



(43) International Publication Date
20 September 2012 (20.09.2012)

- (51) International Patent Classification:
F24J 2/10 (2006.01) *G02B 5/08* (2006.01)
F24J 2/16 (2006.01)
- (21) International Application Number:
PCT/US2012/026910
- (22) International Filing Date:
28 February 2012 (28.02.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/451,670 11 March 2011 (11.03.2011) US
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: DURABLE REFLECTIVE LAMINATES

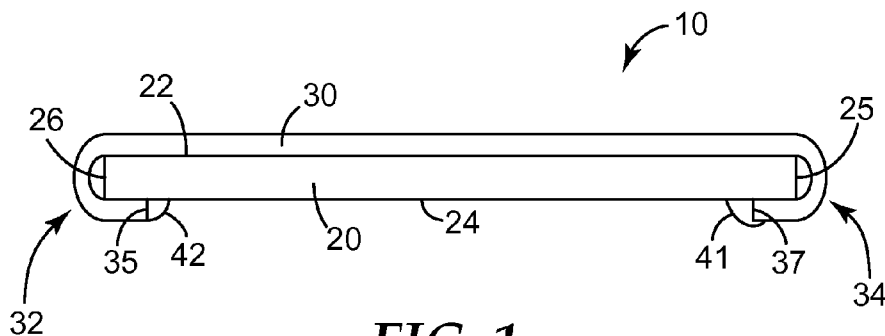


FIG. 1

(57) Abstract: A specular reflector includes a rigid substrate having a front major surface and an opposing back major surface and a multilayer specular reflective film disposed on the front major surface. A portion of the multilayer specular reflective film is wrapped around an edge surface of the rigid substrate and fixed to the back major surface. The multilayer specular reflective film has a film edge surface and a sealing material is disposed on the film edge surface.

DURABLE REFLECTIVE LAMINATES

BACKGROUND

Concentrated solar power (CSP, also known as “concentrating solar power”) technology uses sunlight directed at heat transfer fluids that heat up and whose thermal energy is then transferred (e.g., heating) or turned into electrical power (e.g., by use of a turbine generator). CSP systems typically use lenses or reflectors and tracking systems to focus a large area of sunlight into a small beam. The concentrated sunlight is then used as a heat source for a conventional power plant (e.g., a steam driven turbine generator). A wide range of concentrating technologies exists; the most developed are the solar trough, parabolic dish and solar power tower.

Concentrating or concentrated photovoltaic (CPV) systems include photovoltaic cells or other photovoltaic materials that convert the energy within sunlight to electrical energy. Reflective, refractive, or both reflective and refractive elements are used to concentrate sunlight onto the photovoltaic cells or materials. The use of the reflective and/or refractive materials reduce the quantity of the more expensive photovoltaic materials required in the system.

For both CSP and CPV systems, it is important to accurately reflect solar energy on a target. In order for reflectors to maintain reflected solar energy on a target, they must hold their shape, and they must be able to withstand environmental challenges that may change their shape, position, or integrity. More difficulties in meeting these requirements may be encountered for CSP reflectors due to their relatively larger size.

CSP reflectors made of silver-coated glass panels are relatively expensive, heavy (e.g., more than two times heavier than its sheet metal analogs), difficult to handle, and fragile. Such glass panels may not stand up to extreme environments (e.g., high wind speeds, hail, and debris damage). Recent efforts have been made to make thin film systems to replace these glass based mirrors. Film systems are substantially lighter and more resistant to fracture than glass and can be laminated to rigid substrates. These films are typically multilayer structures that include a polymer layer and a metallic reflective layer. In some instances, these films may only include a plurality of polymeric layers.

These multilayer reflective laminates are susceptible to both corrosion (when a metallic layer is present) and/or interlayer delamination. Interlayer delamination, in some thin film constructions, is also known as “tunneling.” Tunneling can occur when the multilayer reflective laminate is exposed to humidity and often begins at the edge surface of the multilayer reflective laminate. Tunneling and corrosion reduce the effectiveness of the multilayer reflective laminate.

