

Description

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates, in general, to a process for bonding the surfaces of the light coupling material and the encapsulating material of an optocoupler to preclude gaps from forming therebetween, thereby inhibiting air and moisture, and therefore electric current, from passing therebetween.

Background Art

Optocouplers are used for electrical isolation in systems such as computers, power supplies, telecommunications, and controllers. Optocouplers typically comprise a Light Emitting Diode (LED) electrically connected to one or more electrodes and a light sensing diode electrically connected to one or more additional electrodes. The LED, light sensing diode and portions of the electrodes are enclosed in a light coupling material. The light coupling material is then enclosed in an encapsulating material. The light coupling material typically comprises a clear silicone gel that allows light to pass freely from the LED to the light sensing diode, while maintaining electrical isolation between the electrodes. The encapsulating material typically comprises an opaque epoxy that reflects light from the LED back into the clear gel and prevents light from external sources from reaching the clear gel. The encapsulating material also serves as a protective enclosure from external mechanical forces.

However, since the light coupling material and encapsulating material are different in composition and as many as 15,000 volts or more may appear across the electrodes, an electrical breakdown occurs between the electrodes along the boundary surface of the light coupling material and the encapsulating material. The light coupling material and encapsulating material are heated during the manufacturing process and the light coupling material will typically have a coefficient of expansion many times greater than the encapsulating material. During cooling after encapsulation, the light coupling material will therefore contract more than the encapsulating material, causing gaps to form at the interface between the two materials. This gap comprises gas or air and has a lower dielectric strength than the light coupling material and the encapsulating material. Over time, moisture condenses along the electrodes to the boundary between the two materials and into the gaps, thereby substantially increasing the likelihood of electrical breakdown.

One known method of reducing the effect of this electrical leakage path, or separation, is to provide a layer of dielectric strength enhancing material such as glass frit at the boundary between the two materials. The glass particles are placed irregularly and so that each glass particle extends into both materials. However, this method does not improve bonding and does not impede electrical breakdown when a gap forms at the boundary of

the two materials. It increases the electrical leakage path length and results in a higher isolation voltage. Air and moisture will fill the gap, providing a path of least resistance for the current. Furthermore, the manufacturing process is substantially complicated by this procedure. The document DE-A-3,011,902 describes the method of using quartz powder or glass beads as a filler in a plastic light guide of an optocoupler in order to more closely match the thermal coefficients of expansion between the light guide and an epoxy resin.

Another known method comprises roughening the surface of the light coupling material thereby increasing the arc length path of current flowing therealong. However, this method which is further described in document US-A-4,271,365, increases manufacturing processes and does not increase adhesion of the two materials at their interface.

Yet another known method of reducing electrical breakdown, as described in the document US-A-4,284,898, comprises providing an electrically insulating, transparent film on one or more of the electrodes, the LED, and the light sensing diode. However, this procedure does not increase bonding. Manufacturing complexity is increased and air and moisture still can seep between the film and the encapsulating material to the boundary between the light coupling material and the encapsulating material.

Accordingly, there is a need for an improved optocoupler which solves the problem of electrical leakage and breakdown across the optocoupler electrodes.

For miscellaneous methods of bonding two polymeric materials, reference is made to the following documents. US-A-3,655,481 describes one method wherein a surface of a first material is treated with a Werner complex; US-A-3,676,289 describes the method of treating a first material with excited inert gas; and US-A-4,223,074 teaches a method of applying ultraviolet light or ozone for bonding surfaces together.

Summary of the Invention

The above problem is solved by the method of claim 1, in which the bond formed between the outer surface of coupling material and the encapsulating material is improved to a degree that air and moisture are prevented from seeping along the boundary therebetween so that electric current is prevented from passing along the boundary interface from one electrode to another electrode.

A preferred embodiment of the invention will now be described with reference to the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a cross section of an optocoupler.

Fig. 2 is a graph illustrating characteristics of the optocoupler incorporating the present invention and characteristics of previously known optocouplers.

Detailed Description of the Invention

Referring to Fig. 1, an optocoupler is shown that illustrates the advantages of the present invention. Emitter device 11, which typically is a Light Emitting Diode (LED), and detector device 12, which typically is a light sensing diode, are disposed in a predetermined spaced apart relationship on supporting members 13 and 14, respectively.

