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GLASS ARTICLE FOR VEHICLE INTERIOR SYSTEM HAVING A BENDABLE DISPLAY UNIT

Abstract

A bendable glass article having a bendable display unit is disclosed. The glass article includes a glass sheet including a first major surface and a second major surface opposite to the first major surface. A hinge mechanism is disposed on the second major surface of the glass sheet. The hinge mechanism divides the glass sheet into a first side and a second side. A bendable display unit is bonded to the second major surface of the glass sheet and disposed between the glass sheet and the hinge mechanism. An adhesive material is disposed on the second major surface of the glass sheet around the display. The first side is bendable about the hinge mechanism relative to the second side, and the bendable display unit is hermetically sealed within the adhesive material.

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Background/Summary

[0001] This application is a continuation of U.S. application Ser. No. 18/021,072 filed on Feb. 13, 2023, which claims the benefit of priority under 35 U.S.C. § 371 of International Patent Application Serial No. PCT/US2021/045301, filed on Aug. 10, 2021, which claims the benefit of priority under 35 U.S.C. § 119 of U.S. Provisional Application Ser. No. 63/067,526 filed on Aug. 19, 2020, the content of each of which is relied upon and incorporated herein by reference in its entirety.

BACKGROUND

[0002] The disclosure relates generally to glass articles, and more particularly to a bendable glass article for a vehicle interior system having a bendable display unit.

[0003] Vehicle interiors include a variety of display screens. Efforts have been made to incorporate such display screens into the overall aesthetic design of the vehicle. In this way, attempts have been made to incorporate the displays into continuous surfaces, e.g., of a dashboard. Further, in order to enhance both the aesthetic design and functionality, glass has been used to form these continuous surfaces. However, the use of the glass provides additional design challenges over other conventional plastic, metal, and composite materials, which have had significant time to develop in the automotive industry.

SUMMARY

[0004] According to an aspect, embodiments of the disclosure relate to a glass article. The glass article includes a glass sheet including a first major surface and a second major surface opposite to the first major surface. A hinge mechanism is disposed on the second major surface of the glass sheet. The hinge mechanism divides the glass sheet into a first side and a second side. A bendable display unit is bonded to the second major surface of the glass sheet and disposed between the glass sheet and the hinge mechanism. An adhesive material is disposed on the second major surface of the glass sheet around the display. The first side is bendable about the hinge mechanism relative to the second side, and the bendable display unit is hermetically sealed within the adhesive material.

[0005] According to another aspect, embodiments of the disclosure relate to an interior system of a vehicle. The interior system includes a dashboard base positioned across a center line axis of the vehicle. The center line axis divides the vehicle longitudinally into a driver side and a passenger side. A glass article is attached to the dashboard base. The glass article includes a glass sheet having a first major surface and a second major surface opposite to the first major surface. The first glass sheet has a first side and a second side. The first side is located on the driver side of the center line axis. A hinge mechanism is disposed on the second major surface of the glass sheet. The hinge mechanism divides the glass sheet between the first side and the second side. A bendable display unit is bonded to the second major surface of the glass sheet and is disposed between the hinge mechanism and the glass sheet. An adhesive material is disposed on the second major surface of the glass sheet around the bendable display unit. The display is hermetically sealed between the adhesive material and the glass sheet. The bendable display unit is configured to transition between

a curved configuration and a planar configuration when the second side of the glass sheet bends about the hinge mechanism.
[0006] Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the embodiments as described herein, including the detailed description which follows, the claims, as well as the appended drawings.
[0007] It is to be understood that both the foregoing general description and the following detailed description are merely exemplary, and are intended to provide an overview or framework to understanding the nature and character of the claims. The accompanying drawings are included to provide a further understanding, and are incorporated in and constitute a part of this specification.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0008] The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:
[0009] FIG. **1** depicts a vehicle interior including a glass article with a living hinge integrated into a dashboard of the vehicle, according to exemplary embodiments;
[0010] FIG. **2** depicts the glass article of FIG. **1**, according to an exemplary embodiment;
[0011] FIG. **3** depicts a side view of a simplified glass article having a living hinge, according to an exemplary embodiment;
[0012] FIG. **4** depicts an exploded, perspective view of a glass article, according to an exemplary embodiment;
[0013] FIGS. **5**A-**13**A depict cross-sectional views of exemplary embodiments of glass articles; and
[0014] FIGS. **5**B-**13**B depict cross-sectional views of the embodiments of FIG. **5**A-**13**A taken along line A-A in each of FIGS. **5**A-**13**A.
DETAILED DESCRIPTION
[0015] Embodiments of the present disclosure relate to a bendable glass article of a vehicle interior system that has a display unit across the bendable region of the glass article. In embodiments, the glass article is configured to incorporate multiple display screens that might be found on a dashboard of a vehicle, such as an infotainment screen, an instrument panel, and a vehicle perimeter camera. One end of the glass article is configured to rotate about a bend axis, e.g., towards the driver of the vehicle to improve visibility of a screen contained thereon. A bendable display screen is provided across the bend axis such that the bendable display screen can be either curved or flat. In order to provide bendability, the bendable display screen is a thin, flexible display, such as an organic light emitting diode (OLED) display. However, incorporating an OLED display into the glass article raises issues with respect to providing adequate sealing for the OLED display and while also avoiding damaging the OLED display as a result of mechanical stresses transferred to the display from the mounting mechanism.
[0016] The organic layers in OLED displays are extremely thin, and most OLED displays are based on chemically active materials, which can be easily damaged by exposure to moisture or oxygen in the air. Moreover, thin metal layers used as electrodes are also very sensitive to corrosion. Accordingly, the glass article should provide a hermetic seal for the OLED display, while also providing mechanical reliability for the OLED display.
[0017] These and other aspects and advantages will be described in relation to the embodiments discussed below and shown in the figures. These embodiments are presented by way of illustration and not by way of limitation.
[0018] FIG. **1** depicts a vehicle interior **10**, including a dashboard base **12**. In embodiments, the

