



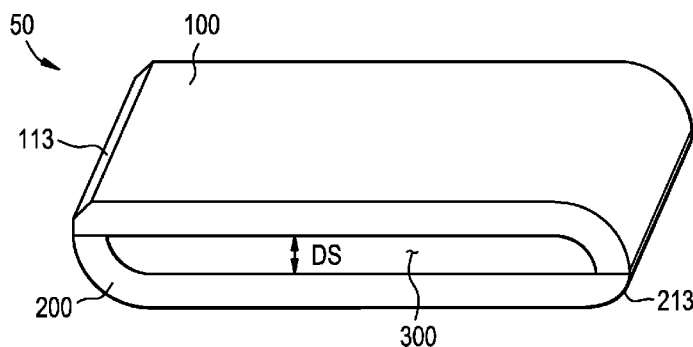
- (51) **International Patent Classification:**
C03C 27/04 (2006.01) *C03C 27/10* (2006.01)
C03C 27/08 (2006.01)
- (21) **International Application Number:**
PCT/US2016/048152
- (22) **International Filing Date:**
23 August 2016 (23.08.2016)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
62/212,115 31 August 2015 (31.08.2015) US
62/212,833 1 September 2015 (01.09.2015) US
- (71) **Applicant:** CORNING INCORPORATED [US/US]; 1 Riverfront Plaza, Corning, New York 14831 (US).
- (72) **Inventors:** DARCANGELO, Charles Michael; 121 Corning Blvd., Corning, New York 14830 (US). LOGUNOV, Stephan Lvovich; 2780 Pinewood Circle, Corning, New York 14830 (US). QUESADA, Mark Alejandro; 3 Ambrose Drive, Horseheads, New York 14845 (US). VADDI, Butchi Reddy; 101 Woodview Way, Painted Post, New York 14870 (US).
- (74) **Agent:** WEGMANN, Zachary J.; Corning Incorporated, Intellectual Property Department, SP-Ti-03-01, Corning, New York 14831 (US).

- (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, BN, 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, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

Published:
— with international search report (Art. 21(3))

(54) **Title:** TWO-PIECE ENCLOSURE

FIG. 5



(57) **Abstract:** A two-piece article for enclosing an electronic device or for storing food and methods of making the same. The two-piece enclosure includes a light absorbing film at the interface between two segments. The two segments are joined together by a bond. The resultant enclosure includes high tensile strength glass part.

TWO-PIECE ENCLOSURE

[0001] This application claims the benefit of priority under 35 U.S.C. § 119 of U.S. Provisional Application Serial No. 62/212,115 filed on August 31, 2015 and U.S. Provisional Application Serial No. 62/212,833 filed on September 1, 2015 the contents of which are relied upon and incorporated herein by reference in its entirety.

BACKGROUND

Field

[0002] The present disclosure relates generally to a two-piece bonded enclosure.

Technical Background

[0003] There is a continued demand in a variety of consumer products for glass structures that have high optical quality and precise shapes along with high bond strengths. Tubular glass shapes with circular or non-circular, such as oval or square, cross sections are of particular interest as they have applications in a number of fields, for example as the exterior structure of food storage containers and electronic devices, such as telephones, and electronic pads or other handhelds.

[0004] Conventional structures for enclosing electronic devices and acting as food storage containers are typically comprised of several parts joined and sealed together to form an enclosure. These several parts also typically require several supporting vectors during assembly of the structure. Once assembled, junctions between the several parts of the enclosure are locations where external stresses often lead to sealing failures. This is especially true when the several parts of the enclosure are glass and the electronic device therein requires a hermetic seal. For example, organic light emitting diode (OLED) devices require light transparency and biasing and absolute hermeticity. Furthermore, the hermetic sealing should be performed near ambient temperatures due to high temperature sensitivity of the organic material to be encapsulated.

[0005] Conventional multi-component structures are sealed together using frit-based sealants, for example, including glass materials ground to a particle size ranging from 2 to 150 microns, a negative CTE material, and an organic solvent or binder. A glass frit layer can be applied to sealing surfaces on one or both of the substrates by spin-coating or screen printing. To join the multiple components of the structure, the glass frit materials typically have a glass transition temperature greater than 450°C and thus require processing at elevated temperatures to form the sealing layer. Further, conventional multi-component structures are susceptible to breakage and bond failure when mishandled by a user. Also, conventional single piece structures are difficult to manufacture by forming processes and to achieve flat surfaces.

[0006] Thus, a need exists for a two-piece structure that includes high tensile strength, optionally transparent, bonds between its structural parts. Accordingly, the present disclosure provides a laser bonded two-piece article.

SUMMARY

[0007] According to embodiments of the present disclosure, a two-piece glass article is disclosed. In embodiments, the article comprises a first glass-based segment and a second segment. In embodiments, the first glass-based segment comprises a top surface opposite a bottom surface, and a first end surface opposite a second end surface. In embodiments, the second end surface of the first glass-based segment includes a light absorbing film. In embodiments, the second segment comprises a top surface opposite a bottom surface, and a first end surface opposite a second end surface. In embodiments, the second end surface of the second segment includes a light absorbing film. In embodiments, the second end surface of the first glass-based segment is bonded to the bottom surface of the second segment at a first junction by a first laser-induced bond. In embodiments, the second end surface of the second segment is bonded to the bottom surface of the first glass-based segment at a second junction by a second laser-induced bond.

[0008] According to another embodiment of the present disclosure, a two-piece glass-based article is disclosed. In embodiments, the two-piece glass-based

article comprises a first L-shaped glass-based segment and a second L-shaped glass-based segment. In embodiments, the first L-shaped glass-based segment comprises a top surface opposite a bottom surface, and a first end surface opposite a second end surface. In embodiments, the top surface of the first L-shaped glass-based segment includes a first portion and a second portion separated by a convexly rounded portion. In embodiments, the first portion of the top surface of the first L-shaped glass-based segment is substantially orthogonal to the second portion of the top surface of the first L-shaped glass-based segment. In embodiments, the second end surface of the first L-shaped glass-based segment includes a laser light absorbing film. In embodiments, the second L-shaped glass-based segment comprises a top surface opposite a bottom surface, and a first end surface opposite a second end surface. In embodiments, the top surface of the second L-shaped glass-based segment includes a first portion and a second portion separated by a convexly rounded portion. In embodiments, the first portion of the top surface of the second L-shaped glass-based segment is substantially orthogonal to the second portion of the top surface of the second L-shaped glass-based segment. In embodiments, the second end surface of the second L-shaped glass-based segment includes a laser light absorbing film. In embodiments, the second end surface of the first L-shaped glass-based segment is bonded to the bottom surface of the second L-shaped glass-based segment by a first laser-induced transparent bond. In embodiments, the second end surface of the second L-shaped glass-based segment is bonded to the bottom surface of the first L-shaped glass-based segment by a second laser-induced transparent bond.

