adhesives. This technology shows strong potential for realizing low-cost modules in the near future as it combines interconnection and lamination in a single step. Presently, climate chamber tests are carried out in order to test the long-term stability of the bonding materials and foils involved. However, since this novel module technology is still under development, commonly applied soldering techniques are necessary to guarantee reliable PV modules with back-contact cells. Therefore, a solderable back-contact cell version was developed that enables soldered interconnections of tabs.

2 Experimental Section

2.1 Approach

The solderable version of the back contacted cells necessitates insulation of base and back contact emitter terminal in order to prevent short-circuiting.

Insulation pads are applied onto the base contact in between back-contact emitter terminals at the rear side of 8-inch (210 x 210 mm^2) cells. The deposition technique of choice is screen-printing. Standard tin-lead plated copper tabs are then spot soldered onto the emitter terminals. Mentioned pads are preventing short-circuiting between the emitter tab and the underlying base contact area of the cell. The materials that were tested are thermally curing epoxies and UV-curing systems. These materials are screen-printable and can be integrated into existing industrial PV cell processing. Furthermore, the selected materials are low-cost materials.

2.2 Experimental Details

For the deposition experiment screen print equipment for 8-inch cells was used. Thermally curing epoxy and UV curable material from different manufacturers was applied. Material viscosities in combination with different mesh sizes and ink volume have been tested. For thermal curing an IR oven of the type Autoveyor 1209 dryer (6 kW) was used. UV curing was carried out with a Technigraf UV cure unit equipped with 2 medium pressure mercury lamps operating at an energy level of 240 W/cm. Layer thickness was measured with a Mahr- perthometer. Climate chamber experiments were carried out in order to test insulation capabilities of the insulation material against short- circuiting. A 28-cells module consisting of 8-inch back-contact cells was manufactured and submitted to climate chamber testing. Each cell comprises screen- printed insulation pads, and soldered interconnections.

3 Results and Discussion

Two-component thermally curing and UV-curable systems have been tested. Both materials are capable of producing homogenous layers with adequate layer thickness to guarantee insulation. Printing of the layer thickness is governed by the mesh width and in particular the ink volume of the screen. Moreover, printing material viscosity in combination with the adequate screen parameters have to be considered.

One of the major demands is to generate a compact, pinhole free insulation layer in a single print step.

Viscosity of the printing material plays herein a vital role. It is necessary, that the material acts to flow directly after printing in order to inherently form a homogenous layer. If viscosity is too low the, screen printed material will overflow (and cover) the emitter terminals. Pinholes can occur if the material is too stiff or if during the printing step air inclusions appear. These pinholes may generate short-circuiting of tab and base if humidity penetrates the module.

A maximum insulation layer thickness of 25 µm should not be exceeded due to an increase of the spacer distance between tab and the emitter. This could cause difficulties during the soldering process.

Measurements of the layer thickness resulted in 15 µm for Epoxy and for UV curable material. Generally, screens with higher ink volumes result in thicker layers and therefore better flow.

The print material should have a very low halogen, and especially low chlorine content. Halogenated material is present in the screen printable resin and being formed during the production process as a rest material. Concentrations occur in pigment carriers of the colour added to the compound. Under the influence of temperature, humidity, and the electrical field, incorporation of water and other substances can cause hydrolysis of halogenated compounds releasing hydrochloric acid. This can promote the corrosion of the soldered connections and the phase boundaries. Electro-migration, low hydrolytic stability, and high chlorine content (higher than 400 ppm) of the resin should therefore be avoided.

Curing speeds differ significantly between thermally curing epoxy and UV curable systems. The UV-curable material requires only two seconds per cell while 8 minutes at 150°C in an IR oven are required to fully cure the thermally curable epoxies. In addition, UV-curable material can be purchased as a single component system whereas thermally curable systems are always two-component. The material cost contribution of both systems is in the order of 0.01-0.02 €/W_P.