Supporting members 13 and 14 comprise a portion of a conductive lead frame for providing electrical contact to emitter device 11 and detector device 12. A conductive lead frame typically comprises a plurality of conductor elements, wherein electrical contact with each additional conductor element to emitter device 11 and detector device 12 is made through conductors 15 and 16, respectively.

A light coupling material 17 surrounds the emitter device 11 and detector device 12 for enhancing the electrical isolation and permitting transfer of light therebetween. "Light" is intended to include both the spectrum visible to human beings as well as wavelengths to which semiconductor materials are or can be made sensitive. Light coupling material 17 typically comprises a clear polymer, such as a silicone gel, but may alternatively comprise a clear epoxy, glass or other suitable material that enhances electrical isolation and permits transmissivity of light. Encapsulating material 18 surrounds light coupling material 17 which provides mechanical integrity while reflecting light from the emitter device back into the light coupling material and preventing light from ambient sources from reaching the light coupling material 17. Encapsulating material 18 typically comprises an opaque, white reflective epoxy. Interface 19 between light coupling material 17 and encapsulating material 18 is usually the path of lowest dielectric strength between support members 13 and 14. Light coupling material 17 and encapsulating material 18 are heated, i.e. 170 degrees Centigrade, during manufacture. Since light coupling material 17 typically has a higher coefficient of expansion, it will contract more during cooling. Unless strongly bonded, light coupling material 17 has a tendency to separate from encapsulating material 18, leaving gaps, or voids, between their respective surfaces. Over time, air or moisture seeps along the surface of support members 13 and 14 to interface 19 and fills these gaps. When high voltages are placed across support members 13 and 14, current may flow through air and moisture along interface 19, thereby decreasing the isolation resistance and possibly causing a voltage breakdown of the optocoupler. Air and moisture typically have a dielectric strength ten times lower than the light coupling material 17 and encapsulating material 18.

The invention described herein comprises a method for treating the surface of light coupling material 17 after support members 13 and 14, LED 11 and light sensitive diode 12 have been enclosed therein, for increasing the chemical

molecular bond at interface 19. A major factor in forming a good adhesive bond between two materials is the interaction of the two surfaces where the bond occurs, i.e., the mutual wettability of the two surfaces with each other as well as the strength of the bonding forces between them. When light coupling material 17 is substantially cured, the outer surface behaves hydrophobically due to methyl ($-\text{CH}_3$) groups present on the siloxane backbone. There are very few reactive sites available for reacting with encapsulating material 18, although both are organic in nature such that some wetting occurs. By changing the chemistry of the surface of light coupling material 17, reactive groups can be formed that can combine with reactive groups in the encapsulating material 18. This improves the mutual wettability of both materials as well as forming covalent bonds between them. In other words, the method comprises treating the surface of the first material such that active functional groups are formed on the surface, thereby leaving it in an activated state. Examples of functional groups which may be chemically active with the encapsulating material comprise hydroperoxy groups, hydroxyl groups, peracid groups, formyl groups and carboxylic acid groups. The treatment may be accomplished in one of several ways, including subjecting the light coupling material 17 to ultraviolet (UV) light, flame, chemical reactants, glow or corona discharge or plasma.

The preferred embodiment comprises applying UV light to light coupling material 17. The UV light could be applied in any of several ways and may comprise one or more frequencies. However, UV light produced with a low pressure quartz-mercury vapor lamp which generates UV emissions of 254 and 185 nanometers works quite well. The UV light treats the surface by line of sight and must be applied accordingly to cover the entire surface to which bonding is desired. This application generates ozone which diffuses into the surface, reacting and activating the surface for subsequent reactions with the second material.

The surface of light coupling material 17 remains in this state for a period of time, typically about 15 minutes and at about 170 degrees Centigrade during which encapsulating material 18 is placed around light coupling material 17. A covalent electrochemical bond is formed at the interface that is so strong, that during cooling and the resultant contraction, the interface will not separate, but stress points will appear in light coupling material 17 instead. The probability of voltage breakdowns due to this event is very low.

Fig. 2 illustrates the percent of optocouplers having voltage breakdown versus voltage applied across support members 13 and 14. Line 21 represents typically the plot of previously known optocouplers. The United States standard, Underwriters Laboratories (UL), or 1,600 volts, below which no voltage breakdowns are acceptable, is represented by line 22. The European standard, Verein Deutscher Elektrotechniker (VDE), or 3,700 volts, is represented by line 23. It may be seen

that previously known optocouplers had a majority of breakdowns occurring between 1,000 volts and 8,000 volts. Several breakdowns occurred below the European standard. The plot of breakdowns for the present invention is illustrated by line 24. The majority of breakdowns occur above 14,000 volts. Curves 21 and 24 would be expected to shift to the left when the optocouplers are exposed to heat and humidity over a period of time. However line 24 should not shift to the left below 12,000 volts.