dashboard base **12** includes a center console region **14** and an instrument panel region **16**. In general, the dashboard base **12** is disposed across a center line axis **18** of the vehicle. The center line axis **18** divides the vehicle longitudinally between a driver side **20** and a passenger side **22**. The instrument panel region **16** is on the driver side **20** of the centerline axis **18**, and the center console region **14** may extend across the center line **18** such that the center console region **14** is on both the driver side **20** and the passenger side **22**. In embodiments, the center console region **14** includes a first display screen **24**, and the instrument panel region **16** includes a second display screen **26**. In embodiments, the dashboard base **12** may include one or more additional display regions **28**, each including an additional display screen **30**. In embodiments, the first display screen **24**, the second display screen **26**, and the additional display screen **30** may be any one of a plasma display, a light-emitting diode (LED) display, an organic LED (OLED) display, a micro-LED display, or a liquid crystal display (LCD).

[0019] In embodiments, the first display screen **24** of the center console region **14** is an infotainment center providing information and a control panel to a driver and/or passenger of the vehicle. For example, the first display screen **24** may display vehicle information, GPS directions, climate controls, audio controls, etc. In embodiments, the second display screen **26** of the instrument panel region **16** may display a speedometer, a fuel gage, a tachometer, a coolant temperature, etc. In embodiments including an additional display screen **30**, the additional display screen **30** may display, e.g., views of a front of the vehicle, a rear of the vehicle, or one or more blindspots of the vehicle as captured by a remote camera. In embodiments, the first display screen **24**, the second display screen **26**, and or additional display screen **30** may be configured as a touch screen.

[0020] The first display screen **24**, the second display screen **26**, and the additional display screen **30** (when included) are all incorporated in the same curved glass article **32**. As will be discussed below, the second display screen **26** (and additional screen **30**) is fixed to the instrument panel region **14** of the dashboard **12**, and the first display screen **24** in the center console region **14** is bendable relative to the second display screen **26**. In embodiments, the first display screen **24** bends from a first position in which the first display screen **24** is oriented substantially equally between the driver side **20** and the passenger side **22** to a second position in which the first display screen **24** is oriented towards the driver side **20**. In order to allow for bending, the glass article **32** has a free end on the first display screen **24** side.

[0021] As will be discussed more fully below, the glass article **32** includes a bendable display unit **33** in the region between the first display screen **24** and second display screen **26** where the glass article **32** bends. A display unit in the bend region of the glass article allows information to be placed at a common focal plane for a viewer (in particular, the driver) to minimize eye strain and improve reaction time. Additionally, information displayed in the bend region increases the available screen area, which may enable displaying of more information, larger font sizes, additional graphics, etc. Still further, graphics on the display may be designed to harmonize with the interior styling of the vehicle. Moreover, in embodiments, while the first display screen **24**, second display screen **26**, and bendable display unit **33** are described as being separate display modules, the first display screen **24**, second display screen **26**, and bendable display unit **33** may be a single continuous display. In any of the foregoing embodiments, the bendable display unit **33** may also be configured as a touch screen. In such embodiments, the bendable display unit **33** may provide a control mechanism to adjust the bending of the glass article **32**.

[0022] FIG. **2** depicts the glass article **32**, including the first display screen **24**, second display screen **26**, the additional display screen **30**, and the bendable display unit **33**. The first display screen **30** is provided on a first side **34** of the glass article **32**, and the second display screen **26** and the additional display screen **30** are provided on a second side **36** of the glass article **32**. The bendable display unit **33** is disposed at least partially on each of the first side **34** and the second side **36**. As depicted in the embodiment of FIG. **2**, the glass article **32** may include one or more

curvatures **38***a-d*. As shown, the combination of curvatures **38***a-d* place the second display screen **26** behind the first display screen **24** and the additional display screen **30**. In this context, "behind" means that the second display screen **26** is in a plane positioned farther from the driver than the planes in which the first display screen **24** and the additional display screen **30** are located. In embodiments, the first display screen **24** and the additional display screen **30** may be located in the same plane, and in other embodiments, the first display screen **24** and the additional display screen **30** may be located in different planed. Further, in embodiments, each plane in which the display screens **24**, **26**, **30** are located may be parallel to none of the other planes, one of the other planes, or both of the other planes. To achieve the positioning shown in FIG. **2**, the glass article **32** includes a first convex curvature **38***a* and a second concave curvature **38***b* between the additional display screen **30** and the second display screen **26**. Further, the glass article includes a third concave curvature **38***c* and a fourth convex curvature **38***d* between the second display screen **26** and the first display screen **24**.

[0023] As mentioned, the second side **36** of the glass article **32** is fixed to the dashboard base **12**, and the first side **34** of the glass article **32** is bendable about a bending axis **40** relative to the second side **36** of the glass article **32**. In embodiments, the fourth convex curvature **38***d* is formed on the bending axis **40**. In this way, the first side **34** is bendable such that the fourth convex curvature **38***d* is variable and, in particular, can be removed from the glass article **32**. That is, the first side **34** of the glass article **32** can be bent so that the glass article **32** is substantially planar between the third concave curvature **38***c* and the first side **34** of the glass article **32**. The bendable display unit **33** is disposed over the bend axis **40** such that the bendable display unit **33** can also be curved or substantially planar.

[0024] In embodiments, at least a portion of the second side **36** of the glass article **32** forms an angle of about 180° (i.e., substantially planar) with the first side **34** in the configuration where the first display screen **24** is oriented towards the driver side **20**. In embodiments at least a portion of the second side **36** forms an angle of 190° to about 360° with the first side **34** in a configuration in which the first display screen is oriented between the driver side **20** and the passenger side **22**. By "about 360°," it is meant that the first side **34** may be able to fold in half with respect to the second side **36**. Thus, the bendable display unit **33** also can be substantially planar (e.g., forming an angle of 180°) or be folded in half.

