

Use of polyamide as an encapsulating material for photovoltaic
modules

5 The invention relates to the use of polyamide as an encapsulating material for photovoltaic modules.

Photovoltaic modules are used to generate electrical power. In this case, part of the structure of photovoltaic modules comprises solar cells which, by exposure to sunlight, generate electrical charges which can be drawn off as current. Depending on
10 the type, these solar cells are sensitive to mechanical influences or weathering influences to different extents. Encapsulating materials are used in order to protect said solar cells from these influences. These materials can consist of one or more layer(s), made of glass and/or plastic composites.

15 At the present time, composites of fluoropolymer materials and polyester (PET) are used as standard for encapsulating materials. A fluoropolymer layer on the outside guarantees weathering resistance, the PET film in the core guarantees the mechanical stability and the electrical insulation and another
20 fluoropolymer layer on the inside guarantees the connection to the embedding material of the solar cells.

With these materials it is found that the adhesion to the embedding material, e.g. ethylvinyl acetate (EVA) is low. Furthermore, relatively thick composites are required to ensure
25 the desired electrical insulation. This is attributable on the one hand to the low insulating capacity of fluoropolymer layers and on the other hand, to the adhesive layers used as standard between the films. The smallest irregularities or inclusions in the adhesive layers have the result that high currents flow in a
30 punctiform manner. This phenomenon must be counteracted by a larger thickness of the PET film in the core as a precaution.

The present invention wishes to remedy this.

The use of polyamide as an encapsulating material for the production of photovoltaic modules is provided according to the
35 invention.

The use of polyamide is advantageously effected as a film or as a film composite containing polyamide (PA). The advantageous use of a plastic composite is further proposed, said composite

comprising a carrier material selected from the group of polyethylene terephthalate (PET), polyethylene naphthenate (PEN) or ethylene tetrafluoroethylene copolymer (ETFE), as well as polyamide-12 layers adjoining the carrier material on both sides.

5 The use of polyamide makes it possible to achieve very good adhesion to the embedding material which, as described above, can be, for example, EVA. In particular, the electrical insulation can be improved significantly by using a polyamide single film with the same thickness as compared to a composite comprising
10 fluoropolymer layers and PET. It is not possible for high currents to flow in a punctiform manner via defects or inclusions in the adhesive layers.

Polyamide films can likewise be designed as weather- and UV-stabilised so that values comparable to those when using
15 fluoropolymers can also be achieved with regard to these properties. Various colour combinations can also be adjusted by means of pigmentation. Furthermore, two production steps, i.e. the production of the PET/fluoropolymer layer composite and the fluoropolymer layer/PET/fluoropolymer layer composite can be
20 saved.

Special standards relating to flame retardancy can be used for photovoltaic modules, in particular when mounted on roofs and integrated in buildings. Detailed explanations on this can be found in the standards of the Underwriter Laboratories UL94 and
25 UL790. In order to be able to likewise use the advantages according to the invention of polyamide under these conditions, it is necessary to produce a composite with a fluoropolymer layer as a flame-retardant layer on the outside. Special applications can also necessitate the additional use of another film, e.g. made of
30 polyethylene terephthalate, between the fluoropolymer layer and the PA film.

Further embodiments of the use according to the invention are disclosed in the patent claims.

The invention is explained in detail hereinafter with
35 reference to possible embodiments- see Figures 1 to 5 - as well as with reference to a possible exemplary embodiment.

Figure 1 shows the exemplary structure of a photovoltaic module which is encapsulated with the material 1 used according to the invention. The encapsulating material 1 comprises a weather-

resistant film which at the same time serves as an adhesion promoter to the embedding material 2. The embedding material 2 produces the non-positive connection to the solar cells 3 and to the embedding material 2'. The embedding material 2' further ensures the non-positive connection to the encapsulating material 4.

Figure 2 shows the exemplary structure of a photovoltaic module which is encapsulated with the material 1 used according to the invention. In contrast to Figure 1, in this exemplary structure, the encapsulating material 1 is used on both sides of the solar cells 3.