The problem of corrosion and/or delamination for thin specular reflective films laminated to rigid substrates is of special importance in outdoor applications where temperature fluctuations, humidity cycles and exposure to UV and salt spray are part of the application of the material and resistance to these, as well as cleaning of these materials are part of the durability expectations of the thin film materials. Such exposure and durability requirements are needed in applications such as window film and, as mentioned earlier, in solar reflectors. In solar applications such as CSP, the durability against corrosion and/or delamination are even more severe since the reflectors are often tracked to point directly at the sun during daytime (increased UV exposure), are frequently washed, often with pressure washers, and maintaining high % reflective surface area is important for performance. Furthermore, reflectors for CSP and CPV applications are typically large (greater than 1 square meter) and in such large laminates the interlaminar stresses of a multilayer laminate are highly concentrated at the laminate edges. See for example, "Thin Film Materials". L.B. Freund and S. Suresh, Cambridge University Press, 2003. These large stresses at the edges further promote corrosion and/or delamination. It is therefore not surprising that corrosion and/or delamination (some of which is manifested as “tunneling”) predominantly originate from the edges (including corners) of thin film laminates. Cleaning of reflectors in CSP and CPV applications is often carried out with pressure washing operated at up to 3,000 psi. This type of washing stream, when directed at an edge of a laminate, further promotes the delamination of the multilayer reflective thin film.

State of the art methods for overcoming the problems of corrosion and/or delamination of thin film reflector laminated is to use an “edge tape”. This edge tape is typically applied over the edge of the thin film/substrate laminate, protruding $\frac{1}{4}$ to $\frac{1}{2}$ ” in from the edge of the reflector. Similarly an adhesive or caulk may be applied over the edges and similarly

may protrude $\frac{1}{4}$ to $\frac{1}{2}$ " in from the edges. While these methods can be effective in overcoming the issues of corrosion and/or delamination if properly applied, they suffer from (1) decreasing the total reflective area of the laminate and (2) providing an edge layer that may not be able to resist the force of the pressure washing and (3) subject to durability requirements since they are fully exposed to the sun.

BRIEF SUMMARY

The present disclosure relates to durable reflective laminates. In particular, the present disclosure relates to specular reflectors that can be used in a concentrating solar mirror panel assembly and provide improved environmental durability.

In one illustrative embodiment, a specular reflector includes a rigid substrate having a front major surface and an opposing back major surface and a multilayer specular reflective film disposed on the front major surface. A portion of the multilayer specular reflective film is wrapped around an edge surface of the rigid substrate and fixed to the back major surface. The multilayer specular reflective film has a film edge surface and a sealing material is disposed on the film edge surface.

These and various other features and advantages will be apparent from a reading of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure may be more completely understood in consideration of the following detailed description of various embodiments of the disclosure in connection with the accompanying drawings, in which:

FIG. 1 is a schematic cross-sectional view of an illustrative specular reflector; and

FIG. 2 is a schematic front view of an illustrative specular reflector.

The figures are not necessarily to scale. Like numbers used in the figures refer to like components. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

DETAILED DESCRIPTION

In the following description, reference is made to the accompanying set of drawings that form a part hereof and in which are shown by way of illustration several specific embodiments. It is to be understood that other embodiments are contemplated and may be made without departing from the scope or spirit of the present disclosure. The following detailed description, therefore, is not to be taken in a limiting sense.

Unless otherwise indicated, all numbers expressing feature sizes, amounts, and physical properties used in the specification and claims are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings disclosed herein.

As used in this specification and the appended claims, the singular forms “a”, “an”, and “the” encompass embodiments having plural referents, unless the content clearly dictates otherwise. As used in this specification and the appended claims, the term “or” is generally employed in its sense including “and/or” unless the content clearly dictates otherwise.

Spatially related terms, including but not limited to, “lower,” “upper,” “beneath,” “below,” “above,” and “on top,” if used herein, are utilized for ease of description to describe spatial relationships of an element(s) to another. Such spatially related terms encompass different orientations of the device in use or operation in addition to the particular orientations depicted in the figures and described herein. For example, if a cell depicted in the figures is turned over or flipped over, portions previously described as below or beneath other elements would then be above those other elements.

The present disclosure relates to durable reflective laminates. In particular, the present disclosure relates to specular reflectors that can be used in a concentrating solar mirror panel assembly and provide improved environmental durability. To be commercially acceptable, a solar specular reflective film should pass at least 1000 hrs, preferably 4000 hrs, of a simulated sunlight exposure test such as one using an ATLAS Ci5000 XENON

