

SPECIAL LOW-FLOWABILITY ENCAPSULANT FILM FOR HETEROJUNCTION CELL MODULES AND PREPARATION METHOD THEREOF

TECHNICAL FIELD

The disclosure relates to encapsulant films, and in particular to a special low-flowability encapsulant film for heterojunction cell modules and a preparation method thereof.

BACKGROUND

With the continuous progress of the battery technology, the cost per kilowatt-hour of photovoltaic industry is decreasing. However, the conversion efficiency of the mainstream PERC cells is gradually approaching its limit, it becomes very difficult to further improve it. New battery technologies have gained more and more attention, and the most discussed ones nowadays are heterojunction and Topcon technologies.

Heterojunction cells are abbreviated as HIT or HJT. The HIT cells use a structure including a monocrystalline silicon substrate and amorphous silicon thin-film heterojunctions. This structure allows the HIT cells to have the advantages of both crystalline silicon cells and thin-film cells, such as high conversion efficiency, low attenuation, low temperature coefficient and high bifaciality, but also determines that the temperature for preparing subsequent heterojunction modules cannot exceed 230°C within a certain period of time, which determines that the preparation of the heterojunction cells must use low-temperature welding process. In the low-temperature welding, a welding strip is spot-welded onto cells, and then the surface of the welding strip is molten by ways of lamination process, so as to form adhesion to the cells. During this process, since the encapsulant film is also melted and solidified, the melted fluid may easily penetrate into the welding point under pressure to cause an open circuit, which leads to a decrease in the power of the module. In order to solve this problem, a typical method is to pre-crosslink the encapsulant film to reduce its flowability. However, in order to achieve a very low flowability, a high pre-crosslinking degree is always required, and the high pre-crosslinking degree leads to an increase in the rigidity of the encapsulant film, which easily causes micro-cracks in the cells during lamination, thus affecting the yield. Therefore, how to achieve both low flowability and enough elasticity on the premise of achieving good and long-lasting adhesion to the

heterojunction cells has become an urgent technical problem to be solved.

SUMMARY

In view of the defects in the prior art, the disclosure provides a special low-flowability encapsulant film for heterojunction cell modules and a preparation method thereof. By designing raw materials for preparing the encapsulant film, the prepared encapsulant film has low flowability, and also has a low enough modulus to effectively reduce micro-cracks produced during lamination. Moreover, the encapsulant film has good and long-lasting adhesion to heterojunction cells, and is suitable for encapsulation of heterojunction modules.

In order to achieve the above objective, the disclosure is realized by the following technical solutions:

The disclosure provides a special low-flowability encapsulant film for heterojunction cell modules. Raw materials for preparing the encapsulant film include, in parts by weight: 40-80 parts of matrix resin, 20-60 parts of functional resin, 0.01-0.6 parts of main crosslinker, 0.2-0.8 parts of assistant crosslinker, 0.01-1 part of anti-UV aging agent, and 0-1 part of silane coupling agent.

The functional resin is a POE graft material.

Preferably, the matrix resin is a POE resin with a melting point of 45-85°C and a melt index of 1-25 g/10 min.

Preferably, the functional resin is the POE graft material with a melting point of 70-120°C and a melt index of 0.5-7 g/10 min. Grafting groups are silane with a boiling point of 100-190°C and a relative graft ratio of >1%.

Preferably, the main crosslinker is any one or more of tert-butylperoxy-2-ethylhexyl carbonate, tert-amylperoxy-2-ethylhexyl carbonate, tert-butylperoxy isopropyl formate, 1,1'-bis(tert-pentylperoxy)cyclohexane, 1,1-bis(tert-butylperoxy)cyclohexane, 1,1'-bis(tert-butylperoxy)-3,3,5-trimethylcyclohexane, 2,5-dimethyl-2,5-bis(tert-butylperoxy)hexane, tert-butylperoxy-3,5,5-trimethyl hexanoate, dicumyl peroxide and tert-amyl peroxybenzoate.

Preferably, the assistant crosslinker is any one or more selected from triallyl isocyanurate, triallyl cyanurate, trimethylolpropane triacrylate, trimethylolpropane trimethacrylate, pentaerythritol triacrylate, tri(2-hydroxyethyl)isocyanurate triacrylate, ethoxylated trimethylolpropane triacrylate, propoxylated trimethylolpropane triacrylate, ethoxylated glycerol triacrylate, propoxylated glycerol triacrylate, pentaerythritol tetraacrylate,

ethoxylated pentaerythritol tetraacrylate, trimethylolpropane tetraacrylate and di(trimethylolpropane) tetraacrylate.