Figure 3 shows the exemplary structure of a photovoltaic module which is encapsulated with the material 1 used according to the invention. In order to satisfy additionally higher requirements on the flame retardancy such as prescribed, for example, in the corresponding standards UL94 and UL790, a fluoropolymer layer 5 is used as an additional layer to the encapsulating material 1 on the side facing away from the solar cells 3. In this exemplary design, the fluoropolymer layer 5 and the encapsulating material 4 thus constitute the respectively outermost layer of the photovoltaic module.

Figure 4 shows the use according to the invention of a plastic composite 1, 1' with the polyamide 12 layers 12 which are disposed on both sides of the carrier material 13. The carrier material consists of polyethylene terephthalate or polyethylene naphthenate or ethylene tetrafluoroethylene copolymer.

Figure 5 shows a possible laminating device for producing a non-positive composite 6 from the materials 1 and 5 according to Figure 3. The encapsulating material 1 which is selected according to the exemplary embodiment is coated with adhesive by means of the applicator unit 7 and after passing through a drier 10 is adhesively bonded to the fluoropolymer layer 5. The contact between the two films is controlled by the pressing pressure between the rollers 11. In this case, the material 1 can be pre-treated by means of physical media 9 before each production step.

The non-positive connection between the encapsulating material 1 and the fluoropolymer layer 5 can also be produced by co-extrusion. In this case, it is also possible to insert an adhesion promoter layer between the materials 1 and 5 and thus

produce a triple-layer co-extrudate. The encapsulating material 1 itself can comprise a monolayer or likewise a co-extrudate of several layers.

Before using the encapsulating material 1 according to the invention or also before adhesive bonding with the fluoropolymer layer 5, the material 1 can be pre-treated by means of chemical or physical media. This pre-treatment can be implemented on one or also on both sides of the encapsulating material 1.

The following exemplary embodiment reproduces possible variants for the selection of the components in the respective layers:

Encapsulating material 1 as film: polyamides (PA) of the type polyamide 6, polyamide 66, polyamide 7, polyamide 9, polyamide 10, polyamide 11, polyamide 12, polyamide 69, polyamide 6 10, polyamide 6 12, PA-6-3-T, PA 6I, polyphthalamide (PPA) as well as other possible aromatic, partially aromatic and co-polyamides comprising these types.

Embedding material 2, 2': ethylvinylacetate (EVA), polyvinylbutyral (PVB), ionomers, polymethylmethacrylate (PMMA), polyurethane, polyester, hotmelt or silicone elastomers.

Encapsulating material 4: glass

Fluoropolymer layer 5 as film: polyvinylfluoride (PVF), polyvinylidene fluoride (PVDF), ethylenechloro trifluoroethylene (ECTFE), polychlorotrifluoroethylene (PCTFE), ethylenetetrafluoroethylene (ETFE), polytetrafluoroethylene (PTFE), tetrafluoroethylene-hexafluoropropylene-vinylidene fluoride (THV), tetrafluoroethylene-perfluoroalkoxy-vinylether-copolymerisate (PFA), perfluoro-ethylene-propylene (FEP).

Fluoropolymer layer 5 as coating: fluoropolymer from the group of selectively soluble fluoropolymers.

The photovoltaic modules constructed from the aforesaid components are extremely stable when used outside which can be attributed, inter alia, to the good adhesion of polyamide to the embedding material.