[0009] According to embodiments of the present disclosure, a method of forming a two-piece glass-based article is disclosed. In embodiments, the method comprises arranging a first glass-based segment relative to a second segment and bonding the first glass-based segment to the second segment. In embodiments, a first light absorbing film on a second end surface of the first glass-based segment contacts the bottom surface of the second segment at a first junction. In embodiments, a second light absorbing film on a second end surface of the second segment contacts the bottom surface of the first glass-based segment at a second junction. In embodiments, bonding the first glass-based segment to a second segment at the first

and second junctions includes locally heating the light absorbing films with laser radiation having a predetermined wavelength. In embodiments, the light absorbing film is transmissive at about 440 nm to about 750 nm.

[0010] The embodiments, and the features of those embodiments, as discussed herein are exemplary and can be provided alone or in any combination with any one or more features of other embodiments provided herein without departing from the scope of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The disclosure will be better understood, and features, aspects and advantages other than those set forth above will become apparent when consideration is given to the following detailed description thereof. Such detailed description makes reference to the following drawings, wherein:

[0012] FIG. 1 is transparent, exploded view of a two-piece enclosure according to an exemplary embodiment.

[0013] FIG. 2 is an assembled, transparent, perspective view of the two-piece enclosure shown in FIG. 1.

[0014] FIG. 3 is a transparent, perspective view of an assembled two-piece enclosure according to an exemplary embodiment.

[0015] FIG. 4 is a plan view of the two-piece enclosure shown in FIG. 3.

[0016] FIG. 5 is a perspective, assembled view of a two-piece enclosure according to an exemplary embodiment.

[0017] FIG. 6 is a photographic image of a laser weld (as viewed along line 2 or 4 provided in FIG. 4) between the segments of an enclosure according to an exemplary embodiment.

DETAILED DESCRIPTION

[0018] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the disclosure belongs. Although any methods and materials similar to or equivalent to those described herein can be used in the practice or testing of the present disclosure, the exemplary methods and materials are described below. It is also to be understood that the terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting.

[0019] The present disclosure is directed to a two-piece article 50 for enclosing an electronic device or acting as a food storage container. The electronic device may be a computer, an integrated circuit chip, electronic circuitry, a media device, a computing device, a telecommunications device, an image display device, or the like. The two-piece article 50 of the present disclosure may be configured to house and protect an electronic device therein and to enable a user to use and manipulate (e.g., though touch screen functionality, fingerprint analysis capabilities, buttons, etc.) the electronic device via the two-piece article 50. The article 50 may also be configured to allow wireless communication there through with the electronic device therein. In embodiments, two-piece article 50 forms the main body, “sleeve”, or integral tube within which the electronic device or perishables (e.g., food) are housed. In other embodiments, the article 50 may act as a hermetically sealed casing for the electronic device therein. In embodiments, article 50 may act as a moisture and air barrier for food storage. The assembled article 50, including the electronic device therein, may be a LCD or an OLED television, a portable mobile device, a cellphone, an electronic tablet, a touchscreen tablet, or similar device requiring a glass display for user manipulation. The assembled article 50 may be fully transparent, partially transparent, or translucent. The assembled article 50 with the electronic device may also be a handheld electronic device.

[0020] Two-piece article 50 includes a first segment 100 and a second segment 200 (also called “substrates” or “pieces” herein). Of course, segments 100, 200 may include the same materials, same lateral dimensions, same coefficients of

thermal expansion (CTE), same optical transmissions, and/or same thicknesses. In embodiments, first segment 100 and second segment 200 may comprise different materials, different lateral dimensions, different coefficients of thermal expansion (CTE), different optical transmissions, different thicknesses, and combinations thereof. For example, segment 100 and/or segment 200 may be a glass, a glass-based material, a glass-ceramic, a ceramic, or a metal. In another example, segment 100 and/or segment 200 may be opaque, transparent, or colored material. That is, for example, segment 100 may be a transparent or colored glass while segment 200 may be a transparent non-colored glass, and vice versa. In another example, segment 100 may be an opaque glass ceramic (or metal) while segment 200 may be a transparent non-colored glass. One of ordinary skill in the art would appreciate the various arrangements based on the disclosure herein. In the case of glass, segments 100, 200 may be soda lime glass, strengthened and unstrengthened glasses, chemically strengthened glass, tempered glass, ion-exchanged glass, aluminosilicate glass, borosilicate glass, alkaline earth boro-aluminosilicate glass, fused silica, LotusTM glass, WillowTM glass, Eagle XG[®] glass Eagle 2000[®] glass, Gorilla[®] glass, etc. Colored glasses may be formed by conventional techniques of adding transition metals to their compositions (e.g., cobalt for blue glass, manganese for red glass, etc.). Opaque glasses may be formed using conventional methods such as adding copper or other elements. Segments 100, 200 may also include anti-reflective coatings, anti-bacterial coatings, anti-scratch coatings, and combinations thereof. All combinations of these glass compositions for segments 100, 200 are according to embodiments of the present disclosure. The material selected may depend on the desired characteristics of article 50 such as electrical conductivity, thermal conductivity, transparency, toxicity, surface finish, weight, etc.

[0021] Exemplary substrates (glass or otherwise) can have any suitable dimensions. Substrates can have real (length and width) dimensions that independently range from 1 cm to 5 m (e.g., 0.1, 1, 2, 3, 4 or 5 m) and a thickness dimension that can range from about 0.5 mm to 2 mm (e.g., 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.5 or 2 mm). In further embodiments, a substrate thickness can range from about 0.05 mm to 0.5 mm (e.g., 0.05, 0.1, 0.2, 0.3, 0.4 or 0.5 mm). In still further

embodiments, a glass substrate thickness can range from about 2 mm to 10 mm (e.g., 2, 3, 4, 5, 6, 7, 8, 9 or 10 mm). Lateral dimensions and thicknesses of segments 100, 200 making up article 50 provide a light, ridged structure.