[0025] FIG. **3** depicts a simplified, schematic side view of the glass article **32** showing the region of the fourth curvature **38***d*. As can be seen, the glass article **32** includes a glass sheet **42** having a first major surface **44** and a second major surface **46**. The second major surface **46** is opposite to the first major surface **44**, and a thickness T**1** (average thickness or maximum thickness) is defined between the first major surface **44** and the second major surface **46**. In embodiments, the thickness is, on average, from 0.3 mm to 2.0 mm, in particular from 0.4 mm to 1.1 mm. A minor surface **48** extends around the perimeter of the glass sheet **42** and connects the first major surface **44** and the second major surface **46**.

[0026] Disposed on the second major surface **46** is a hinge mechanism **50**. In embodiments, the hinge mechanism **50** divides the glass sheet **42** between the first side **34** and the second side **36** and allows for the first side **34** to bend relative to the second side **36** of the glass article **32**. In embodiments, the hinge mechanism **50** is positionable such that the first side **34** can be put at any angle between maximum travel positions of the first side **34** (i.e., between the planar configuration oriented toward the driver side and the bent configuration oriented equally between the driver side and the passenger side). Further, in embodiments, the hinge mechanism **50** is manually actuatable, i.e., a user can position the first side **34** of the glass article **32** by hand. In other embodiments, the hinge mechanism **50** is electro-mechanically actuatable such that the first side **34** is positioned by an actuator activated, e.g., by a touch feature, voice command, or push button, by the user. The hinge mechanism **50** can be any of a variety of hinges suitable to provide a bending axis **40**, such as a living hinge, a mandrel hinge, a flexure hinge, a lattice hinge, or a links hinge, among others.

[0027] In embodiments, the hinge mechanism **50** is a single hinge. In embodiments, the single hinge **50** extends from 10% up to an entire length of the bending axis **40** between the first side **34** and the second side **36**. In other embodiments, at least two hinges **50** are provided along the bending axis **40** between the first side **34** and the second side **36**. In such embodiments, the hinges **50** may be equidistantly spaced along the bending axis **40**.
[0028] An adhesive material **52** is molded or applied onto a least a portion of the second major surface **46** of the glass sheet **42**. In embodiments, the adhesive material **52** is selected to encapsulate, support, and/or protect the glass sheet **42**. In particular, the adhesive material **52** may be used to protect the glass sheet **42** from edge stresses at a free end **54** of the glass sheet **42**. Further, in embodiments, the adhesive material **52** covers not only a portion of the second major surface **46** but also at least a portion of the minor surface **48**. In still other embodiments, the adhesive material **52** may cover a portion of the first major surface **44** of the glass sheet **42**. In embodiments, the adhesive material **52** also bonds the hinge **50** to the second major surface **46** of the glass sheet **42**. In other embodiments, the hinge mechanism **50** is not bonded to the second major surface **46** of the glass sheet **42** but may be held in place by the adhesive material **52**.
[0029] In embodiments, the adhesive material **52** comprises, e.g., polyurethane, polyvinylchloride, and reaction injection molding materials, among others. As used herein, "reaction injection molding materials" include thermosetting polymers that cure within a mold during an injection molding procedure. In embodiments, reaction injection molding materials include polyurethane, polyureas, polyisocyanurates, polyesters, polyphenols, polyepoxides, and nylon 6. In embodiments, the adhesive material **52** may include reinforcing agents, such as glass fiber or mica.
[0030] As can be seen in FIG. **3**, the hinge mechanism **50** may be connected to or may incorporate a first frame **56***a* and a second frame **56***b* (referred to generally as frame or frames **56**). As will be discussed below, the frames **56** may be used to position the free end **54** of the glass article **32** and to attach the glass article **32** to a vehicle interior base. In embodiments, the frames **56** are made of an aluminum alloy, a steel alloy, or an acrylic material. FIG. **3** also depicts the bendable display unit **33** (e.g., OLED display unit, micro-LED display, or flexible LCD) embedded in the adhesive material **52** such that the adhesive material **52** hermetically seals the bendable display unit **33**.
[0031] FIG. **4** depicts an exploded, perspective view of a glass article **32** according to the present disclosure. As can be seen in FIG. **4**, the first frame **56***a* and second frame **56***b* each include a respective first aperture **58***a* and second aperture **58***b* (generally, aperture or apertures **58**) that accommodate a respective first display unit **60***a* and a second display unit **60***b* (generally, display unit or display units **60**), e.g., the first display screen **24** and the second display screen **26** (as shown in FIGS. **1** and **2**). Further, the first display unit **60***a* and the second display unit **60***b* may each be mechanically reinforced by a respective first support member **62***a* and second support member **62***b* (generally, support member or support members **62**). In embodiments, the hinge mechanism **50** is not connected to the frames **56** and is instead connected to the support members **62**. In such embodiments (including embodiments depicted below), the glass article **32** may not include the frames **56**. Further, in embodiments (e.g., as shown in FIG. **3**), the hinge mechanism **50** may be embedded in the adhesive material **52** and not directly connected to either a frame **56** or a support member **62**.
[0032] Returning to the embodiment depicted in FIG. **4**, the adhesive material **52** bonds the frames **56** and hinge mechanism **50** to the glass sheet **42**. An optically clear adhesive may be used to bond the display units **60** to the glass sheet **42** within respective apertures **58** of the frames **56**. Another layer of adhesive (not shown) may join the support members **62** to the rear surface of the display units **60**, and/or the support members **62** may mechanically interlock with the frames **56**.
[0033] Having described generally the components of the glass article **32**, FIGS. **5-13** depict various embodiments in which such components are assembled in a glass article **32**.
[0034] Referring first to FIG. **5**A, a cross-section across the width of the fourth curvature **38***d* of a glass article **32** is depicted. In particular, with reference to the orientation shown in FIG. **5**A (as