The additional embodiments discussed below all perform in a similar manner in that ozone is produced which diffuses into the first material, reacting with the surface and thereby activating this surface through oxidation and radical formation. A second embodiment comprises subjecting light coupling material 17 to a plasma. A chamber is evacuated to about 0.0133 N/m² or lower to remove air and contaminants. Oxygen gas is bled into the chamber while a voltage is applied across two electrodes to create an oxygen plasma. The light coupling material must typically remain in the plasma for approximately seven minutes.

A third embodiment comprises subjecting light coupling material 17 to a glow discharge. A glow discharge is typically created by placing a voltage of about 10,000 to 20,000 volts, depending on the design of the dielectric electrodes and the airgap therebetween, across two dielectric electrodes separated by ambient air. Ozone is created therebetween which attacks the surface of light coupling material 17 when placed between the electrodes.

A fourth embodiment comprises applying a flame to the surface of light coupling material 17. The flame, i.e., hydrogen or propane, must have enough energy to activate the surface of the heated material and should be applied for only milliseconds.

A fifth embodiment comprises submerging light coupling material 17 in a chemical reactant, i.e. liquid sodium, for a period of time depending on the chemical reactant used.

All of the above disclosed embodiments create a voltage breakdown curve similar to line 24 of FIG. 2.

By now it should be appreciated that there has been provided a process for bonding the surfaces of two polymeric materials and an improved optocoupler manufactured therewith. The bond created inhibits the materials from separating, thereby preventing air, moisture, and electrical current from passing therebetween. Optocouplers manufactured with this process exhibit a substantially higher voltage breakdown.

Claims

1. A method of making an optocoupler having a first support member (13) and a second support member (14) in a predetermined spaced apart relationship, an emitter device (11) attached to a first portion of the first support member (13), and a detector device (12) attached to a first portion of

the second support member (14), including the step of encasing the emitter device (11), the detector device (12), and the first portions of the first and second support members (13, 14) within a coupling material (17) which is electrically non-conductive and transparent to radiation in both the visible and non-visible spectrum; said method characterized by treating the outer surface (19) of the coupling material (17) so that active functional groups are formed on the surface leaving it in an activated state; and encasing the coupling material (17) within an encapsulating material (18) which is opaque so that the treated outer surface (19) of the coupling material (17) forms a bond with the encapsulating material (18) therein substantially increasing the breakdown voltage therebetween.

2. The method according to claim 1 wherein the treating step is further characterized by the step of subsection of the outer surface (19) of the coupling material (17) to ultraviolet light.

3. The method according to claim 2 wherein the ultraviolet light is further characterized by at least two frequencies.

4. The method according to claim 3 wherein the ultraviolet light is further characterized by emissions substantially similar to 254 and 185 nanometers.

5. The method according to claim 1 wherein the treating step is further characterized by subjecting the outer surface (19) of the coupling material (17) to a plasma.

6. The method according to claim 1 wherein the treating step is further characterized by subsection of the outer surface (19) of the coupling material (17) to a glow discharge.

7. The method according to claim 1 wherein the treating step is further characterized by subsection of the outer surface (19) of the coupling material (17) to a flame.

8. The method according to claim 1 wherein the treating step is further characterized by subsection of the outer surface (19) of the coupling material (17) to ozone.

Patentansprüche

1. Verfahren zum Herstellen eines Optokopplers mit einem ersten Trägerelement (13) und einem zweiten Trägerelement (14) in vorbestimmtem gegenseitigem Abstand, einer Emittervorrichtung (11), die an einem ersten Abschnitt des ersten Trägerelements (13) befestigt ist und einer Detektorvorrichtung (12), die an einem ersten Abschnitt des zweiten Trägerelements (14) befestigt ist, enthaltend den Schritt des Einschließens der Emittervorrichtung (11), der Detektorvorrichtung (12) und der ersten Abschnitte der ersten und zweiten Trägerelemente (13, 14) in einem Kopplungsmaterial (17), das elektrisch nicht leitfähig und für Strahlung sowohl im sichtbaren als auch im nicht sichtbaren Spektrum transparent ist, gekennzeichnet durch das Behandeln der Außenfläche (19) des Kopplungsmaterials (17) derart, daß aktive Funktionsgruppen auf der Oberfläche