[0022] Referring to an embodiment of two-piece article 50 (or sleeve) shown in FIG. 1 (electronic device not shown), segment 100 includes a top surface 102 opposite a bottom surface 104, and a first end surface 106 opposite a second end surface 108. In certain embodiments, top surface 106 and/or bottom surface 108 may include near optical-quality to optical-quality surfaces. In another embodiment, top surface 106 and/or bottom surface 108 may include index-matching materials or coatings. Segment 100 may also include an electrical device (e.g., a sensor) therein between top surface 106 and bottom surface 108. Segment 100 further includes a first side surface 110 opposite a second side surface 112. Segment 100 may be L-shaped, U-shaped, or C-shaped when viewing the lateral profile of top surface 102 via side surfaces 110, 112. In one embodiment, glass segment 100 top surface 102 includes a first portion 101 and a second portion 109 separated by a third convexly rounded portion 103. Portions 101, 109 of top surface 102 may be substantially flat across their lateral dimensions. Portion 101 may be substantially orthogonal to portion 109. Further, portion 101 may be adjacent end surface 106 and convexly rounded portion 103 may be adjacent end surface 108. In yet another embodiment, glass segment 100 bottom surface 104 includes a first portion 105 and a second portion 111 separated by a third concavely rounded portion 107. Portions 105, 111 of bottom surface 104 may be substantially flat across their lateral dimensions. Portion 105 may be substantially orthogonal to portion 111. Further, portion 105 may be adjacent surface 106 and a concavely rounded portion 107 may be adjacent end surface 108.

[0023] Referring again to the FIG. 1 embodiment, second segment 200 comprises a top surface 202 opposite a bottom surface 204, and a first end surface 206 opposite a second end surface 208. In certain embodiments, top surface 206 and/or bottom surface 208 may include near optical-quality to optical-quality surfaces. In another embodiment, top surface 206 and/or bottom surface 208 may include index-matching materials or coatings. Segment 200 may also include an electrical device (e.g., a sensor) therein between top surface 206 and bottom surface 208. Segment 200

further includes a first side surface 210 opposite a second side surface 212. In exemplary embodiments, side surface 110 of segment 100 is level with side surface 210 of segment 200. In another embodiment, side surface 112 of segment 100 is level with side surface 212 of segment 200. Segment 200 may be L-shaped, U-shaped, or C-shaped when viewing the lateral profile of top surface 202 via side surfaces 210, 212. In one embodiment, glass segment 200 top surface 202 includes a first portion 201 and a second portion 209 separated by a third convexly rounded portion 203. Portions 201, 209 of top surface 202 may be substantially flat across their lateral dimensions. Portion 201 may be substantially orthogonal to portion 209. Further, portion 201 may be adjacent end surface 206 and convexly rounded portion 203 may be adjacent end surface 208. In yet another embodiment, glass segment 200 bottom surface 204 includes a first portion 205 and a second portion 211 separated by a third concavely rounded portion 207. Portions 205, 211 of bottom surface 204 may be substantially flat across their lateral dimensions. Portion 205 may be substantially orthogonal to portion 211. Further, portion 205 may be adjacent surface 206 and a concavely rounded portion 207 may be adjacent end surface 208.

[0024] In exemplary embodiments of segments 100, 200 end surfaces 108, 208 include a low melting film. End surfaces 106, 206 may also include the low melting film. In other embodiments, bottom surfaces 104, 204 may include the low melting film. The low melting film is typically applied to a surface acting as an interface boundary between the two segments, but may be applied to the entire surface of segments 100, 200. The low melting film may be the same or a different material on each of segments 100, 200 surfaces. The low melting film of the present disclosure is used to bond segments 100 and 200 together to form article 50. The low melting film is also used to locally define and effectuate a sealing interface between the two segments.

[0025] The low melting film of the present disclosure may be used to create a laser weld at the interfacial boundary between segment 100 and 200. The low melting film may be a low melting glass, for example, used for temperature induced absorption or color center absorption in the glass. In another embodiment, the low melting film of the present disclosure may be a laser light absorbing material, an

ultraviolet (UV) light absorbing material, a near-infrared (NIR) absorbing material, an infrared (IR) absorbing material, or another film that absorbs, melts at an incidental light wavelength within the electromagnetic spectrum.

[0026] Light absorbing film 116 may also be an inorganic film. The composition of the inorganic films of the present disclosure may comprise SnO₂, TiO₂, TiO, Zn, Ti, Ce, Pb, Fe, Va, Cr, Mn, Mg, Ge, SnF₂, ZnF₂, NbO, NbO₂, Nb₂O₅, TaO, TaO₂, Ta₂O₅, and combinations thereof. Inorganic films of the present disclosure may also include Niobium and Tantalum based compounds including other elements including fluoride, chloride, bromide, sulfide, and tellurides, for example. In other embodiments, the composition of the inorganic film can be selected to lower the activation energy for inducing creep flow of the first substrate, the second substrate, or both the first and second substrates. In another embodiment, the composition of the inorganic film can be a laser absorbing low liquidus temperature material with a liquidus temperature less than or equal to about 1000°C, less than or equal to about 600°C, or less than or equal to about 400°C. In a further embodiment, the composition of the inorganic film comprises 20-100 mol% SnO, 0-50 mol% SnF₂, and 0-30 mol% P₂O₅ or B₂O₃. In some embodiments, the inorganic film and the substrates have a combined internal transmission of more than 80% at approximately 420 nm to approximately 750 nm.

[0027] A total thickness of an exemplary film can range from about 100 nm to 10 microns. In various embodiments, a thickness of the film can be less than 10 microns, e.g., less than 10, 5, 2, 1, 0.5 or 0.2 microns. Exemplary glass sealing film thicknesses include 0.1, 0.2, 0.5, 1, 2, 5 or 10 microns.

[0028] Light absorbing film 116 may be applied to various surfaces of segments 100, 200 by vapor deposition, 3-D printing, sputtering from a sputtering target, dip coating, spray coating, spin coating, blading, brushing, printing processes, or roll-to-roll processes, or other commonly known methods. In embodiments, the thickness of light absorbing film 116 may range from about 1 micron to 1 mm, or from about 10 nm to about 100 micrometers. When assembling segment 100 and

segment 200 to form article 50, light absorbing film 116 is applied to a contact surface or surfaces between the segments 100, 200.

[0029] FIG. 2 provides an example, transparent assembled article 50. Segments 100, 200 from FIG. 1 are arranged relative to one another in FIG. 2. In one embodiment, light absorbing film 116 on end surface 108 of glass segment 100 contacts the bottom surface 204 of the second glass segment 200 at a junction 302. In another embodiment, light absorbing film 116 on end surface 208 of the second glass segment 200 contacts the bottom surface 104 of the first glass segment 100 at a junction 304. In yet another embodiment, end surfaces 108, 208 are pressed onto bottom surfaces 204, 104 at junctions 302, 304, respectively, including light absorbing film 116. Junctions 302, 304 are shown as shaded areas in FIG. 2. Light absorbing film 116 may cover all or a portion of junctions 302, 304. Depending on how segments 100, 200 are disposed relative to one another, residual members 306 and 308 may exist and may need to be removed after bonding segments 100, 200. Residual members 306, 308 may act as grip points or stabilizing members while bonding segments 100, 200 to form article 50. The configuration of segment 100 and segment 200 relative to each other, as shown in FIG. 2, only necessitates a compressive force (orthogonal the top surfaces 102, 202 of segments 100, 200) to keep the segments stationary for bonding and later processing. Further, once assembled, compressive forces do not exhibit strain on seals, bonds, or welds within junctions 302, 304. In comparison, conventional structures often require several vectors to support the individual substrates for bonding and later processing. The bonds of conventional structures are also typically strained by a compressive force (orthogonal the top surfaces 102, 202 of segments 100, 200) in FIG. 2.