well as FIGS. **6**A-**13**A), the bend axis would be perpendicular to the page relative to what is depicted (or parallel to the plane depicted in each of FIG. **5**B-**13**B). As can be seen in FIG. **5**A, this embodiment of the glass article **32** includes the hinge mechanism **50** having adhesive material **52** applied thereon. The adhesive material **52** surrounds the bendable display unit **33** and bonds the second major surface **46** of the glass sheet **42** to the hinge mechanism **50**. In embodiments, the bendable display unit **33** includes a front display surface, a peripheral display surface, and a rear display surface. The front display surface of the bendable display unit **33** is bonded to the second major surface **46** of the glass sheet **42** using an optically clear adhesive **64**. The adhesive material **52** is bonded to the peripheral display surface and the rear display surface of the bendable display unit **33**.

[0035] FIG. **5**B depicts another cross-section of the fourth curvature **38***d* of the glass article **32** taken along line A-A of FIG. **5**A. As can be seen in FIG. **5**B, the adhesive material **52** entirely surrounds the bendable display unit **33** and adheres not only the glass sheet **42** to the hinge mechanism **50** but also the bendable display unit **33** to the hinge mechanism **50**. In embodiments, the adhesive material **52** defines a second thickness of, e.g., 5 μm to 10 mm between the glass sheet **42** and hinge mechanism **50**, and the adhesive material **52** defines a third thickness of, e.g., 5 μm to 10 mm between the rear display surface of the bendable display unit **33** and hinge mechanism **50**. Further, by bonding to the peripheral display surface and rear display surface, the adhesive material **52** provides hermetic sealing of the bendable display unit **33** between the glass sheet **42** and the adhesive material **52**.

[0036] FIG. **6**A depicts a cross-section of the fourth curvature **38***d* of another embodiment of a glass article **32**. The glass article **32** is similar to what is depicted in FIG. **5**A with the exception that the adhesive material **52** is not bonded to the peripheral surface or rear surface of the bendable display unit **33**. The adhesive material **52** still bonds the second major surface **46** of the glass sheet to the hinge mechanism **50** and the adhesive material **52** is disposed between the hinge mechanism **50** and the bendable display unit **33**. In FIG. **6**A, a gap **66** is shown between the adhesive material **52** and the bendable display unit **33**. In embodiments, the gap **66** separates the bendable display unit **33** from the adhesive material **52** by a distance d of, e.g., 1 μm to 10 mm.

[0037] Further, in embodiments, the second major surface **46** of the glass sheet **42** includes an anti-splinter film (ASF) **68**, e.g., a polyester film material. The ASF **68** provides protection against impact and pressure on the glass sheet **42**. As shown in FIG. **6**A, the ASF **68** surrounds the bendable display unit **33**, and in embodiments, the ASF **68** may also be disposed between the bendable display unit **33** and the glass sheet **42**. In embodiments, the ASF **68** provides a border around the display unit **33** that prevents contact and minimizes transfer of mechanical stresses between the bendable display unit **33** and the surrounding hinge mechanism **50** and/or frame **56** (e.g., that might otherwise result from differential thermal expansion of the materials of the glass sheet **42**, the hinge mechanism **50**, and/or frame **56**). In embodiments, the border thickness of the ASF **68** is from 1 μm to 10 mm.

[0038] FIG. **6**B depicts another cross-section of the fourth curvature **38***d* of the glass article **32** taken along line A-A of FIG. **6**A. As can be seen in FIG. **6**B, the adhesive material **52** entirely surrounds the bendable display unit **33**. Further, as can be seen in FIG. **6**B, the gap **66** also extends across the entire bendable display unit **33**. Still further, in embodiments, the ASF **68** extends around the entirety of the bendable display unit **33**. In the embodiments according to FIGS. **6**A and **6**B, the adhesive material **52** still provides hermetic sealing of the bendable display unit **33**, but because the bendable display unit **33** is not bonded to the hinge mechanism **50**, transfer of mechanical forces from the hinge mechanism **50** to the bendable display unit **33** is diminished. In this way, the hinge mechanism **50** does not interfere with the bendable display unit **33** and vibrations from the hinge mechanism **50** are diminished. Additionally, thermally induced shear stresses between the bendable display unit **33** and the hinge mechanism **50** are de-coupled, which can help prevent delamination of the bendable display unit **33** from the glass sheet **42**. Further, user touch force response can be

tuned for the bendable display unit **33** when the gap **66** is provided. Notwithstanding the lack of bond between the bendable display unit **33** and the hinge mechanism **50**, headform impact testing (HIT) performance, discussed in more detail below, is not detrimentally affected.

[0039] FIG. **7**A depicts a cross-section of the fourth curvature **38***d* of another embodiment of a glass article **32**. The embodiment of FIG. **7**A is substantially similar to the embodiment of FIG. **6**A with the exception that, in FIG. **7**A, a spacer **70** is provided in the gap **66** between the adhesive material **52** and the bendable display unit **33**. The spacer **70** is compliant by virtue of its construction and/or material from which it is made. In embodiments, the spacer **70** comprises a honeycomb structure material, a rubber gasket, or an air bladder, among others. In embodiments, the spacer **70** is not bonded to either the display unit **60** or the adhesive material **52** but is in contact with both. In other embodiments, the spacer **70** is bonded to only one of the bendable display unit **33** or the adhesive material **52**. In embodiments, the spacer **70** fills the gap **66** between the bendable display unit **33** and the adhesive material **52**. Further, as shown in FIG. **7**A, the spacer **70** is co-extensive with the rear surface of the bendable display unit **33**, but in other embodiments, the spacer **70** could have a larger area than the bendable display unit **33** or even a slightly smaller area than the bendable display unit **33**. In embodiments in which the spacer **70** is coextensive with or smaller than the area of the bendable display unit **33**, the space around the bendable display unit **33** provides a non-contact region, reducing stress and creating a thermal barrier. Further, the space may provide room for housing other components (e.g., wires or other electronics associated with the display or touch functionality, including buttons). As with the previous embodiment, an ASF **68** may be provided on the second major surface **46** of the glass sheet **42** to help prevent damage from impact or pressure on the glass sheet **42**.