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The additional embodiments discussed below all perform in a similar manner in that ozone is produced which diffuses into the first material, reacting with the surface and thereby activating this surface through oxidation and radical formation. A second embodiment comprises subjecting light coupling material 17 to a plasma. A chamber is evacuated to about 0.0133 N/m², or lower to remove air and contaminants. Oxygen gas is bled into the chamber while a voltage is applied across two electrodes to create an oxygen plasma. The light coupling material must typically remain in the plasma for approximately seven minutes.

A third embodiment comprises subjecting light coupling material 17 to a glow discharge. A glow discharge is typically created by placing a voltage of about 10,000 to 20,000 volts, depending on the design of the dielectric electrodes and the airgap therebetween, across two dielectric electrodes separated by ambient air. Ozone is created therebetween which attacks the surface of light coupling material 17 when placed between the electrodes.

A fourth embodiment comprises applying a flame to the surface of light coupling material 17. The flame, i.e., hydrogen or propane, must have enough energy to activate the surface of the heated material and should be applied for only milliseconds.

A fifth embodiment comprises submerging light coupling material 17 in a chemical reactant, i.e. liquid sodium, for a period of time depending on the chemical reactant used.

All of the above disclosed embodiments create a voltage breakdown curve similar to line 24 of FIG. 2.

By now it should be appreciated that there has been provided a process for bonding the surfaces of two polymeric materials and an improved optocoupler manufactured therewith. The bond created inhibits the materials from separating, thereby preventing air, moisture, and electrical current from passing therebetween. Optocouplers manufactured with this process exhibit a substantially higher voltage breakdown.

Claims

1. A method of making an optocoupler having a first support member (13) and a second support member (14) in a predetermined spaced apart relationship, an emitter device (11) attached to a first portion of the first support member (13), and a detector device (12) attached to a first portion of

the second support member (14), including the step of encasing the emitter device (11), the detector device (12), and the first portions of the first and second support members (13, 14) within a coupling material (17) which is electrically non-conductive and transparent to radiation in both the visible and non-visible spectrum; said method characterized by treating the outer surface (19) of the coupling material (17) so that active functional groups are formed on the surface leaving it in an activated state; and encasing the coupling material (17) within an encapsulating material (18) which is opaque so that the treated outer surface (19) of the coupling material (17) forms a bond with the encapsulating material (18) therein substantially increasing the breakdown voltage therebetween.

2. The method according to claim 1 wherein the treating step is further characterized by the step of subsection of the outer surface (19) of the coupling material (17) to ultraviolet light.

3. The method according to claim 2 wherein the ultraviolet light is further characterized by at least two frequencies.

4. The method according to claim 3 wherein the ultraviolet light is further characterized by emissions substantially similar to 254 and 185 nanometers.

5. The method according to claim 1 wherein the treating step is further characterized by subjecting the outer surface (19) of the coupling material (17) to a plasma.

6. The method according to claim 1 wherein the treating step is further characterized by subsection of the outer surface (19) of the coupling material (17) to a glow discharge.

7. The method according to claim 1 wherein the treating step is further characterized by subsection of the outer surface (19) of the coupling material (17) to a flame.

8. The method according to claim 1 wherein the treating step is further characterized by subsection of the outer surface (19) of the coupling material (17) to ozone.

Patentansprüche

1. Verfahren zum Herstellen eines Optokopplers mit einem ersten Trägerelement (13) und einem zweiten Trägerelement (14) in vorbestimmtem gegenseitigem Abstand, einer Emittervorrichtung (11), die an einem ersten Abschnitt des ersten Trägerelements (13) befestigt ist und einer Detektorvorrichtung (12), die an einem ersten Abschnitt des zweiten Trägerelements (14) befestigt ist, enthaltend den Schritt des Einschließens der Emittervorrichtung (11), der Detektorvorrichtung (12) und der ersten Abschnitte der ersten und zweiten Trägerelemente (13, 14) in einem Kopplungsmaterial (17), das elektrisch nicht leitfähig und für Strahlung sowohl im sichtbaren als auch im nicht sichtbaren Spektrum transparent ist, gekennzeichnet durch das Behandeln der Außenfläche (19) des Kopplungsmaterials (17) derart, daß aktive Funktionsgruppen auf der Oberfläche



gebildet werden, die sie in einem aktivierten Zustand zurücklassen; und das Einschließen des Kopplungsmaterials (17) in einem Vergußmaterial (18), das lichtundurchlässig ist, so daß die behandelte äußere Oberfläche (19) des Kopplungsmaterials (17) eine Verbindung mit dem Vergußmaterial (18) darin bildet, die die Durchbruchspannung zwischen ihnen wesentlich steigert.