[0030] In the illustrated embodiment, segments 100, 200 are brought into a mating configuration and cooperate to define an interior volume or cavity 300. Cavity 300 is between bottom surface 104 of segment 100 and bottom surface 204 of segment 200. Cavity 300 is configured to contain and surround the electronic device to be enclosed or protected by article 50. Cavity 300 may also be configured to contain food or other similar perishable consumer products. In an exemplary embodiment, bottom surface 104 is separated from bottom surface 204 by a distance

DS of about 0.1 millimeters to about 30 centimeters, or about 2 millimeters to about 5 millimeters. The electronic device may be positioned within cavity 300 before, during, or after laser-induced bonding of segment 100 to segment 200.

[0031] An exemplary method of bonding segments 100, 200 together starts by directing a laser at an interface of the two glass sheets with suitably chosen parameters to initiate a welding process. In exemplary embodiments, the interface is along junctions 302, 304 at a location including light absorbing film 116. A focused laser beam from a laser can be used to locally heat and melt the light absorbing film 116 and adjacent glass substrate materials (e.g., segments 100, 200) to form a sealed interface within junctions 302, 304. In one approach, the laser can be focused through segment 100 to junction 304 and then translated (scanned) across junction 304 at the sealing surface to locally heat the light absorbing film 116. In another approach, the laser can be focused through segment 200 to junction 302 and then translated (scanned) across junction 302 at the sealing surface to locally heat the light absorbing film 116. Of course, the process of welding along junctions 302 and 304 can be applied in parallel areas to form redundant seals between segment 100 and segment 200. In exemplary embodiments, the laser beam contacts segments 100, 200 substantially orthogonal to top surfaces 102, 202, respectively. To affect local intermigration of the glass layers, light absorbing film 116 absorbs the laser processing wavelength. Also, a low melting film may be used to absorb sufficient energy from the incident laser to induce welding. The glass substrates can be initially transparent (e.g., at least 50%, 70%, 80% or 90% transparent) at the laser processing wavelength. Thus article 50 has a minimal number of bonding sites (i.e., 2 junctions 303 and 304) for bonding segments 100, 200. Also, the bonds may be positioned opposite article 50 to minimize bond failure in the event of a localized force along the periphery of article 50. Methods and examples of laser bonding various substrates together (such as segments 100, 200) to form a bonded article is provided in U.S. Patent Publication No. 2015/0027168A1, the entire contents of which is incorporated herein by reference.

[0032] The optimum welding can be a function of three mechanisms, namely, absorption by an exemplary film and/or substrate of laser radiation and the

heating effect based of this absorption process, increase of the film and substrate absorption due to the heating effects (band gap shift to the longer wavelength) which can be transient and depends upon the processing conditions, and defect or impurity absorption or color center absorption generated by UV radiation. As noted above, strong, hermetic, transparent bonds can be achieved using embodiments of the present disclosure by an exemplary low melting film or another film that absorbs/melts at an incident wavelength, color center formation in the film and glass, and temperature induced absorption in the film and glass substrates. In some embodiments, the color center formation can be reversible if transparent seals are desired.

[0033] As used herein, a hermetic seal is an area (e.g., cavity 300) which, for practical purposes, is considered substantially airtight and substantially impervious to moisture and/or oxygen. By way of example, the hermetic seal can be configured to limit the transpiration (diffusion) of oxygen to less than about 10^{-2} $\text{cm}^3/\text{m}^2/\text{day}$ (e.g., less than about 10^{-3} $\text{cm}^3/\text{m}^2/\text{day}$), and limit the transpiration (diffusion) of water to about 10^{-2} $\text{g}/\text{m}^2/\text{day}$ (e.g., less than about 10^{-3} , 10^{-4} , 10^{-5} or 10^{-6} $\text{g}/\text{m}^2/\text{day}$). In embodiments, the hermetic seal substantially inhibits air and water from contacting a protected workpiece (e.g., an electronic device within cavity 300).

[0034] The laser can have any suitable output to affect sealing. An exemplary laser can be a UV laser such as, but not limited to, a 355 nm laser, which lies in the range of transparency for common display glasses. A suitable laser power can range from about 0.51 W to about 10 W. The width of the sealed region between segments 100, 200, which can be proportional to the laser spot size, can be about 0.04 to 2 mm, e.g., 0.06, 0.1, 0.2, 0.5, 1, 1.5 or 2 mm. A translation rate of the laser (i.e., sealing rate) can range from about 1 mm/sec to 400 mm/sec or even to 1 m/sec or greater, such as 1, 2, 5, 10, 20, 50, 100, 200, or 400 mm/sec, 600 mm/sec, 800 mm/sec, 1 m/sec. The laser spot size (diameter) can be about 0.02 to 2 mm. The laser weld dimension was found to be slightly less than the dimensions of the incident beam (approximately 500 microns less).

[0035] Suitable glass substrates exhibit significant induced absorption during sealing. In some embodiments, the segment 100 can be a transparent glass

plate like those manufactured and marketed by Corning Incorporated. Alternatively, segment 100 can be any transparent glass plate such as those manufactured and marketed by Asahi Glass Co. (e.g., AN100 glass), Nippon Electric Glass Co., (e.g., OA-10 glass or OA-21 glass), or Corning Precision Materials. In another embodiment, segment 200 can be the same glass material as segment 100, or a non-transparent substrate such as, but not limited to, a ceramic substrate or a metal substrate. Exemplary glass substrates can have a coefficient of thermal expansion of less than about $150 \times 10^{-7}/^{\circ}\text{C}$, e.g., less than $50 \times 10^{-7}/^{\circ}\text{C}$, $20 \times 10^{-7}/^{\circ}\text{C}$ or $10 \times 10^{-7}/^{\circ}\text{C}$. Of course, in other embodiments the segment 100 can be a ceramic, metal or other material substrate, patterned or continuous, as provided above.