[0040] FIG. **7**B depicts another cross-section of the fourth curvature **38***d* of the glass article **32** taken along line A-A of FIG. **7**A. Like the previous embodiment, the adhesive material **52** still provides hermetic sealing of the display unit **60**, but because the bendable display unit **33** is not bonded to the hinge mechanism **50**, transfer of mechanical forces from the hinge mechanism **50** to the bendable display unit **33** is diminished. In this way, the hinge mechanism **50** does not interfere with the bendable display unit **33** and vibrations from the hinge mechanism **50** are diminished. Additionally, thermally induced shear stresses between the bendable display unit **33** and the hinge mechanism **50** are de-coupled, which can help prevent delamination of the bendable display unit **33** from the glass sheet **42**. Further, user touch force response can be tuned for the bendable display unit **33**. Moreover, the use of the spacer **70** between the bendable display unit **33** and the hinge mechanism **50** enhances headform impact testing performance. Still further, using a spacer having, e.g., a honeycomb aluminum structure can provide a heatsink for the bendable display unit **33** to improve conduction of heat away from the bendable display unit **33**.

[0041] FIG. **8**A depicts a cross-section of the fourth curvature **38***d* of another embodiment of a glass article **32**. The embodiment of FIG. **8**A is substantially similar to the embodiment of FIG. **5**A with the exception that, in FIG. **8**A, the glass article **32** includes a frame **56** along with the hinge mechanism **50** (e.g., as shown in FIGS. **3** and **4**). The bendable display unit **33** is positioned between the hinge mechanism **50** and the glass sheet **42**. The adhesive material **52** bonds the glass sheet **42** to the frame **56** outside of the region of the bendable display unit **33**, and in the region of the bendable display unit **33**, the adhesive material **52** does not bond the bendable display unit **33** to the hinge mechanism **50** at least in the region below the bendable display unit **33**. Thus, as shown in FIG. **8**A, a gap is shown between the hinge mechanism **50** and the adhesive material **52** (although, in practice, the adhesive material **52** may actually be in contact with but not bonded to the hinge mechanism **50**). In particular, in FIG. **8**A, the adhesive material **52** is not bonded to the hinge mechanism **50** at all across the width of the fourth curvature **38***d*. However, in FIG. **8**B, the adhesive material **52** is bonded to the hinge mechanism along the length in the regions outside the bendable display unit **33**; although, in other embodiments, the hinge mechanism **50** may not be bonded to the adhesive material **52** at all along both the length and width of the fourth curvature

38*d*.
[0042] As with previously described embodiments, the de-coupling of the adhesive material **52** and hinge mechanism **50** reduces the transfer of thermal and mechanical stresses from the hinge mechanism **50** to the bendable display unit **33**. Nevertheless, the adhesive material **52** is bonded to the peripheral and rear surfaces of the bendable display unit **33** so as to still provide hermetic sealing for reliable operation of the bendable display unit **33**.
[0043] FIGS. **9**A and **9**B depict an embodiment substantially similar to the previous embodiment shown in FIGS. **8**A and **8**B. The primary difference between the previous embodiment and the embodiment of FIGS. **9**A and **9**B is that the bendable display unit **33** extends past the frame **56** on one side of hinge mechanism **50**. However, in other embodiments, the bendable display unit **33** extends past both frames **56** on either side of the hinge mechanism **50**. For example, as discussed above, the bendable display unit **33**, first display screen **24**, and second display screen **26** may be one continuous display unit extending across the bend axis from the first side **34** to the second side **36**.
[0044] FIG. **10**A depicts a cross-section of the fourth curvature **38***d* of another embodiment of a glass article **32**. In the embodiment of FIG. **10**A, the bendable display unit **33** is not bonded to the adhesive material **52**; however, the adhesive material is bonded to both the hinge mechanism **50** and the frames **56**. While a gap is depicted between the bendable display unit **33** and the adhesive material **52**, in other embodiments, the bendable display unit **33** may be in contact (but not bonded) with the adhesive material **52**. By not bonding the bendable display unit **33**, the bendable display unit **33** is closer to a neutral stress plane when bending the glass article **32**, minimizing shear stresses on the bendable display unit **33**. Further, a spacer **70** is provided around the bendable display unit **33**. In particular, the spacer **70** may provide a border around the bendable display unit **33** to prevent contact between the bendable display unit **33** and the hinge mechanism **50** and/or frame **56**. Further, because the spacer **70** is not bonded to the bendable display unit **33**, shear stresses cannot be transferred from the spacer **70** to the bendable display unit **33**. The spacer **70** can the same as the spacer **70** described above in relation to FIGS. **7**A and **7**B. Further, like the previous embodiment, the bendable display unit **33** extends past the frame **56** on at least one side of the hinge mechanism **50**.
[0045] FIG. **10**B depicts another cross-section of the glass article **32** taken along line A-A of FIG. **10**A. As can be seen in FIG. **10**B, the adhesive material **52** surrounds the bendable display unit **33**. Thus, as with the previous embodiments, the adhesive material **52** provides hermetic sealing of the bendable display unit **33**. Further, because the adhesive material **52** does not couple the bendable display unit **33** to the hinge mechanism **50**, mechanical and thermal stresses are not transferred from the hinge mechanism **50** to the bendable display unit **33**.
[0046] FIGS. **11**A and **11**B depict a cross-section of the fourth curvature **38***d* of another embodiment of a glass article **32**. In the embodiment of FIGS. **11**A and **11**B, the hinge mechanism **50** includes a protrusion **72** that extends into contact with the bendable display unit **33**. As can be seen in FIGS. **11**A and **11**B, the bendable display unit **33** is not bonded to the protrusion **72**. Instead, the bendable display unit **33** is bonded to the second major surface **46** of the glass sheet **42**, and the second major surface **46** of the glass sheet **42** is bonded to the hinge mechanism **50** and to the frames **56** via the adhesive material **52**. In the embodiment of FIGS. **11**A and **11**B, the protrusion **72** provides heat conduction away from the bendable display unit **33**. However, because the bendable display unit **33** is not bonded to the protrusion **72**, at least some of the mechanical and thermal stresses from the hinge mechanism **50** are not transferred to the bendable display unit **33**. Further, in this embodiment, the hermetic seal is created between the glass sheet **42**, adhesive material **52**, and the hinge mechanism **50**.
[0047] FIGS. **12**A and **12**B depict a cross-section of the fourth curvature **38***d* of another embodiment of a glass article **32**. In the embodiment of FIGS. **12**A and **12**B, the hinge mechanism **50** includes a recess **74** into which the bendable display unit **33** extends. As can be seen in FIGS.