WEATHER-OMETER (Atlas Material Testing Technology, Chicago IL), xenon light source, full spectrum, with constant exposure to 60 degrees centigrade and 60% relative humidity. The concentrating solar mirror panel assembly should pass at least 480 hours of “Neutral Salt Spray Testing” and at least 70 days of “Soak Testing” (all described in the Example section). The specular reflectors include a rigid substrate and a multilayer specular reflective film disposed on the front major surface. A portion of the multilayer specular reflective film is wrapped around an edge surface of the rigid substrate and fixed to the back major surface. The multilayer specular reflective film has an edge surface and a sealing material can be disposed on the edge surface. Wrapping the multilayer specular reflective film around the edge surface of the rigid substrate improves the environmental durability of the multilayer specular reflective film and maximizes the available reflective surface area of the specular reflectors. It has been found that corrosion and delamination or “tunneling” are reduced when the multilayer specular reflective film is wrapped around the edge surface of the rigid substrate and especially when a sealing material is disposed on the edge surface of the multilayer specular reflective film. The present disclosure describes specular reflectors and methods of making specular reflectors that reduces or eliminates the deficiencies of the current art as follows: (1) no or minimal loss in total reflective area; (2) not exposing the edges of the thin film laminate to the force of pressure washing; (3) placing the sealing materials (tapes, adhesives & caulks) mostly out of direct exposure to the sun so that their durability is improved; and (4) placing the edges of the thin film mostly out of direct exposure to the sun. While the present disclosure is not so limited, an appreciation of various aspects of the disclosure will be gained through a discussion of the examples provided below.

FIG. 1 is a schematic cross-sectional view of an illustrative specular reflector **10**. **FIG. 2** is a schematic front view of an illustrative specular reflector **10**. The specular reflector **10** includes a rigid substrate **20** having a front major surface **22** and an opposing back major surface **24**. A multilayer specular reflective film **30** is disposed on the front major surface **22**. In some embodiments, the multilayer specular reflective film **30** is fixed or adhered to the front major surface **22** with an adhesive material.

A portion **32, 34** of the multilayer specular reflective film **30** is wrapped around an edge surface **25, 26** of the rigid substrate **20** and fixed to the back major surface **24**. The

multilayer specular reflective film **30** includes a film edge surface **35**, **37** and a sealing material **41**, **42** is disposed on the film edge surface **35**, **37**. The sealing material **42** can be disposed only on the film edge surface **35** as shown with element **42** or in some embodiments, the sealing material **41** can be disposed on the film edge surface **35** and on a top surface of the multilayer specular reflective film **30** as shown with element **41**.

The multilayer specular reflective film **30** can be wrapped 180 degrees around at least one edge **25**, **26** of the rigid substrate **20** forming a U-fold edge **32**, **34**. The U-fold edge **32**, **34** of the multilayer specular reflective film **30** is sealed with an adhesive material **41**, **42**. The U-fold edge **32**, **34** can be wrapped around the rigid substrate **20** that is relatively thin. The U-fold edge **32**, **34** can be wrapped around the rigid substrate **20** having a thickness of 5 mm or less, or 4 mm or less, or 3 mm or less, or 2 mm or less, or 1 mm or less.

FIG. 2 illustrates the specular reflector **10** having the multilayer specular reflective film **30** wrapped around two edges **25**, **26** of the rigid substrate **20** and two channel elements **51**, **52** securing the remaining edges of the multilayer specular reflective film **30**. The channel elements **51**, **52** can include a sealing material such as an adhesive, for example. One purpose of the channel is to aid sealing and prevent moisture penetration of the top and bottom edges of the specular reflector **10**. In other embodiments, the remaining edges (e.g., top and bottom edges) of the multilayer specular reflective film **30** are also wrapped around the remaining two edges (e.g., top and bottom) of the rigid substrate **20** and fixed to the back major surface **24**, as described in **FIG. 1**.

The term “specular reflector (or reflective) film” is defined as a film that has greater than 86% specular reflectivity as measured with a model 15R specular reflectometer (Design and Services Company, Dallas, TX) measured at a receiving cone angle of 25 mrad. In some embodiments, the specular reflective film has a specular reflectivity of at least 88%, or at least 90%, or at least 92%, or at least 94%, or at least 96%, or at least 98%.

In many embodiments, the sealing material **41**, **42** is disposed on all of the film edge surfaces **35**, **37** of the multilayer specular reflective film **30**. The sealing material can be any useful sealing material such as, an adhesive material or a tape, for example. Some commercially available sealing materials include, VHB (Very High Bond) type tapes such as “Extreme Sealing Tape 4412N” from 3M Company, St. Paul, MN or “4422B”

commercially available under the stock number JT-2700-6294-9 from 3M Company, Japan, “3M Polyurethane Protective Tape 8672” from 3M Company, St. Paul, MN, “3M Weather Resistant Film Tape 838” from 3M Company, St. Paul, MN, “Marine Adhesive/Sealant Fast Cure 4000 UV” from 3M Company, St. Paul, MN, a 2-part acrylic adhesive commercially available under the trade designation “SCOTCH-WELD DP810NS” from 3M Company, St. Paul, MN, a 2-part epoxy adhesive commercially available under the trade designation “SCOTCH-WELD DP920” (DP920 is not very UV stable), a 2 part urethane adhesive commercially available under the trade designation “SCOTCH-WELD DP600.” Sealants, adhesives and tapes do not necessarily need to be UV stable but provide a durable water impermeable seal. In some embodiments, the sealants, adhesives and tapes are not UV stable and degrade in the presence of UV light. In many embodiments, the sealing material is disposed on corner edge surfaces of the multilayer specular reflective film **30**. In many embodiments, the sealing material **41, 42** is resistant to moisture or humidity, for example, conventional “Scotch” tape from 3M Company, St. Paul, MN would not be an appropriate sealing material **41, 42**.