[0036] The step of bonding together the segments can create a bond having an integrated bond strength greater than an integrated bond strength of a residual stress field in segment 100, segment 200 or both segments 100, 200. For example, the laser-induced bonds between segment 100 and segment 200 may have strengths from about 5 MPa to about 120 MPa, or even from about 10 MPa to about 100 MPa. In some exemplary embodiments, such a bond will fail only by cohesive failure. In other embodiments, the step of bonding further comprises welding article 50 between the first and second segments 100, 200 as a function of the composition of impurities in the first segment 100 or second segment 200 and as a function of the composition of the inorganic film though the local heating of the inorganic film with laser radiation having a predetermined wavelength. The predetermined wavelength of the laser radiation is based on or compatible with the absorption spectrum of the low melting film, the material of segment 100, and/or the material of segment 200 to effectuate local inter-migration of there between. Exemplary impurities in the first or second substrates can be, but are not limited to, As, Fe, Ga, K, Mn, Na, P, Sb, Ti, Zn, Sn and combinations thereof. A microscopic photograph of the laser weld bond between segments 100, 200 comprised of Eagle XG® glass is provided in FIG. 6. The view of the weld location in FIG. 6 at junction 302, 304 is provided by dashed lines 2 and 4 in FIG. 4.

[0037] Once the segments are assembled, as illustrated in FIG. 2, it may be desirable to remove residual members 306 and 308 by cutting, scoring and

breaking, polishing, or other conventional glass, glass ceramic, ceramic, or metal separation techniques. FIG. 2 illustrates example cutting lines 6 and 8 that may be used to remove residual members 306 and 308. With residual member 308 removed, end surface 106 of segment 100 is adjacent top surface 202 of segment 200. Further, with residual member 306 removed, end surface 206 of segment 200 is adjacent top surface 201 of segment 100.

[0038] FIG. 3 is a transparent, perspective view of an example assembled article 50 without residual members 306 and 308. The laser-induced weld, seal or bond between segment 100 and segment 200 is at a location within junctions 302 and 304. The width D_w of the weld, seal or bond lines can be varied by modification of the spot size at the interface of the respective substrates. As shown in FIG. 6, weld 216 has a width D_w of 80 microns. Another weld may be placed next to weld 216 in exemplary embodiments to redundancy in weld strength and sealing. The width D_w of the weld, seal or bond may also be from about 5 microns to about 200 microns. In other embodiments, width D_w of the sealed region, which can be proportional to the laser spot size, can be about 0.05 to 2 mm, e.g., 0.05, 0.1, 0.2, 0.5, 1, 1.5 or 2 mm. As shown in the example embodiment in FIG. 3, end surface 108 of segment 100 is bonded to bottom surface 204 of segment 200 at junction 302 by laser-induced bond. Also shown, second end surface 208 of segment 200 is bonded to bottom surface 104 of segment 100 at junction 304 by another laser-induced bond. Again, the laser-induced bond may be at any location along junctions 302 and 304. Two-piece article 50 creates an enclosure for an electronic device or a container for food that is simpler to form compared to conventional single piece articles manufactured using forming processes, and multi-piece articles bonded together using glass frit.

[0039] According to exemplary methods of manufacturing article 50, it may be desirable to polish adjacent to junctions 302 and 304 where residual members 306 and 308 may have been removed and after the laser-induced bond is formed. Polishing this area may diminish or eliminate the visibility of the bond between segment 100 and segment 200. Polishing the area around junctions 302 and 304 may also create a smooth circumference around segments 100, 200 or improve the aesthetic feel of article 50 when manipulated by a user. In one embodiment, segments

100, 200 may also include edges 351, 350, respectively (shown in FIG. 4). Edges 350, 351 together or individually may assist a user grasping article 50 and when manipulating the electronic device therein. That is, edges 350, 351 may act as friction areas where the user is able to more easily grasp article 50 than other smooth surfaces around its periphery.

[0040] In an alternative embodiment of manufacturing article 50, edges 350 and 351 may be round beveled to create a continually rounded circumference around article 50. In another exemplary method, edges 350 and 351 may be flat beveled to create a one flat-edge embodiment, or two flat-edge embodiment. Edge 351 is between end surface 106 of segment 100 and top surface 102 of segment 100. Edge 350 is between end surface 206 of segment 200 and top surface 202 of segment 200. As shown in FIG. 5, edge 350 is round beveled to form beveled edge 213 and edge 351 is flat beveled to form beveled edge 113. Of course, various combinations of these flat and rounded beveled edges are possible for article 50. In yet alternative methods, two-piece bonded article 50 may be annealed to improve overall strength. In yet another embodiment, two piece bonded article 50 may be thermally or chemically tempered for added strength for use of the sleeve in portable electronic applications. Techniques for chemical tempering, or ion exchange, are well known in the art – e.g., U.S. Pat. Nos. 3,410,673 and 8,561,429 – both of which are herein incorporated by reference in their entireties.

[0041] Again referring to FIG. 5, a top member 310 and a bottom member 321 (not shown in the Figures) may be attached to article 50 to fully enclose cavity 300. Specifically, top member 320 may be connected to first side surfaces 110 and 210 of segment 100 and segment 200, respectively. Further, bottom member 321 may be connected to second side surfaces 112 and 212 of segment 100 and segment 200, respectively. Article 50 together with top member 320 and bottom member 321 would fully enclose cavity 300 and the electronic device or food storage area therein. Top member 320 and bottom member 320 may be sealed, bonded, or welded to article 50 accordingly to the methods disclosed herein, or using conventional methods. Of course one of ordinary skill in the art will appreciate the various shapes possible for top member 320 and bottom member 321. Top member 320 may be directly or

indirectly coextensive or joined with bottom member 321. In one particular embodiment, top member 320 and bottom member 321 may each have a rounded bottom with sides extending up and terminating in a plane to attach to the sides of segments 100, 200. Top member 320 and bottom member 321 may also have cavities therein that adjoin with and expand cavity 300 for holding the electronic device. The electronic device may be a quantum dot, a display, a light emitting diode, or an organic light emitting display. Top member 320 and bottom member 321 may also be removable such that cavity 300 can act as a food storage area.

[0042] As used herein, the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to a “metal” includes examples having two or more such “metals” unless the context clearly indicates otherwise.

[0043] Ranges can be expressed herein as from “about” one particular value, and/or to “about” another particular value. When such a range is expressed, examples include from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent “about,” it will be understood that the particular value forms another aspect. It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint.

[0044] Unless otherwise expressly stated, it is in no way intended that any method set forth herein be construed as requiring that its steps be performed in a specific order. Accordingly, where a method claim does not actually recite an order to be followed by its steps or it is not otherwise specifically stated in the claims or descriptions that the steps are to be limited to a specific order, it is no way intended that any particular order be inferred.