12A and **12**B, the bendable display unit **33** is not bonded to the recess **74**. Instead, the bendable display unit **33** is bonded to the second major surface **46** of the glass sheet **42**, and the second major surface **46** of the glass sheet **42** is bonded to the hinge mechanism **50** and to the frames **56** via the adhesive material **52** (having a thickness, e.g., of 1 μm to 10 mm). In such embodiments, a gap may be provided between the rear surface of the bendable display unit **33** and the floor of the recess **74** and/or between the peripheral surface of the bendable display unit **33** and the sidewalls of the recess **74**. In the embodiment of FIGS. **12**A and **12**B, the recess **74** provides heat conduction away from the bendable display unit **33**. In such embodiments, the recess **74** may be filled with a thermal conduction paste. In other such embodiments, no gap is provided between the peripheral and/or rear surfaces of the bendable display unit **33** and the sidewalls and/or floor of the recess **74** such that the bendable display unit **33** is in contact with the floor and/or sidewall of the recess **74**. However, because the bendable display unit **33** is not bonded to the recess **74**, at least some of the mechanical and thermal stresses from the hinge mechanism **50** are not transferred to the bendable display unit **33**.

[0048] FIG. **13**A depicts a cross-section of the fourth curvature **38***d* of another embodiment of a glass article **32**. Similar to the embodiment of FIGS. **6**A and **6**B, the glass article **32** of FIG. **13**A includes a gap **66** between the bendable display unit **33** and the adhesive material **52**. Like with that embodiment, the bendable display unit **33** is bonded to the second major surface **46** of the glass sheet **42** via an optically clear adhesive **64**. The bendable display unit **33** may also be surrounded with an ASF **68**. The adhesive material **52** bonds to the second major surface **46** of the glass sheet **42** outside of the region where the bendable display unit **33** is located. Further, the adhesive material **52** bonds to a backing plate **76**, and the hinge mechanism **50** is connected to the backing plate **76**. In embodiments, the backing plate **76** may be a thin and bendable sheet of material (e.g., a metal, such as aluminum or a steel alloy, in particular stainless steel). In other embodiments, the backing plate **76** may be segmented for bending. In embodiments, the backing plate **76** has a thickness of 2 mm or less (e.g., 10 um to 1 mm). In embodiments, the backing plate **76** is configured to survive cyclic bending up to 500,000 cycles.

[0049] As can be seen in the cross-section of FIG. **13**B (taken along line A-A of FIG. **13**A), the hinge mechanism **50** is less substantial than in previous embodiments, extending only across a top and bottom of the glass article **32** and providing reduced weight and potentially a less expensive construction. In embodiments, the backing plate **76** includes sealed ports to allow accessibility of the bendable display unit **33** for, e.g., connection to the bendable display unit **33** and/or cable management.

[0050] Having described various embodiments of the glass article **32**, a method of forming the glass article **32** is now described. In embodiments, the adhesive material **52** is molded onto the glass sheet **42** by an injection molding process. For example, the glass article **32** is formed by arranging the glass sheet **42** in a mold (e.g., a clam shell mold) and positioning the hinge mechanism **50**, including any frames **56**, support members **62**, and/or backing plates **76** within the mold. Additionally, the mold may be shaped to create a void where the bendable display unit **33** is to be positioned, or a removable molding block may be arranged to create a void where the bendable display unit **33** is to be positioned. Thereafter, the adhesive material **52** is injected into the mold so as to cover the second major surface **46** and minor surface **48** as desired. Additionally, the adhesive material **52** bonds to the glass sheet **42**, hinge mechanism **50**, backing plate **76**, frames **56**, and/or support members **62** without the need for additional adhesives. Thus, the adhesive material **52** also joins the glass sheet **42**, the hinge mechanism **50**, backing plate **76**, frames **56**, and/or the support members **62** into an integral glass article **32**. In embodiments, a primer may be applied to one or more of the foregoing components in order to facilitate bonding with the encapsulating material **52**.

[0051] The curvatures **38***a-c* of the glass article **32**, particularly on the second side **36**, can be produced by either hot-forming or cold-forming. By “cold-forming,” it is meant that the curvatures

38 are introduced to the glass sheet **42** at a temperature below the softening temperature of the glass. More particularly, cold-forming takes place at below 200° C., below 100° C., or even at room temperature. "Hot-forming" by contrast, takes place at temperatures at or above the softening temperature of the glass sheet **42**, using presses, sagging apparatuses, forming lehrs, etc. A further distinguishing feature between hot-forming and cold-forming is that the curvatures **38** introduced by hot-forming are permanent in that the glass sheet **42** will retain the curvatures until re-formed at a temperature at or above the softening temperature.