The specular reflector **10** can be utilized as a concentrating solar mirror panel. While the figures illustrate that the specular reflector **10** is flat or planar, in many embodiments the specular reflector **10** is non-planar (i.e., not flat). In some embodiments, the specular reflector **10** is parabolic. However, other shapes are possible (e.g., cylindrically curved or otherwise curved troughs). The specular reflector **10** can have a reflective major surface that is a concave surface. In some embodiments the specular reflector **10** has a radius of curvature of up to about 1600 meters, 10 meters, 5 meters, 3 meters, or 1 meter in at least one direction. In some embodiments, the specular reflector **10** can have radii of curvature in two orthogonal directions

The specular reflectors **10** described herein have a rigid or substantially rigid substrate **20**. Rigid or substantially rigid refers to the ability of the specular reflector **10** to hold its shape. In many embodiments, the rigid substrates **20** can hold their shape while subjected to wind loadings of at least 50, 75, 80, 90, 100, 110, 120 or 125 miles per hour (mph) (80.5, 120, 129, 145, 160, 177, 193, or 200 kilometers per hour (kph)). The ability to hold their shape can be related to their accuracy in keeping reflected radiant energy on its target, for example, while subjected to the wind loadings above.

The rigid substrate **20** is relatively thin. In many embodiments, the rigid substrate **20** has a thickness of 5 mm or less, or 4 mm or less, or 3 mm or less, or 2 mm or less, or 1 mm or less. The rigid substrate **20** can be formed of any material rigid material such as, for example, a metal.

5 The multilayer specular reflective film **30** includes at least two layers. The multilayer specular reflective film **30** can be fixed to the front surface **22** and back surface **24** of the rigid substrate **20** in any useful manner such as, with an adhesive layer, for example. The multilayer specular reflective film **30** can be any useful thickness. In many embodiments, the multilayer specular reflective film **30** has a thickness in a range from 50 to 500
10 micrometers. In many embodiments, the multilayer specular reflective film **30** includes at least one reflective metallic layer and one polymeric layer disposed on the reflective metallic layer (e.g., metalized solar reflective film laminates). In some embodiments, the multilayer specular reflective film **30** includes a plurality of polymeric layers (e.g., reflective mutillayer optical films). In some embodiments, the multilayer specular
15 reflective film **30** includes a plurality of polymeric layers and at least one reflective metallic layer.

Metalized solar reflective film laminates have been found to be susceptible to corrosion and/or delamination when exposed to prolonged environmental conditions. Useful examples of metalized solar reflective film laminates can be found, for example, in U.S.
20 Pat. Nos. 6,989,924 (Jorgensen et al.), 4,645,714 (Roche, et al.), and 6,088,163 (Gilbert et al.). One illustrative commercially available metalized solar reflective film laminate is commercially under the trade designation SMF-1100 or ECP-305 PLUS from 3M Company (St. Paul, MN). SMF-1100 is a silver metalized weatherable acrylic film.

25 Reflective multilayer optical films have been found to be susceptible to delamination when exposed to prolonged environmental conditions. Useful examples of reflective multilayer optical films can be found, for example, in U.S. Pat. Nos. 6,744,561 (Condo et al.) and 7,345,137 (Hebrink et al.). The constructions described herein reduce or eliminate corrosion and/or delamination of these multilayer specular reflective films **30**.

It has been found that wrapping the edge portions **32, 34** of the multilayer specular
30 reflective film **30** unexpectedly improves the durability of the multilayer specular

reflective film **30** while also maximizing the total reflective surface area of the multilayer specular reflective film **30**. These results are illustrated in the Example section below. The edge portions **32, 34** of the multilayer specular reflective film **30** can be heated and then wrapped around the edge surface **25, 26** of the rigid substrate **20**.