2. Verfahren nach Anspruch 1, bei dem der Behandlungsschritt weiterhin dadurch gekennzeichnet ist, daß die äußere Oberfläche (19) des Kopplungsmaterials (17) ultraviolettem Licht ausgesetzt wird.

3. Verfahren nach Anspruch 2, bei dem das ultraviolette Licht weiterhin durch wenigstens zwei Frequenzen gekennzeichnet ist.

4. Verfahren nach Anspruch 3, bei dem das ultraviolette Licht weiterhin durch Emissionen gekennzeichnet ist, die im wesentlichen vergleichbar 254 und 185 nm sind.

5. Verfahren nach Anspruch 1, bei dem der Behandlungsschritt weiterhin dadurch gekennzeichnet ist, daß die äußere Oberfläche (19) des Kopplungsmaterials (17) einem Plasma ausgesetzt wird.

6. Verfahren nach Anspruch 1, bei dem der Behandlungsschritt weiterhin dadurch gekennzeichnet ist, daß die äußere Oberfläche (19) des Kopplungsmaterials (17) einer Klimmentladung ausgesetzt wird.

7. Verfahren nach Anspruch 1, bei dem der Behandlungsschritt weiterhin dadurch gekennzeichnet ist, daß die äußere Oberfläche (19) des Kopplungsmaterials (17) einer Flamme ausgesetzt wird.

8. Verfahren nach Ansprüche 1, bei dem der Behandlungsschritt weiterhin dadurch gekennzeichnet ist, daß die äußere Oberfläche (19) des Kopplungsmaterials (17) Ozon ausgesetzt wird.

Revendications

1. Procédé de fabrication d'un optocoupleur ayant un premier organe de support (13) et un second organe de support (14) placés à une distance prédéterminée l'un de l'autre, à un dispositif émetteur (11) fixé à une première partie du

premier organe de support (13), et un dispositif détecteur (12) fixé à une première partie du second organe de support (14), le procédé comprenant une étape d'enrobage du dispositif émetteur (11), du dispositif détecteur (12) et des premières parties du premier et du second organe de support (13, 14) dans une matière de couplage (17) qui n'est pas conductrice de l'électricité et qui est transparente à un rayonnement à la fois dans les spectres visible et non visible, ledit procédé étant caractérisé par traitement de la surface externe (19) de la matière de couplage (17) afin que des groupes fonctionnels actifs se forment à la surface et la laissent à un état activé et l'enrobage de la matière (17) de couplage dans une matière d'enrobage (18) qui est opaque afin que la surface externe traitée (19) de la matière de couplage (17) forme une liaison avec la matière d'enrobage (18) et augmente notablement la tension de claquage entre elles.

2. Procédé selon la revendication 1, dans lequel l'étape de traitement se caractérise en outre par l'application de lumière ultraviolette à la surface externe (19) de la matière de couplage (17).

3. Procédé selon la revendication 2, dans lequel la lumière ultraviolette est en outre caractérisée en ce qu'elle est à au moins deux fréquences.

4. Procédé selon la revendication 3, dans lequel la lumière ultraviolette se caractérise en outre par des émissions sensiblement analogues à 254 et 185 nm.

5. Procédé selon la revendication 1, dans lequel l'étape de traitement se caractérise en outre par l'application d'un plasma à la surface externe (19) de la matière de couplage (17).

6. Procédé selon la revendication 1, dans lequel l'étape de traitement se caractérise en outre par l'application d'une décharge électroluminescente à la surface externe (19) de la matière de couplage (17).

7. Procédé selon la revendication 1, dans lequel l'étape de traitement se caractérise en outre par l'application d'une flamme à la surface externe (19) de la matière de couplage (17).

8. Procédé selon la revendication 1, dans lequel l'étape de traitement se caractérise en outre par l'application d'ozon à la surface externe (19) de la matière de couplage (17).