Preferably, the anti-UV aging agent is any one or more of (2,2,6,6-tetramethyl-4-hydroxypiperidine)benzoate, poly(4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol)succinate, bis(1,2,2,6,6-pentamethylpiperidyl)sebacate, bis(2,2,6,6-tetramethyl-4-hydroxypiperidine)sebacate and bis(1-octyloxy-2,2,6,6-tetramethyl-4-piperidyl)sebacate.

Preferably, the silane coupling agent is any one or more of vinyltrimethoxysilane, γ -methacryloyloxypropyltrimethoxysilane, vinyltris(tert-butylperoxy)silane, 3-aminopropyltriethoxysilane, vinyltriethoxysilane, vinyltriacetoxysilane and 3-glycidylpropyltrimethoxysilane.

The disclosure further provides a preparation method of the special low-flowability encapsulant film for heterojunction cell modules. The preparation method includes the following steps:

(1) adding the raw materials in parts by weight into a stirred tank, uniformly stirring the raw materials, adding the mixture into a screw extruder, and after melting and plasticizing, casting a smooth and uniform encapsulant film through a die lip, the encapsulant film having a thickness of 0.1 mm-1 mm; and

(2) carrying out irradiation-induced crosslinking on the cold-set film to obtain the encapsulant film.

Preferably, the irradiation-induced crosslinking is electron beam irradiation-induced crosslinking with an irradiation dose of 20-60 KGY.

Preferably, after the irradiation-induced crosslinking, the encapsulant film has a pre-crosslinking degree of 20%-40%.

Compared with the prior art, the disclosure has the following beneficial effects:

In the prior art, the overall flowability of the encapsulant film is typically reduced by ways of pre-crosslinking process so as to avoid affecting welding points, In the solution provided by the disclosure, grafted POE with a high melting point and a low melt index is introduced into the raw materials for preparing the encapsulant film, which can reduce the flowability on the premise of a low pre-crosslinking degree and also ensure a low enough modulus to avoid micro-cracks of cells produced during lamination. In addition, the grafted POE is a silane grafted polymer, which ensures good and long-lasting adhesion to the cells.

DETAILED DESCRIPTION

The technical solutions in the examples of the disclosure will be clearly and completely described below with reference to the examples of the disclosure. It is apparent that the described examples are merely some, rather than all of the examples of the disclosure.

Example 1: A special low-flowability encapsulant film for heterojunction cell modules is prepared from the following raw materials in parts by weight: 40 parts of POE matrix resin with a melting point of 60°C and a melt index of 14 g/10 min, 60 parts of POE graft material with a melting point of 99°C and a melt index of 1 g/10 min (grafting silane groups have a boiling point of 160°C and a graft ratio of 1.5%), 0.3 parts of tert-butylperoxy-2-ethylhexyl carbonate, 0.6 parts of trimethylolpropane triacrylate, 0.1 parts of poly(4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol)succinate, and 0.5 parts of vinyltrimethoxysilane.

A preparation method of the encapsulant film includes: Step I: The raw materials in parts by weight are added into a stirred tank and uniformly stirred, and the mixture is added into a screw extruder, and extruded and cast to obtain an encapsulant film with a thickness of 0.5 mm. Step II: Irradiation-induced crosslinking is carried out on the cold-set film to obtain the encapsulant film. The irradiation dose is 15 KGY, and the pre-crosslinking degree is 23.6%.

Example 2: A special low-flowability encapsulant film for heterojunction cell modules is prepared from the following raw materials in parts by weight: 70 parts of POE matrix resin with a melting point of 73°C and a melt index of 20 g/10 min, 30 parts of POE graft material with a melting point of 103°C and a melt index of 1.8 g/10 min (grafting silane groups have a boiling point of 122°C and a graft ratio of 2%), 0.5 parts of tert-amylperoxy-2-ethylhexyl carbonate, 0.7 parts of trimethylolpropane trimethacrylate, 0.1 parts of poly(2,2,6,6-tetramethyl-4-hydroxypiperidine)benzoate, and 0.7 parts of vinyltriethoxysilane.

A preparation method of the encapsulant film includes: Step I: The raw materials in parts by weight are added into a stirred tank and uniformly stirred, and the mixture is added into a screw extruder, and extruded and cast to obtain an encapsulant film with a thickness of 0.6 mm. Step II: Irradiation-induced crosslinking is carried out on the cold-set film to obtain the encapsulant film. The irradiation dose is 30 KGY, and the pre-crosslinking degree is 35.1%.