5 In many embodiments, the specular reflectors **10** described herein are formed with a continuous process. A continuous length of multilayer specular reflective film **30** is laminated onto a continuous length of rigid substrate and two edge portions of the multilayer specular reflective film **30** are folded around edge portions of the rigid substrate and adhered to the back surface of the rigid substrate. In some embodiments, edge heaters
10 heat the edge portions of the multilayer specular reflective film **30** before or while they are folded around the edge portions of the rigid substrate. The multilayer specular reflective film **30** is wrapped 180 degrees around edge portions of the rigid substrate and adhered to the back surface of the rigid substrate. Lengths of the specular reflectors **10** can be cut and the cut edges can be sealed with the channel elements **51, 52** described in **FIG. 2**.

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EXAMPLES

Materials

A polymeric silver mirror commercially available from 3M Company, St. Paul, MN under the trade designation "SMF-1100"

20 VHB1: An acrylic foam pressure sensitive adhesive tape commercially available under the trade designation "Extreme Sealing Tape 4412N" from 3M Company, St. Paul, MN

VHB2: A 25 mm wide thin black weather resistant tape commercially available under the trade designation "4422B" and stock number JT-2700-6294-9 from 3M Company, Japan.

8672 tape: An 8 mil general purpose outdoor grade tape commercially available under the
25 trade designation "3M Polyurethane Protective Tape 8672" from 3M Company, St. Paul, MN.

838 tape: A weather resistant tape commercially available under the trade designation "3M Weather Resistant Film Tape 838" from 3M Company, St. Paul, MN.

UV4000 caulk: A one part adhesive sealant with superior UV resistant properties commercially available under the trade designation "Marine Adhesive/Sealant Fast Cure 4000 UV" from 3M Company, St. Paul, MN.

A 2-part acrylic adhesive commercially available under the trade designation "SCOTCH-WELD DP810NS" from 3M Company, St. Paul, MN

Test Methods

Neutral Salt Spray Testing:

Neutral salt spray testing is useful in comparative evaluation of samples in their ability to withstand corrosion, particularly in corrosive environments (e.g., sea salt spray).

The procedure followed for these samples was that described by DIN EN ISO 9227 NSS 2006 (equivalent to ASTM B117). Specimens were examined at various time intervals and observations recorded. Three specimens were tested for each sample preparation type. The time to failure was recorded when any evidence of corrosion was noted on the front reflective surface of any of the three specimen of a sample set. The results are shown in Table 1. The number of hours survived in the Neutral Salt Spray (NSS) for a sample was recorded as "at least" for the hours elapsed before any defects were seen on the specimen, and "at most" for the hours elapsed when any defects were first observed.

Soak Testing:

Static soak testing of laminated mirror film samples has been shown to be an effective way to test the resistance of laminated silvered acrylic mirror films. These types of metalized polymeric films show failure at the metal (silver) and polymer (acrylic) interface upon prolonged soaking in de-ionized (DI) water. This type of failure is characterized at its worst as "tunneling" and at its best as edge delamination. Tunneling is typically characterized by half inch to one inch wide channels randomly across the film surface. The driver behind the formation of "tunnels" and/or delamination of the layers can be many factors, including, but not limited to: interfacial adhesion drop, interfacial shear forces, photo-chemical degradation, differential expansion (contraction) of the layers due to heat and/or humidity, corrosion (galvanic or environmental). Usually it is a combination of inter-layer shear forces with the lowering of interfacial adhesion. In general, samples larger than 8" x 8" are best for the static soak test.

The samples were all placed outdoors in a south facing location and tilted back 45 degrees to the vertical. The outdoor exposure was done to allow any potential “annealing” or photo-chemical activity to take place, as may happen in actual application conditions. The samples were left outdoors for 2 to 3 weeks and then immersed in a plastic tub filled with DI water. The samples in the tub were separated by plastic layers and kept in a vertical position during the soak period. Samples were periodically examined for defects and time to first failure of any of the three specimen of a sample set recorded. All samples were left to soak for 70 days at which point they were removed, dried, photocopy scanned to a digital file, and the unaffected reflective area of all specimen digitally measured. The % reflective area of each specimen was determined as a percentage of the original reflective area. For each sample set the % reflective area was determined by averaging the measured % reflective area of the three specimen of the sample set. The values after 70 days of static soak are shown in Table 2.

Comparative Examples CE1-CE6

Samples were all prepared by laminating a reflective mirror film (see footnotes on Tables 1 and 2 for mirror film used) onto a 0.020” thick painted aluminum substrate (grade 5052-H38) and cutting into 4” x 4” squares with a shear cutter. Specimens (three) of sample CE1 were used as is, while specimens (three) for samples CE2 and CE3 were taped on all four sides with a tape as indicated in Table 1. The tape extended about ¼” in from all edges. Comparative example CE3 was further sealed in the corners, where the tape created overlaps, with a 2-part acrylic adhesive commercially available under the trade designation "SCOTCH-WELD DP810NS" from 3M Company, St. Paul, MN.