[0045] It is also noted that recitations herein refer to a component of the present invention being “configured” or “adapted to” function in a particular way. In this respect, such a component is “configured” or “adapted to” embody a particular property, function in a particular manner, where such recitations are structural

recitations as opposed to recitations of intended use. More specifically, the references herein to the manner in which a component is “configured” or “adapted to” denotes an existing physical condition of the component and, as such, is to be taken as a definite recitation of the structural characteristics of the component.

[0046] It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the invention. Since modifications combinations, sub-combinations and variations of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and their equivalents.

CLAIMS

What is claimed is:

1. A laser bonded two-piece article comprising:
 - a first glass-based segment comprising a top surface opposite a bottom surface, and a first end surface opposite a second end surface,
 - wherein the second end surface of the first glass-based segment includes a first light absorbing film,
 - a second segment comprising a top surface opposite a bottom surface, and a first end surface opposite a second end surface,
 - wherein the second end surface of the second segment includes a second light absorbing film,
 - wherein the second end surface of the first glass-based segment is bonded to the bottom surface of the second segment at a first junction by a first laser-induced bond, and
 - wherein the second end surface of the second segment is bonded to the bottom surface of the first glass-based segment at a second junction by a second laser-induced bond.
2. The article of claim 1 wherein the light absorbing films are inorganic films selected from the group consisting of SnO₂, TiO₂, TiO, Zn, Ti, Ce, Pb, Fe, Va, Cr, Mn, Mg, Ge, SnF₂, ZnF₂, NbO, NbO₂, Nb₂O₅, TaO, TaO₂, Ta₂O₅, and combinations thereof.
3. The article according to claims 1 or 2 wherein the light absorbing films are the same material.
4. The article as in any one of claims 1-3 wherein the second segment is a glass, a glass-based material, a glass ceramic, a ceramic, or a metal.
5. The article as in any one of claims 1-4 wherein the first light absorbing film, the first glass-based segment, and the second segment are together transmissive from about 420 nm to about 750 nm.

6. The article as in any one of claims 1-5 wherein the first end surface of the first glass-based segment is adjacent the top surface of the second segment.

7. The article as in any one of claims 1-6 wherein the first end surface of the second segment is adjacent the top surface of the first glass-based segment.

8. The article as in any one of claims 1-7 wherein the top surface of the first glass-based segment includes a substantially flat first portion adjacent the first end surface of the first glass-based segment and a convexly rounded portion adjacent the second end surface of the first glass-based segment.

9. The article as in any one of claims 1-8 wherein the top surface of the second segment includes a substantially flat first portion adjacent the first end surface of the second segment and a convexly rounded portion adjacent the second end surface of the second segment.

10. The article as in any one of claims 1-9 wherein the bottom surface of the first glass-based segment includes a substantially flat portion adjacent the first end surface of the first glass-based segment and a concavely rounded portion adjacent the second end surface of the first glass-based segment; and

wherein the bottom surface of the second segment includes a substantially flat portion adjacent the first end surface of the second segment and a concavely rounded portion adjacent the second end surface of the second segment.

11. The article as in any one of claims 1-10 wherein the first glass-based segment and the second segment have different glass materials, lateral dimensions, different coefficients of thermal expansion, different thicknesses, different optical transmissions, and combinations thereof.

12. The article as in any one of claims 1-11 wherein the first glass-based segment includes a beveled edge between the first end surface of the first glass-based segment and the top surface of the first glass-based segment.

13. The article as in any one of claims 1-12 wherein the second segment includes a beveled edge between the first end surface of the second segment and the top surface of the second segment.

14. The article as in any one of claims 1-13 wherein the first glass-based segment further comprises a first side surface opposite a second side surface, and

wherein the second segment further comprises a first side surface opposite a second side surface.

15. The article as in any one of claims 1-14 wherein the first side surface of the first glass-based segment is level with the first side surface of the second segment.

16. The article as in any one of claims 1-15 wherein the bottom surface of the first glass-based segment is separated from the bottom surface of the second segment by a distance DS of 0.1 mm to 30 cm.

17. The article as in any one of claims 1-16 further comprising a cavity between the first glass-based segment and the second segment for enclosing an electronic device or for storing food.

18. The article of claim 17 wherein the cavity is further defined by a top member connected to the first side surface of the first glass-based segment and the first side surface of the second segment.

19. The article as in any one of claims 1-18 where the cavity includes a quantum dot, a display, a light emitting diode, or an organic light emitting diode.

20. A laser bonded two-piece glass-based article comprising:

a first L-shaped glass-based segment comprising a top surface opposite a bottom surface, and a first end surface opposite a second end surface,

wherein the top surface of the first L-shaped glass-based segment includes a first portion and a second portion separated by a convexly rounded portion, the first portion of the top surface of the first L-shaped glass-based segment is substantially orthogonal to the second portion of the top surface of the first L-shaped glass-based segment,

wherein the second end surface of the first L-shaped glass-based segment includes a laser light absorbing film,

a second L-shaped glass-based segment comprising a top surface opposite a bottom surface, and a first end surface opposite a second end surface,

wherein the top surface of the second L-shaped glass-based segment includes a first portion and a second portion separated by a convexly rounded portion, the first portion of the top surface of the second L-shaped glass-based segment is substantially orthogonal to the second portion of the top surface of the second L-shaped glass-based segment, wherein the second end surface of the second L-shaped glass-based segment includes a laser light absorbing film,

wherein the second end surface of the first L-shaped glass-based segment is bonded to the bottom surface of the second L-shaped glass-based segment by a first laser-induced transparent bond,

wherein the second end surface of the second L-shaped glass-based segment is bonded to the bottom surface of the first L-shaped glass-based segment by a second laser-induced transparent bond, and

a cavity between the first L-shaped glass-based segment and the second L-shaped glass-based segment.

21. The article of claim 20 where the cavity includes a quantum dot, a display, a light emitting diode, or an organic light emitting diode.

22. A method of manufacturing the article of claim 1, the method comprising:

arranging the first glass-based segment relative to the second segment,

wherein the first light absorbing film on the second end surface of the first glass-based segment contacts the bottom surface of the second segment at the first junction,

wherein the second light absorbing film on the second end surface of the second segment contacts the bottom surface of the first glass-based segment at the second junction,

bonding the first glass-based segment to the second segment at the first and second junctions by locally heating the light absorbing films with laser radiation having a predetermined wavelength, and

wherein the light absorbing films, the first glass-based segment, and the second glass-based segment are together transmissive at about 420 nm to about 750 nm.