Additionally, voltage break- down measurements between base and insulation material revealed values between 800 to 1000 Volts for a layer thickness of 15 µm.

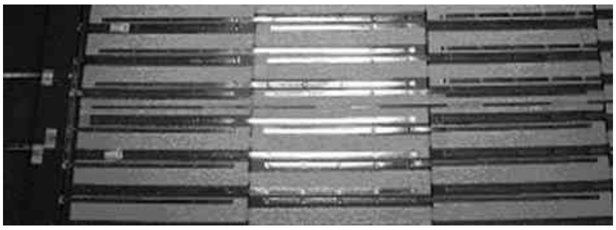

Figure. 1 Soldered back- contacted cells with insulation pads on rear side

3.1 Climate chamber

Cells of the size 210 x 210 mm^2 (8-inch) equipped with the insulation pads have been successfully manufactured into a 28-cells module. This fully functional module was submitted to climate chamber testing in order to determine the reliability of the soldered interconnections and the insulation material. In analogy with the IEC 61215, design qualification and type approval, climate chamber tests have been conducted. Consecutively, a 1000 hours damp heat test involving 85% relative humidity at 85ºC and a thermal cycling test of 200 cycles comprising -40ºC to +85ºC were performed. This series was completed with a humidity-freeze test (-40ºC to +85ºC) of 10 cycles. Module parameters have been measured in combination with a class (A) flash tester and are displayed in Table 1. Analyzing the measured IV parameters no degradation in the module current and voltage values were observed incorporating all mentioned test sequences. A minor fill factor discrepancy was evident between first measurement and 1000 hours of humidity testing. Low fill factor during first measurement of the module might have been caused due to a short relaxation time right after manufacturing.

Climate chamber test	Voc [V]	Isc [A]	FF [-]
First measurement	16,7	11,9	67,00
Humidity test 85ºC at 85% relative humidity	16,7	12,3	71,00
200 temperature cycles -40 to 85ºC	16,7	12,2	68,5
10 cycles humidity freeze	16,8	12,1	67,6

Table I Climate chamber test in analogy to IEC61215. Measurement conditions of module during flash test: 1000 W/m², AM 1,5, Temp 25ºC.

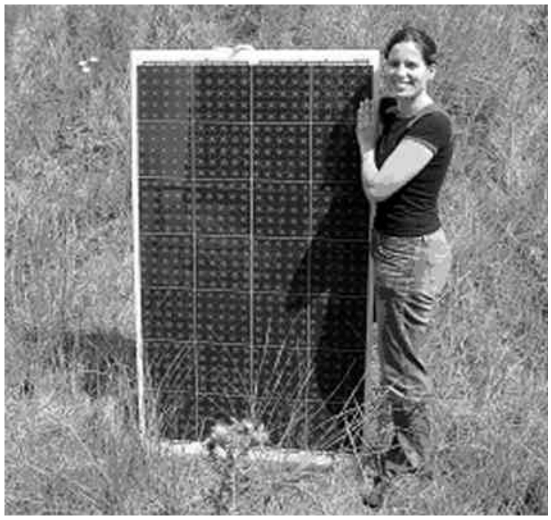

Figure 2. Completed 28 cells 8-inch module

4 Conclusion

The relevance of a solderable version for any back-contact solar cell is evident for a fast market introduction. Screen-printing of one layer of insulating material (insulation pad) with a homogenous and pinhole free surface has been successfully applied onto 8-inch back-contact cells. UV-curable systems are prefered because of their ease of handling and their ability to cure within a few seconds. Climate chamber testing indicates promising results concerning the insulation material. A firm basis has been established to achieve fast market introduction of back contacted cells of the soldered type. The material cost contribution is in the order of 0.01-0.02 €/Wp. This will be easily compensated by the high-efficiency potential of back-contact cell modules. It is advisable to have printing material with added color to determine pinholes optically during processing quality control. These materials should consist of low halogen content.

References

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