Comparative example C3 was shear cut on all four sides. Comparative example C4 was shear cut on all four sides (as for C3) and the top and bottom edges were sealed using a plastic channel filled with UV 4000 caulk. The plastic channel used was a commercially available extruded plastic 0.25" x 0.5". The purpose of the channel was simply to constrain the uncured sealant and may be made of a number of other materials such as metal, rubber, etc. Comparative example C5 was prepared by over-laminating the film on the left and right edges by 0.5” and wrapping these to the back of the sheet using a heated platen at 160°F.

Note that none of the comparative examples include both wrapping (fold-back) AND sealing of the edges.

Comparative examples CE4 and CE5 demonstrate that leaving the edges untreated leads to failure (CE3); that wrapping two of the edges and, but not sealing the cut edges also leads to failure (CE4); and that simply sealing two of the edges, but leaving the other two untreated also leads to failure (CE4). However, the combination of edge wrapping and sealing (EX6) dramatically improves the resistance to tunneling and delamination. Optimal results are obtained when the edge of the folded mirror film is also sealed (EX7). CE6 shows some improvement when all four edges are wrapped but not substantial enough for robust applications. Having all four edges wrapped can be considered to have two edges wrapped and the other two "sealed" by wrapping the film over these edges. Wrapping of all edges with the film can be further made optimal by sealing the wrapped edges and the corners. In such a case the full extent of the substrate surface area can be made effectively reflective and durable.

Examples 1-5

Samples were all prepared by removing the pressure sensitive adhesive (PSA) liner from the mirror film and laminating a 5" wide reflective mirror film (see footnotes for Tables 1 and 2 for specific film used) onto a 4" wide, 0.020" thick painted aluminum substrate (grade 5052-H38). The mirror film extended about ½" out over the left and right edges of the substrate and these film edge portions were folded to the back of the substrate (wrapped) with the aid of heat (50-70°C) to prevent any cracking of the film. The top and bottom edges of the samples were cut with a shears to produce 4" x 4" specimens. The wrapped edges of the reflective film were sealed using various sealant types as shown in Table 1. The top and bottom shear cut edges, as indicated in Table 1, were either sealed using acrylic foam tapes or sealed by placing a one part adhesive sealant commercially available under the trade designation "Marine Adhesive/Sealant Fast Cure 4000 UV" from 3M Company, St. Paul, MN in a plastic channel. The plastic channel used was a commercially available extruded plastic 0.25" x 0.5".

The samples that had the edges wrapped all provided a full substrate width of reflective surface, while in the comparative examples a full reflective width area is only available when the edges are shear cut. As can be seen in Table 1, the wrapping of the

film over the edges not only provides a full reflective width, but also significant resistance to corrosion. Typically a value of 480 hrs or more in the NSS test is considered to be good. It can also be seen from Table 1 that the proper sealing of the cut (top and bottom) edges of the samples is important to get the best corrosion resistance. For instance in EX1, the VHB2 sealing tape was noted to peel up from the reflective substrate during the test, allowing for corrosion.

Examples 6-7

Examples 6-7 were made as examples 1-5, as indicated in Table 2, but included both wrapping (fold-back) AND sealing of the edges. A preferred embodiment is exemplified by example 7 where at least two of the edges are wrapped with the reflective film and where both the cut edges and the folded edges of the film are sealed. Three specimens were prepared for each sample/example set.

TABLE 1

Example	Left & right edges		Top & bottom edges		Results		
	treatment	sealant	treatment	sealant	Hrs NSS (at most)	Hrs NSS (at least)	Reflective width (%)
CE1	Cut	none	cut	none	<168	0	100
CE2	Cut	838 tape	cut	838 tape	<168	0	89
CE3	Cut	838 tape	cut	838 tape	1008+	1008	88
EX1	wrapped	VHB2	cut	VHB2	<336	216	100
EX2	wrapped	VHB1	cut	VHB1	672	672	100
EX3	wrapped	838 tape	cut + channel	UV4000 caulk	1032	1032	100
EX4	wrapped	8672 tape	cut + channel	UV4000 caulk	1368+	1368	100
EX5	wrapped	UV4000 caulk	cut + channel	UV4000 caulk	1368+	1368	100

All samples in Table 1 used "SMF-1100" mirror film

TABLE 2

Example	Left & right edges		Top & bottom edges		Results		
	treatment	sealant	treatment	sealant	Soak time to failure (days)	Failure type	Reflective area after 70 days soak (%)
CE3	cut	none	cut	none	1	tunneled	83
CE4	wrapped	none	cut	none	1	tunneled	64
CE5	cut	none	cut + channel	UV4000	1	tunneled	71
CE6	wrapped	none	wrapped	none	4	delamination	90
EX6	wrapped	none	cut + channel	UV4000	NA	none	97
EX7	wrapped	UV4000	cut + channel	UV4000	NA	none	99

All samples used in Table 2 used an earlier generation mirror film previously commercially available under the trade designation "ECP-305 PLUS" similar to "SMF-1100" but inferior to "SMF-1100" in tunneling and edge delamination.

