Polymers in Photovoltaics 2011

Polymers in Solar Modules

The AMI international conference, Polymers in Photovoltaics 2010, held in April in Cologne had well over 200 registered delegates to discuss the use of polymer materials in solar module production. BP Solar reviewed the current situation highlighting the opportunities to cut production costs of modules by using polymers. The key features of polymers in this application are: longevity, reliability, cost-effectiveness, manufacturability, safety in use and in disposal, and commercial availability in large quantities. As one specific example, encapsulants for solar cells must have: excellent adhesion to cells, back sheet and glass; high light transmission over the lifetime of the module; weatherability; be thermoplastic for recyclability; inert in the module (low VOC); good moisture barrier; high flexibility; flame spread index of less than 100; fire resistance of at least UL960 Class C; and be REACH and RoHS compliant. Typical polymers in use in encapsulants are ethylene vinyl acetate (EVA), polydimethylsiloxane (PDMS), polyvinyl butyral (PVB), polyethylene ionomers, polyolefins and thermoplastic polyurethane (TPU). EVA is the dominant material and a high VA content gives good light transmission, however it needs to be crosslinked and has degraded generating acetic acid, with volatiles from decaying peroxide. BP Solar currently uses a special grade of EVA, with a polyester backsheet and high strength frame materials for module packaging.

There have been more module failures in recent years due to the use of alternative materials with limited long-term experience. TUV Rheinland has been looking at the IEC standards and requirements for polymers in photovoltaics. Problems seen in the field include delamination, electric arc damage and local heating spots. Laboratory tests have been developed from UV preconditioning and thermal cycling to damp heat tests. The Underwriters Laboratories (UL) has reviewed the North American markets: shipments of modules rose from 500,000 in 2007 to nearly 1 million in 2008. The standard UL 1703 covers polymeric materials: superstrate (the top surface of the module), encapsulant, substrate (back sheet), adhesive, sealants and enclosures. Factors examined include risk of shock and fire, water exposure and immersion, UV resistance and hot wire ignition (HWI). If materials are pre-certified, it can speed up the time to market.

There is a move to find alternative materials as solar covers. PMMA from Evonik Degussa is being used in glazing in photovoltaics: it has a history of use outdoors of over 70 years and light transmittance of 92% (2mm DIN 5036). A patented flexible connection is used between the glazing and the solar cell to solve the issue of mechanical decoupling caused by the difference in thermal expansion. PMMA is also used in solar concentrators, and as an encapsulant for thin film photovoltaics. Nexolve has developed a transparent nanocomposite of POSS and polyimide. This new development shields the polyimide from degradation by atomic oxygen, by forming a self-passivating surface layer after exposure. This composite is now in production as a lightweight solar cover.

Crystalsol produces monograin solar cells using CZTS semiconductor. In the production process the membrane is printed, embedding semiconductor powder is applied, the front contact is deposited then sealed, and the back contact is printed and sealed, all using the roll-to-roll process.

Specialized Technology Resources (STR) provides encapsulants from manufacturing plants in the USA, Europe and Asia. The current research aims to reduce cure times and give high dimensional stability for EVA, which can shrink during module lamination. 3S lamination trials tested modules for cell breakage, bubbles, gel content, glass and back sheet adhesion. At 145C platen temperature results were good. The material has also been tested as encapsulant for thin film photovoltaics.

Silicon-based materials are used extensively in photovoltaics from wafers and passivation coatings, to silicone sealants and encapsulants. Dow Corning Solar Solutions supplies this technology. The silicone encapsulants are UV stable, durable, increase light transmission (and therefore efficiency), and the liquid process is less labour intensive and more cost-effective.

The Dow Chemical Company has a new encapsulant film with good adhesion to glass, low water vapour transmission rate, colour stability, no curing (high melting temperature), low glass transition temperature and good electrical insulation. Light transmission is similar to that of current encapsulants. It has been tested in modules, for example in a 1000h damp heat test, followed by 50 cycles of thermal cycling and 10 cycles of humidity freeze. SBM Solar has been using this encapsulant in a non-glass module that is UL certified.