[0052] Curvatures introduced by cold-forming are not permanent. In particular, during cold forming, pressure is applied to the glass sheet **42** to bring the glass sheet **42** into conformity with a desired shape. Pressure may be applied in a variety of different ways, such as vacuum pressure, a mechanical press, rollers, etc. The glass sheet **42** is then bonded to a support structure (e.g., frames **56**) to retain the glass sheet **42** in its cold-formed shape. However, if debonded from the support structure, the glass sheet **42** will spring back to its planar configuration. This property is exploited for the fourth curvature **38***d* shown in FIG. **2**, and by using the hinge mechanism **50**, the glass sheet **42** is allowed to bend between the planar configuration (oriented towards the driver side **20**) and the bent configuration (oriented between the driver side **20** and the passenger side **22**). However, the other curvatures **38***a-c*, being on the fixed, second side **36**, would be retained in their cold-formed position.

[0053] In embodiments, the glass sheet **42** is hot-formed to introduce desired curvatures **38***a-c* prior to injection molding or application of the adhesive material **52**. In other embodiments, the glass sheet **42** is cold-formed prior to injection molding or application of the adhesive material **52** to introduce desired curvatures **38**. In still other embodiments, the glass sheet **42** is cold-formed during injection molding or application of the adhesive material **52** to introduce desired curvatures **38**.

[0054] Advantageously, the glass articles **32** described herein are configured to pass head impact testing (HIT) requirements. During HIT, interior surfaces of a vehicle are investigated to determine whether vehicle interior systems meet relevant head injury criterion (HIC) based on simulated head impact with the vehicle interior system during a crash. In particular, a headform simulating a human head is used to determine the deceleration characteristics of an impact with the tested vehicle interior system. Successful test performance is achieved by reducing both the magnitude of deceleration and the time over which it occurs. As defined in US DOT FMVSS 201, the headform should not exceed 80 g for more than 3 ms when the headform impacts at a speed of 15 mph. Additionally, it is desired that the glass sheet **42** remain intact after HIT so that sharp glass fragments are not produced, which may also contribute to injury.

[0055] HIT performance of the disclosed glass article **32** can be manipulated through the constructions described above. Specifically, the hinge mechanism **50**, frame **56**, support members **62**, bonded or un-bonded regions of adhesive material **52**, gap **66**, spacer **70**, and/or backing plate **76** can be tailored to provide a degree of stiffness and flexural rigidity that is not so high as to create too large of a magnitude of deceleration and not so low as to create a large deflection of the glass sheet, contributing to fracture of the glass sheet **42**. These considerations are relevant to any glass surface in a vehicle interior, and the presently disclosed glass article **32** presents the additional issue of accounting for the dynamic motion of the glass article **32** based on the ability of the first side **34** to bend relative to the second side **36**. Notwithstanding, the glass article **32** can be configured to provide the stiffness and flexural rigidity necessary to pass HIT through the constructions disclosed herein.

[0056] In the following paragraphs and with reference to FIGS. **1-3**, various geometrical properties of the glass sheet **42** as well as compositions of the glass sheet are provided. As mentioned above, the glass sheet **42** has a thickness T**1** that is substantially constant and is defined as a distance between the first major surface **44** and the second major surface **46**. In various embodiments, T**1** is from 0.3 mm to 2.0 mm. In addition, the glass sheet **42** includes a width W defined as a first

maximum dimension of one of the first or second major surfaces **44**, **46** orthogonal to the thickness T**1**, and a length L defined as a second maximum dimension of one of the first or second major surfaces **44**, **46** orthogonal to both the thickness T**1** and the width. In other embodiments, width W and length L may be the average width and the average length of the glass sheet **42**, respectively, and in other embodiments, width W and length L may be the maximum width and the maximum length of the glass sheet **42**, respectively (e.g., for glass sheets **42** having a variable width or length). In various embodiments, width W is in a range from 5 cm to 250 cm, and length L is in a range from about 5 cm to about 1500 cm. Further, in various embodiments, the curvatures **38***a-d* of the glass article **32** may have each have a radius of curvature in a range from about 20 mm to about 10,000 mm.

[0057] Further, the various embodiments of the vehicle interior system may be incorporated into vehicles such as trains, automobiles (e.g., cars, trucks, buses and the like), sea craft (boats, ships, submarines, and the like), and aircraft (e.g., drones, airplanes, jets, helicopters and the like).

[0058] In embodiments, the glass sheet **42** may be strengthened. In one or more embodiments, glass sheet **42** may be strengthened to include compressive stress that extends from a surface to a depth of compression (DOC). The compressive stress regions are balanced by a central portion exhibiting a tensile stress. At the DOC, the stress crosses from a positive (compressive) stress to a negative (tensile) stress.

[0059] In various embodiments, glass sheet **42** may be strengthened mechanically by utilizing a mismatch of the coefficient of thermal expansion between portions of the article to create a compressive stress region and a central region exhibiting a tensile stress. In some embodiments, the glass sheet may be strengthened thermally by heating the glass to a temperature above the glass transition point and then rapidly quenching.