23. The method of claim 22 wherein bonding the first glass-based segment to the second segment includes providing laser radiation to the light absorbing film through the second segment and substantially orthogonal the top surface of the second segment.

24. The method according to claims 22 or 23 further comprising polishing adjacent the first and second junctions.

25. The method as in any one of claims 22-24 further comprising inserting an electronic device in a cavity between the first glass-based segment and the second segment.

FIG. 1

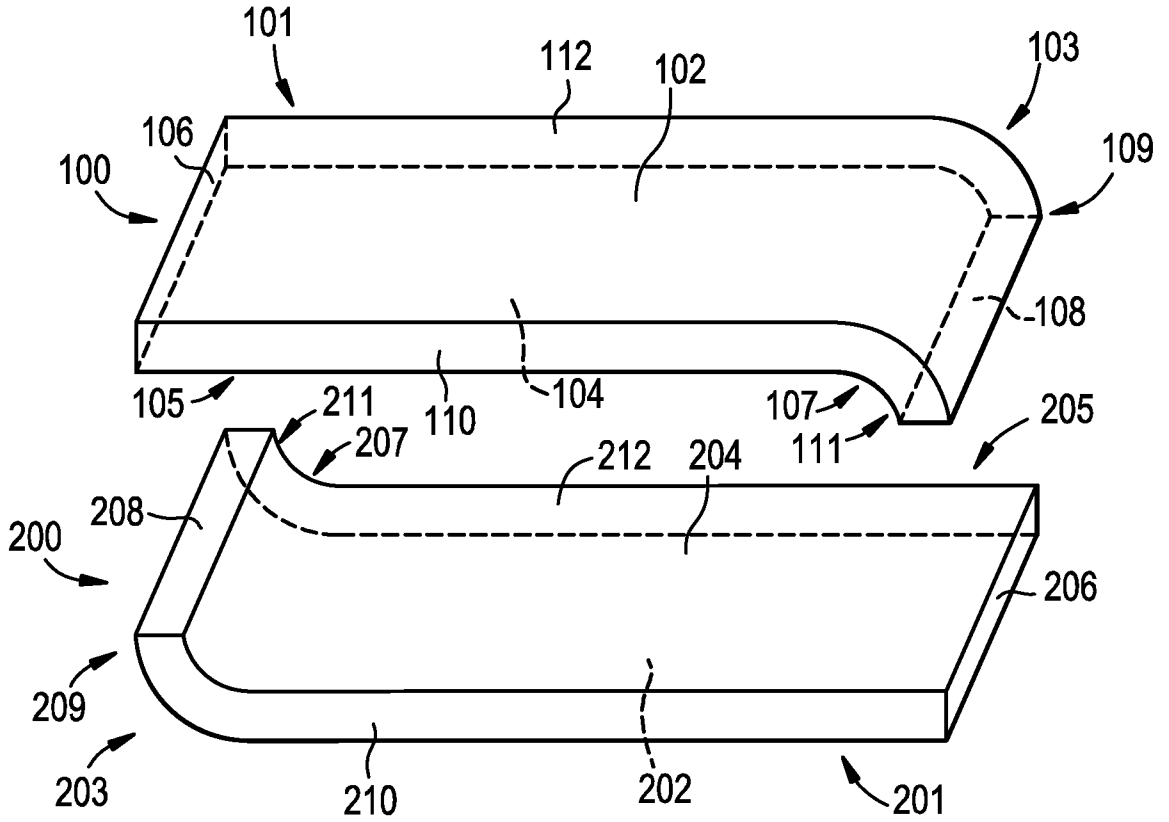


FIG. 2

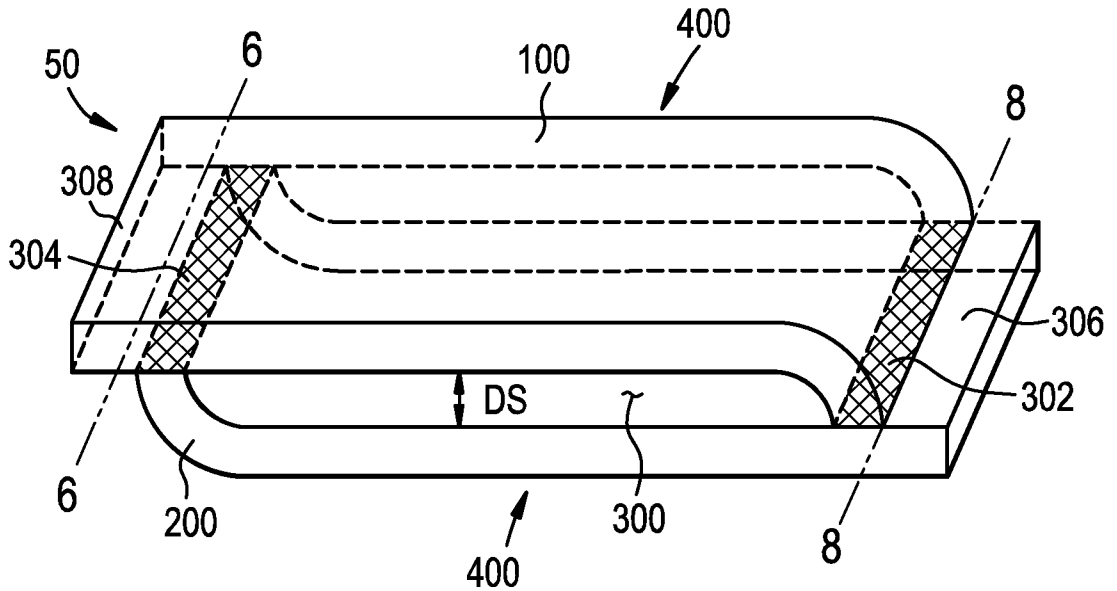


FIG. 3

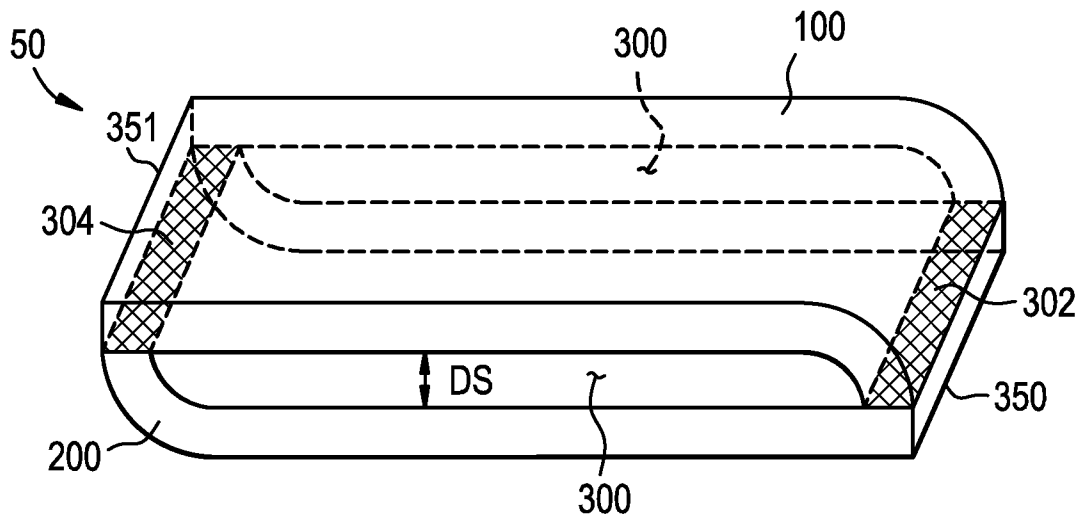


FIG. 4

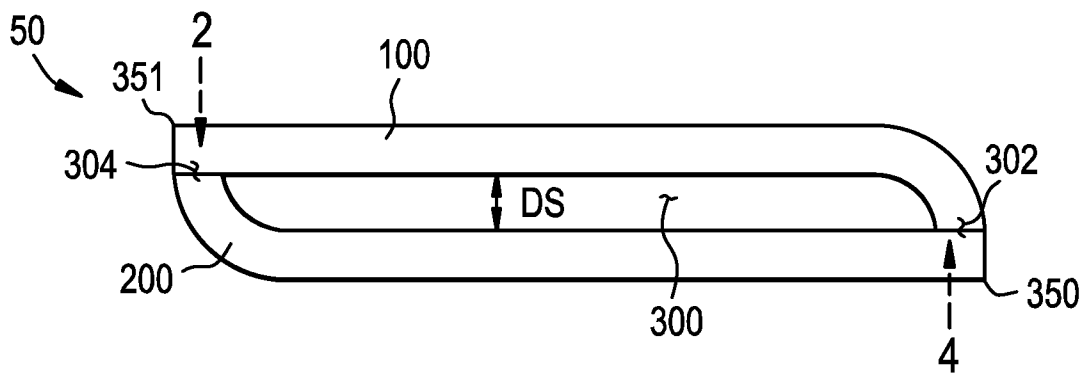


FIG. 5

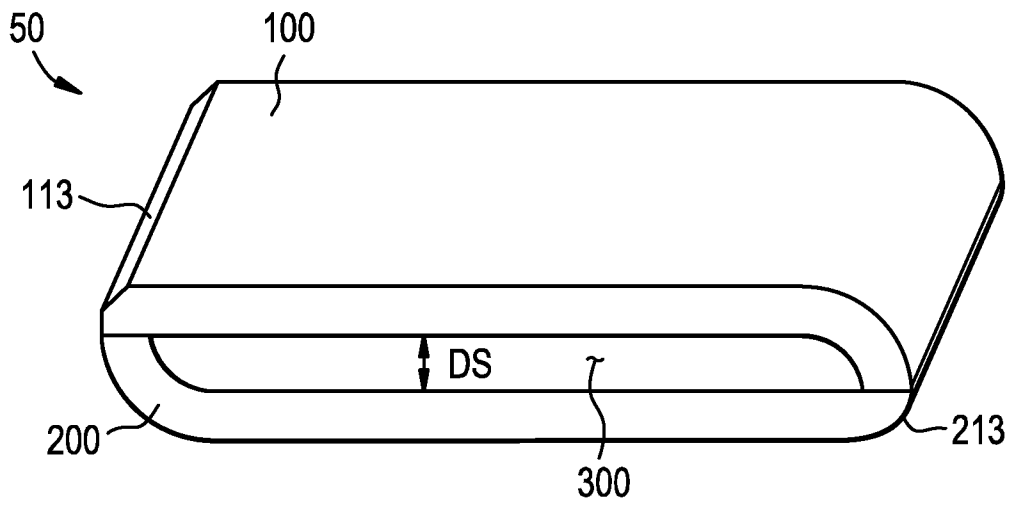
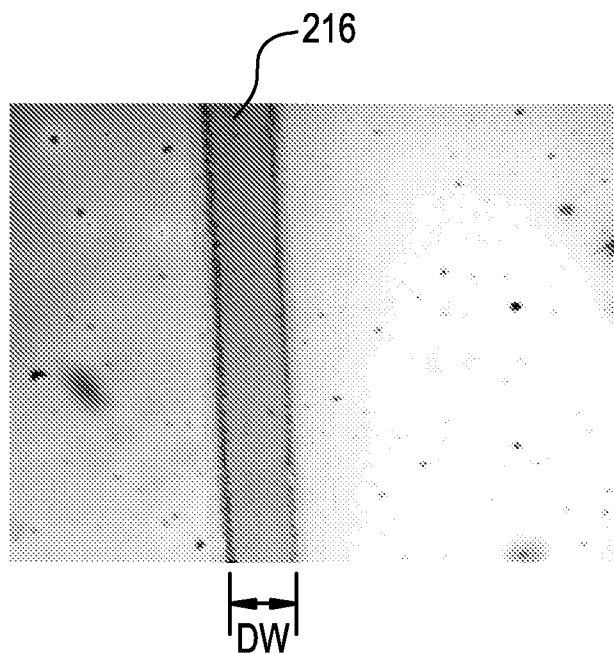


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/048152

A. CLASSIFICATION OF SUBJECT MATTER
INV. C03C27/04 C03C27/08 C03C27/10
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)
C03C H05B C03B

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.
X	US 2009/242017 A1 (YASUDA RYOSUKE [JP]) 1 October 2009 (2009-10-01) paragraphs [0003], [0053]; figure 8A -----	1-25
A	US 2013/134396 A1 (SHIMOMURA AKIHISA [JP] ET AL) 30 May 2013 (2013-05-30) paragraphs [0007], [0104]; figure 2B -----	1-25
A	US 5 489 321 A (TRACY C EDWIN [US] ET AL) 6 February 1996 (1996-02-06) claims 5-7; figures 3-8 -----	1-25

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 31 October 2016	Date of mailing of the international search report 08/11/2016
--	--

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 Flügel, Alexander
--	---

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/048152

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009242017	A1	01-10-2009	JP 2009245705 A
			US 2009242017 A1

US 2013134396	A1	30-05-2013	JP 2013137997 A
			KR 20130059277 A
			US 2013134396 A1

US 5489321	A	06-02-1996	AU 3135095 A
			DE 69519028 D1
			DE 69519028 T2
			EP 0771313 A1
			US 5489321 A
			WO 9602473 A1