There is great potential for building-integrated photovoltaics (BIPV) and this requires innovative materials: one trend is to include PV in architectural glazing. Safety glass must meet specific criteria including hurricane impact in the US. Polyvinyl butyral (PVB) from companies such as Saflex have been used for many years as an interlayer in automotive glazing and more recently in thin film PV applications. Thus PVB has great potential in the BIPV market.

Lanxess Deutschland has EVM materials for encapsulation with varying content of vinyl acetate. In tests the material cured under UV in less than 120s and silanes increased adhesion. Stress-strain properties were similar to standard EVA.

Sealants and adhesives are essential components of photovoltaic modules. Koemmerling Chemische Fabrik compared moisture vapour transmission rates of silicone and polyisobutylene (PIB) and found that PIB was around 2000 times better (<0.01 g/m2d). It is used in sealants, and thermoset PIB can be used as a flexible PV attachment to roofing membranes. Electrically-conductive adhesives are used in thin film, c-Si module and concentrator cell assembly. Henkel supplies this type of material, which is typically based on epoxy, acrylic or silicone, filled with conductive particles.

3S Swiss Solar Systems is a leading supplier of solar module production lines including encapsulation equipment. The company is aiming to develop a 1GW line, and a module cycle time of 5 seconds. It will need proper understanding and integration of polymers to achieve this aim.

Fluoropolymers are used in applications such as back sheets where they are durable, UV-resistant, low flame spread components of laminates. Krempel has been involved with this technology for some time, using PVF/PVDF + adhesive + PET. The company tests its module materials including UL and IEC standards. Arkema provides Kynar PVDF fluoropolymer film and emphasises the stability to many factors including heat, abrasion and radiation. It can also be recycled.

Saint-Gobain Performance Plastics has extensive experience of producing fluoropolymer for outdoor use; one example is the pavilion roof at the University of La Verne built in 1973 with PTFE and FEP. The company makes fluoropolymer front and back sheets, as well as bonding tapes and EVA encapsulants. The ETFE or FEP front sheets act as light-weight glass replacements with good light transmission, and surface treatment promotes long-term adhesion. PTFE films are being developed for back sheets with improved performance.

DuPont Teijin Films supplies polyester films for photovoltaic applications. This is mainly used in back sheets for c-Si modules with outer layers of Tedlar™ PVF. The PET supplies electrical insulation and strength, while the fluoropolymer provides resistance to hydrolysis and UV. Sometimes EVA is used as the inner layer of the laminate instead. PET grades are being stabilised to move towards an all-PET back sheet. The company is also developing film for the latest generation II/III thin film cells, as both substrate and encapsulant.

Solar panels are traditionally framed with materials like aluminium. BASF is developing a polyurethane product as an alternative for this application. It has high UV stability, excellent weathering performance and can be processed on standard equipment. It has been field tested at locations such as Arizona. It brings design freedom, for example the solar module can be fully roof integrated.

Cables for photovoltaic modules must perform in light, heat, rain and other weathering conditions and the markets are expanding. Each solar panel produces between 120 to 230MW. The main challenge in PV applications is fire safety and long-term ageing for a 90C continuous operating temperature. PolyOne makes low smoke and fume, zero halogen (LSFOH) compounds for flame retardant cable insulation systems, as well as coloured concentrates. There are different requirements for PV cables in different regions according to Kemmler Consulting, such as vermin resistance, and extended UV and heat strain in deserts. Developers also need to consider that the operating voltage of cables could be increased, and cable materials need to be selected to allow for this.

The next conference on Polymers in Photovoltaics is scheduled for 12-14 April 2011 at the Maritim Hotel in Cologne, Germany. Offers of papers can be sent to Dr Sally Humphreys, sh@amiplastics.com before the deadline of 8th October 2010.

Date and Contact person

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