Example 3: A special low-flowability encapsulant film for heterojunction cell modules is prepared from the following raw materials in parts by weight: 50 parts of POE matrix resin with a melting point of 55°C and a melt index of 18 g/10 min, 50 parts of POE graft material with a melting point of 109°C and a melt index of 3 g/10 min (grafting silane groups have a

boiling point of 112°C and a graft ratio of 2.3%), 0.6 parts of 2,5-dimethyl-2,5-bis(tert-butylperoxy)hexane, 0.5 parts of pentaerythritol triacrylate, 0.2 parts of bis(1,2,2,6,6-pentamethylpiperidyl)sebacate, and 0.4 parts of γ -methacryloyloxypropyltrimethoxysilane.

A preparation method of the encapsulant film includes: Step I: The raw materials in parts by weight are added into a stirred tank and uniformly stirred, and the mixture is added into a screw extruder, and extruded and cast to obtain an encapsulant film with a thickness of 0.8 mm. Step II: Irradiation-induced crosslinking is carried out on the cold-set film to obtain the encapsulant film. The irradiation dose is 33 KGY, and the pre-crosslinking degree is 28.4%.

Example 4: A special low-flowability encapsulant film for heterojunction cell modules is prepared from the following raw materials in parts by weight: 80 parts of POE matrix resin with a melting point of 55°C and a melt index of 12 g/10 min, 20 parts of POE graft material with a melting point of 110°C and a melt index of 1 g/10 min (grafting silane groups have a boiling point of 122°C and a graft ratio of 2.1%), 0.3 parts of tert-butylperoxy-2-ethylhexyl carbonate, 0.5 parts of triallyl isocyanurate, 0.3 parts of (2,2,6,6-tetramethyl-4-hydroxypiperidine)benzoate, and 0.3 parts of vinyltriacetoxysilane.

A preparation method of the encapsulant film includes: Step I: The raw materials in parts by weight are added into a stirred tank and uniformly stirred, and the mixture is added into a screw extruder, and extruded and cast to obtain an encapsulant film with a thickness of 0.5 mm. Step II: Irradiation-induced crosslinking is carried out on the cold-set film to obtain the encapsulant film. The irradiation dose is 40 KGY, and the pre-crosslinking degree is 38.6%.

Comparative Example 1:

The POE matrix resin used in Example 1 is increased to 100 parts, and the raw materials for preparing the encapsulant film do not contain the POE graft material. The rest is the same as in Example 1. The obtained encapsulant film has a pre-crosslinking degree of 29.2%.

Comparative Example 2:

The POE matrix resin used in Example 4 is increased to 100 parts, and the raw materials for preparing the encapsulant film do not contain the POE graft material. The rest is the same as in Example 4. The obtained encapsulant film has a pre-crosslinking degree of 42.7%.

Comparative Example 3:

The POE matrix resin used in Example 4 is increased to 100 parts, the raw materials for preparing the encapsulant film do not contain the POE graft material, and the irradiation dose is increased to 45 KGY. The rest is the same as in Example 4. The obtained encapsulant film has a pre-crosslinking degree of 48.2%.

The heterojunction cells were encapsulated according to the above examples and comparative examples and subjected to performance testing. The cells used were HJTM6-12BB 22.5%. The lamination process was carried out at 145°C, with 5 min of evacuation and 10 min of lamination. The test methods and results are as follows:

Sample	Adhesive strength to cells N/cm		Appearance after lamination	EL	
	Initial	PCT48h		Initial	TC200
Test standard	ASTM D903		/	IEC 61215	
Example 1	43.7	37.1	Has no defects	Has no micro-cracks or shades	Has no micro-cracks or shades
Example 2	48.1	35.5	Has no defects	Has no micro-cracks or shades	Has no micro-cracks or shades
Example 3	50.3	40.8	Has no defects	Has no micro-cracks or shades	Has no micro-cracks or shades
Example 4	42.5	32.3	Has no defects	Has no micro-cracks or shades	Has no micro-cracks or shades
Comparative Example 1	40.7	35.2	Has no defects	Has no micro-cracks, but shades	Has no micro-cracks, but shades
Comparative Example 2	44.3	30.7	Has a few bubbles	Has micro-cracks and a few shades	Has micro-cracks and a few shades
Comparative Example 3	38.6	17.4	Has bubbles	Has micro-cracks, but no shades	Has delamination

As can be seen from the table above, compared with Example 1, in Comparative Example 1, although the lamination does not cause micro-cracks, the pre-crosslinking degree is not high enough, which causes disconnection at the welding points during the lamination, causing EL shades. Compared with Example 4, in Comparative Example 2, after the POE graft material is removed, the irradiation dose is increased such that a higher pre-crosslinking degree is obtained, but EL shades are still produced. Moreover, the high pre-crosslinking

degree causes an excessively high rigidity, which causes the micro-cracks of cells after the lamination, and a few bubbles are produced due to the reduction in adhesion. Compared with Example 4, in Comparative Example 3, the irradiation dose is further increased, and a low enough flowability is obtained, which avoids the EL shades. However, due to the excessively high rigidity, the micro-cracks are more significant, and the adhesion is significantly reduced, which leads to local delamination after TC aging.