Claims

- 5 1. Use of polyamide as an encapsulating material for producing photovoltaic modules.
2. The use according to claim 1, characterised in that the polyamide is selected from the group polyamide 6, polyamide 66, polyamide 7, polyamide 9, polyamide 10, polyamide 11, polyamide
10 12, polyamide 69, polyamide 6 10, polyamide 6 12, PA-6-3-T, PA 6I, polyphthalamide (PPA).
3. The use according to claim 1 or 2, characterised in that the polyamide is a copolymer of various aromatic or partially aromatic monomers.
- 15 4. The use according to one of claims 1 to 3, characterised in that the polyamide is used as a monofilm.
5. The use according to one of claims 1 to 3, characterised in that the polyamide is contained in a film composite.
6. The use according to one of claims 1 to 5, characterised in
20 that the polyamide film or the polyamide film composite are coloured.
7. The use according to one of claims 1 to 6, characterised in that additives, preferably UV stabilisers, hydrolysis stabilisers, antioxidants, heat stabilisers or flame retardants are added to
25 the polyamide film or the polyamide film composite.
8. The use according to one of claims 1 to 7, characterised in that the polyamide film or the polyamide film composite contain fillers.
9. The use according to one of claims 1 to 8, characterised in
30 that the polyamide film is pre-treated by means of physical media.
10. The use according to one of claims 1 to 9, characterised in that the film composite contains a polyamide film and a fluoropolymer film.
- 35 11. The use of a film composite according to claim 10, characterised in that the fluoropolymers are selected from the group polyvinylfluoride (PVF), polyvinylidene fluoride (PVDF),

ethylenechloro trifluoroethylene (ECTFE),
polychlorotrifluoroethylene (PCTFE), ethylenetetra-fluoroethylene
(ETFE), polytetrafluoroethylene (PTFE), tetrafluoroethylene-
hexafluoropropylene-vinylidenefluoride (THV), tetrafluoroethylene-
5 perfluoroalkoxy-vinylether-copolymerisate (PFA) or perfluoro-
ethylene-propylene (FEP).

12. The use according to claim 10 or 11, characterised in that
the fluoropolymer film is coloured.

13. The use according to one of claims 10 to 12, characterised in
10 that the non-positive connection between the films is produced by
an adhesive layer.

14. The use according to claim 13, characterised in that the
adhesive layer comprises a polyurethane or polyester adhesive.

15. The use according to one of claims 10 to 12, characterised in
15 that the non-positive connection between the films is produced by
means of co-extrusion.

16. The use of according to claim 15, characterised in that
during the co-extrusion between the films additionally at least
one adhesion promoter is extruded.

20 17. The use according to one of claims 1 to 16, characterised in
that the polyamide film additionally comprises a fluoropolymer
layer.

18. The use according to claim 17, characterised in that the
fluoropolymer layer contains selectively soluble fluoropolymers.

25 19. The use according to claim 17 or 18, characterised in that
the fluoropolymer layer is coloured.

20. The use according to one of claims 17 to 19, characterised in
that an adhesion promoter layer is located between the polyamide
film and the fluoropolymer layer.

30 21. The use according to claim 20, characterised in that the
adhesion promoter is polyurethane and/or polyester and/or
polyacrylate.

22. The use according to one of claims 17 to 19, characterised in
that a film of polyethylene terephthalate (PET) or polybutylene
35 terephthalate (PBT) is additionally provided between the polyamide
film and the fluoropolymer layer.

23. The use according to claim 22, characterised in that the non-
positive connection is produced by adhesive layers.

24. The use according to claim 23, characterised in that the adhesive is a polyurethane or polyester adhesive.
25. The use according to claim 22, characterised in that the non-positive connection is produced by means of co-extrusion.
- 5 26. The use according to claim 25, characterised in that during the co-extrusion additionally at least one adhesion promoter is extruded.
27. Use of an encapsulating material according to one of claims 1 to 26 in combination with an embedding material selected from the
10 group ethylvinylacetate (EVA), polyvinylbutyral (PVB), ionomers, polymethylmethacrylate (PMMA), polyurethane, polyester, hotmelt or silicone elastomers to produce photovoltaic modules.
28. The use according to claim 27, characterised in that the embedding material is applied to the encapsulating material by
15 means of co-extrusion.
29. The use according to claim 28, characterised in that an adhesion promoter layer is located between the encapsulating material and the embedding material.
30. The use according to claim 29, characterised in that the
20 adhesion promoter is single- or multi-layer and consists of polyurethane and/or polyester and/or polyacrylate.
31. The use of a plastic composite comprising a carrier material selected from the group polyethylene terephthalate, polyethylene naphthenate or ethylene-tetrafluoroethylene copolymer as well as
25 polyamide 12 layers adjoining the carrier material on both sides as encapsulating material for producing photovoltaic modules.