[01] Thus, embodiments of the DURABLE REFLECTIVE LAMINATES are disclosed. The implementations described above and other implementations are within the scope of the following claims. One skilled in the art will appreciate that the present disclosure can be practiced with embodiments other than those disclosed. The disclosed embodiments are

presented for purposes of illustration and not limitation, and the present disclosure is limited only by the claims that follow.

What is claimed is:

1. A specular reflector comprising:
a rigid substrate having a front major surface and an opposing back major surface;
a multilayer specular reflective film disposed on the front major surface, a portion
5 of the multilayer specular reflective film wrapped around an edge surface of
the rigid substrate and fixed to the back major surface, the multilayer specular
reflective film comprises an film edge surface and a sealing material is
disposed on the film edge surface.
- 10 2. The specular reflector according to claim 1 wherein the rigid substrate has a
thickness of less 2 mm or less.
3. The specular reflector according to claim 1 wherein the multilayer specular
reflective film includes a plurality of polymeric layers and the specular reflective film has
15 a specular reflectivity of at least 92%.
4. The specular reflector according to claim 1 wherein the multilayer specular
reflective film includes at least one polymeric layer and one metallic layer and the
specular reflective film has a specular reflectivity of at least 92%.
- 20 5. The specular reflector according to claim 1 wherein the sealing material is
disposed on all of the film edge surfaces of the multilayer specular reflective film.
6. The specular reflector according to claim 1 wherein the sealing material is an
25 adhesive material or a tape.
7. The specular reflector according to claim 1 wherein the multilayer specular
reflective film is wrapped around at least two edge surfaces of the rigid substrate and fixed
to the back major surface.
- 30 8. The specular reflector according to claim 1 wherein the multilayer specular
reflective film is wrapped around at least two corner edge surfaces of the rigid substrate

and fixed to the back major surface and the film edge surface is sealed with an adhesive material or tape at least at two corner edge surfaces of the rigid substrate.

9. The specular reflector according to claim 1 wherein the multilayer specular reflective film is wrapped 180 degrees around at least one edge of the rigid substrate forming a U-fold edge and wherein the U-fold edge of the multilayer specular reflective film is sealed with an adhesive material.

10. A concentrating solar mirror panel comprising:
a rigid substrate having a front major surface and an opposing back major surface;
a multilayer specular reflective film comprising at least one metallic layer and one polymeric layer, the multilayer specular reflective film disposed on the front major surface, a portion of the multilayer specular reflective film wrapped around an edge surface of the rigid substrate and fixed to the back major surface, the multilayer specular reflective film comprises a film edge surface and a sealing material is disposed on the film edge surface..

11. The concentrating solar mirror panel according to claim 10 wherein the rigid substrate has a thickness of less 2 mm or less.

12. The concentrating solar mirror panel according to claim 10 wherein the sealing material is disposed on all of the film edge surfaces.

13. The concentrating solar mirror panel according to claim 12 wherein the sealing material is an adhesive material or a tape.

14. The concentrating solar mirror panel according to claim 10 wherein the sealing material degrades in UV light.

15. The concentrating solar mirror panel according to claim 10 wherein the multilayer specular reflective film is wrapped around at least two edge surfaces of the rigid substrate and fixed to the back major surface.

16. The concentrating solar mirror panel according to claim 10 wherein the multilayer specular reflective film is wrapped around at least two corner edge surfaces of the rigid substrate and fixed to the back major surface and an edge surface of the multilayer specular reflective film is sealed with an adhesive material or tape at the two corner edge surfaces of the rigid substrate.