Based on the above, by designing the raw materials for preparing the encapsulant film, the prepared encapsulant film has low flowability to avoid adverse effects on the welding points and also has a low enough modulus to effectively reduce micro-cracks produced during lamination. Moreover, the encapsulant film has good and long-lasting adhesion to heterojunction cells, and is suitable for encapsulation of heterojunction modules.

Finally, the above examples are intended to illustrate the disclosure, but not to limit the technical solutions described in the disclosure. Those skilled in the art can make modifications or equivalent substitutions on the basis of the disclosure, but all technical solutions and improvements that do not depart from the spirit and scope of the disclosure shall fall into the scope of the claims of the disclosure.

CLAIMS

What is claimed is:

1. A special low-flowability encapsulant film for heterojunction cell modules, wherein

raw materials for preparing the encapsulant film comprise, in parts by weight: 40-80 parts of matrix resin, 20-60 parts of functional resin, 0.01-0.6 parts of main crosslinker, 0.2-0.8 parts of assistant crosslinker, 0.01-1 part of anti-UV aging agent and 1 part of silane coupling agent;

the functional resin is a POE graft material;

the matrix resin is a POE resin with a melting point of 45-85°C and a melt index of 1-25 g/10 min;

the functional resin is the POE graft material with a melting point of 70-120°C and a melt index of 0.5-7 g/10 min, and grafting groups are silane with a boiling point of 100-190°C and a relative graft ratio of >1%; and

a preparation method of the encapsulant film comprises the following steps:

(1) adding the raw materials in parts by weight into a stirred tank, uniformly stirring the raw materials, adding the mixture into a screw extruder, and after melting and plasticizing, casting a smooth and uniform encapsulant film through a die lip, the encapsulant film having a thickness of 0.1 mm-1 mm; and

(2) carrying out irradiation-induced crosslinking on the cold-set film to obtain the encapsulant film, after the irradiation-induced crosslinking, the encapsulant film having a pre-crosslinking degree of 20%-40%.

2. The special low-flowability encapsulant film for heterojunction cell modules according to claim 1, wherein the main crosslinker is any one or more of tert-butylperoxy-2-ethylhexyl carbonate, tert-amylperoxy-2-ethylhexyl carbonate, tert-butylperoxy isopropyl formate, 1,1'-bis(tert-pentylperoxy)cyclohexane, 1,1-bis(tert-butylperoxy)cyclohexane, 1,1'-bis(tert-butylperoxy)-3,3,5-trimethylcyclohexane, 2,5-dimethyl-2,5-bis(tert-butylperoxy)hexane, tert-butylperoxy-3,5,5-trimethyl hexanoate, dicumyl peroxide and tert-amyl peroxybenzoate.

3. The special low-flowability encapsulant film for heterojunction cell modules according to claim 1, wherein the assistant crosslinker is any one or more selected from triallyl isocyanurate, triallyl cyanurate, trimethylolpropane triacrylate, trimethylolpropane trimethacrylate, pentaerythritol triacrylate, tri(2-hydroxyethyl)isocyanurate triacrylate, ethoxylated trimethylolpropane triacrylate, propoxylated trimethylolpropane triacrylate, ethoxylated glycerol triacrylate, propoxylated glycerol triacrylate, pentaerythritol tetraacrylate, ethoxylated pentaerythritol tetraacrylate, trimethylolpropane tetraacrylate and di(trimethylolpropane) tetraacrylate.

4. The special low-flowability encapsulant film for heterojunction cell modules according to claim 1, wherein the anti-UV aging agent is any one or more of (2,2,6,6-tetramethyl-4-hydroxypiperidine)benzoate, poly(4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol)succinate, bis(1,2,2,6,6-pentamethylpiperidyl)sebacate, bis(2,2,6,6-tetramethyl-4-hydroxypiperidine)sebacate and bis(1-octyloxy-2,2,6,6-tetramethyl-4-piperidyl)sebacate.

5. The special low-flowability encapsulant film for heterojunction cell modules according to claim 1, wherein the silane coupling agent is any one or more of vinyltrimethoxysilane, γ -methacryloyloxypropyltrimethoxysilane, vinyltris(tert-butylperoxy)silane, 3-aminopropyltriethoxysilane, vinyltriethoxysilane, vinyltriacetoxysilane and 3-glycidylpropyltrimethoxysilane.

6. The special low-flowability encapsulant film for heterojunction cell modules according to claim 1, wherein the irradiation-induced crosslinking is electron beam irradiation-induced crosslinking with an irradiation dose of 20-60 KGY.