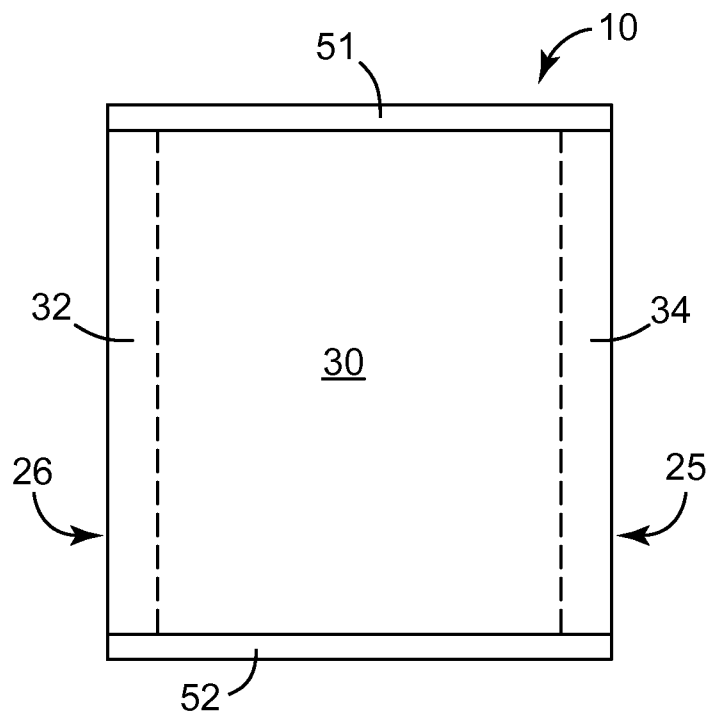
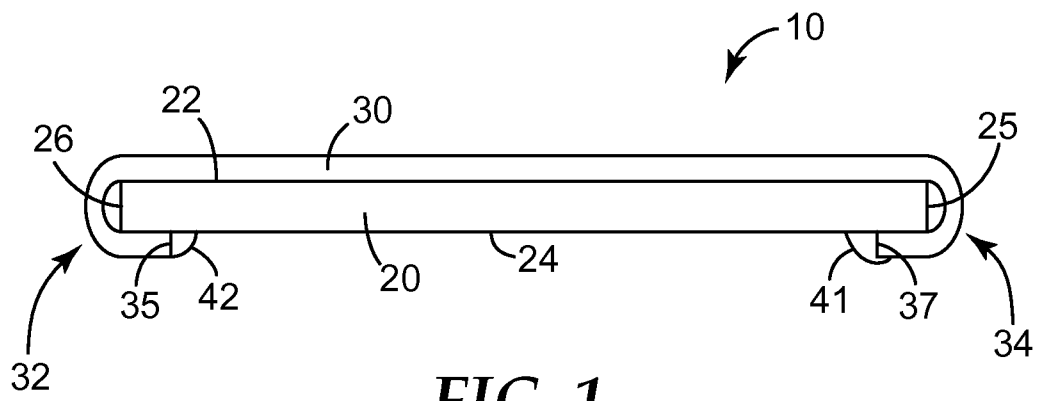
17. A method of forming a specular reflector comprising:
fixing a multilayer specular reflective film comprising at least one polymeric layer to a rigid substrate;
wrapping an edge portion of the multilayer specular reflective film about an edge of the rigid substrate, the edge separating a front major surface and an opposing back major surface of the rigid substrate;
fixing the edge portion of the multilayer specular reflective film to the back major surface of the rigid substrate; and
sealing a film edge surface of the multilayer specular reflective film with an adhesive material or a tape.

18. The method according to claim 17, further comprising heating the film edge portion to form a heated film edge portion and wrapping the heated film edge portion about an edge of the rigid substrate.

19. The method according to claim 17, wherein the sealing step comprises sealing all of the film edge surfaces of the multilayer specular reflective film with an adhesive material or a tape.

20. The method according to claim 17, wherein the multilayer specular reflective film is wrapped around at least two edge surfaces of the rigid substrate and fixed to the back major surface.

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/026910

A. CLASSIFICATION OF SUBJECT MATTER INV. F24J2/10 F24J2/16 G02B5/08 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F24J G02B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 877 139 A (MARTINEZ EUGENE) 15 April 1975 (1975-04-15) figures 1-11 column 2, line 65 - column 3, line 4 column 3, lines 40-60	1-20
Y	----- US 6 532 119 B1 (MARTINEZ SR EUGENE [US]) 11 March 2003 (2003-03-11) figure 2 column 1, line 66 - column 2, line 3 column 5, lines 5-9	1-9, 17-20
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 26 July 2012		Date of mailing of the international search report 02/08/2012
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Parmentier, Hélène

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A	----- US 4 456 332 A (ANDERSON ALFRED J [US]) 26 June 1984 (1984-06-26) figure 10a	1-20
A	----- JP 57 004002 A (NIPPON SHEET GLASS CO LTD) 9 January 1982 (1982-01-09) abstract; figures 7-9	1-20
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