[0060] In various embodiments, glass sheet **42** may be chemically strengthened by ion exchange. In the ion exchange process, ions at or near the surface of the glass sheet are replaced by—or exchanged with—larger ions having the same valence or oxidation state. In those embodiments in which the glass sheet comprises an alkali aluminosilicate glass, ions in the surface layer of the article and the larger ions are monovalent alkali metal cations, such as Li.sup.+, Na.sup.+, K.sup.+, Rb.sup.+, and Cs.sup.+. Alternatively, monovalent cations in the surface layer may be replaced with monovalent cations other than alkali metal cations, such as Ag.sup.+ or the like. In such embodiments, the monovalent ions (or cations) exchanged into the glass sheet generate a stress

[0061] Ion exchange processes are typically carried out by immersing a glass sheet in a molten salt bath (or two or more molten salt baths) containing the larger ions to be exchanged with the smaller ions in the glass sheet. It should be noted that aqueous salt baths may also be utilized. In addition, the composition of the bath(s) may include more than one type of larger ions (e.g., Na.sup.+ and K.sup.+) or a single larger ion. It will be appreciated by those skilled in the art that parameters for the ion exchange process, including, but not limited to, bath composition and temperature, immersion time, the number of immersions of the glass sheet in a salt bath (or baths), use of multiple salt baths, additional steps such as annealing, washing, and the like, are generally determined by the composition of the glass sheet (including the structure of the article and any crystalline phases present) and the desired DOC and CS of the glass sheet that results from strengthening. Exemplary molten bath compositions may include nitrates, sulfates, and chlorides of the larger alkali metal ion. Typical nitrates include KNO.sub.3, NaNO.sub.3, LiNO.sub.3, NaSO.sub.4 and combinations thereof. The temperature of the molten salt bath typically is in a range from about 380° C. up to about 450° C., while immersion times range from about 15 minutes up to about 100 hours depending on glass sheet thickness, bath temperature and glass (or monovalent ion) diffusivity. However, temperatures and immersion times different from those described above may also be used.

[0062] In one or more embodiments, the glass sheets may be immersed in a molten salt bath of 100% NaNO.sub.3, **100**% KNO.sub.3, or a combination of NaNO.sub.3 and KNO.sub.3 having a

temperature from about 370° C. to about 480° C. In some embodiments, the glass sheet may be immersed in a molten mixed salt bath including from about 5% to about 90% KNO.sub.3 and from about 10% to about 95% NaNO.sub.3. In one or more embodiments, the glass sheet may be immersed in a second bath, after immersion in a first bath. The first and second baths may have different compositions and/or temperatures from one another. The immersion times in the first and second baths may vary. For example, immersion in the first bath may be longer than the immersion in the second bath.

[0063] In one or more embodiments, the glass sheet may be immersed in a molten, mixed salt bath including NaNO.sub.3 and KNO.sub.3 (e.g., 49%/51%, 50%/50%, 51%/49%) having a temperature less than about 420° C. (e.g., about 400° C. or about 380° C.). for less than about 5 hours, or even about 4 hours or less.

[0064] Ion exchange conditions can be tailored to provide a “spike” or to increase the slope of the stress profile at or near the surface of the resulting glass sheet. The spike may result in a greater surface CS value. This spike can be achieved by a single bath or multiple baths, with the bath(s) having a single composition or mixed composition, due to the unique properties of the glass compositions used in the glass sheets described herein.

[0065] In one or more embodiments, where more than one monovalent ion is exchanged into the glass sheet, the different monovalent ions may exchange to different depths within the glass sheet (and generate different magnitudes stresses within the glass sheet at different depths). The resulting relative depths of the stress-generating ions can be determined and cause different characteristics of the stress profile.

[0066] CS is measured using those means known in the art, such as by surface stress meter (FSM) using commercially available instruments such as the FSM-6000, manufactured by Orihara Industrial Co., Ltd. (Japan). Surface stress measurements rely upon the accurate measurement of the stress optical coefficient (SOC), which is related to the birefringence of the glass. SOC in turn is measured by those methods that are known in the art, such as fiber and four point bend methods, both of which are described in ASTM standard C770-98 (2013), entitled “Standard Test Method for Measurement of Glass Stress-Optical Coefficient,” the contents of which are incorporated herein by reference in their entirety, and a bulk cylinder method. As used herein CS may be the “maximum compressive stress” which is the highest compressive stress value measured within the compressive stress layer. In some embodiments, the maximum compressive stress is located at the surface of the glass sheet. In other embodiments, the maximum compressive stress may occur at a depth below the surface, giving the compressive profile the appearance of a “buried peak.”

[0067] DOC may be measured by FSM or by a scattered light polariscope (SCALP) (such as the SCALP-04 scattered light polariscope available from Glasstress Ltd., located in Tallinn Estonia), depending on the strengthening method and conditions. When the glass sheet is chemically strengthened by an ion exchange treatment, FSM or SCALP may be used depending on which ion is exchanged into the glass sheet. Where the stress in the glass sheet is generated by exchanging potassium ions into the glass sheet, FSM is used to measure DOC. Where the stress is generated by exchanging sodium ions into the glass sheet, SCALP is used to measure DOC. Where the stress in the glass sheet is generated by exchanging both potassium and sodium ions into the glass, the DOC is measured by SCALP, since it is believed the exchange depth of sodium indicates the DOC and the exchange depth of potassium ions indicates a change in the magnitude of the compressive stress (but not the change in stress from compressive to tensile); the exchange depth of potassium ions in such glass sheets is measured by FSM. Central tension or CT is the maximum tensile stress and is measured by SCALP.

[0068] In one or more embodiments, the glass sheet may be strengthened to exhibit a DOC that is described as a fraction of the thickness T of the glass sheet 42 (as described herein). For example, in one or more embodiments, the DOC may be equal to or greater than about 0.05 T to about 0.25 T. In some instances, the DOC may be about 20 μm to about 300 μm. Further, in one or more

embodiments, the strengthened glass sheet may have a CS (which may be found at the surface or a depth within the glass sheet) of about 200 MPa or greater, about 500 MPa or greater, or about 1000 MPa or greater. In one or more embodiments, the strengthened glass sheet may have a maximum tensile stress or central tension (CT) of about 20 MPa or greater, about 50 MPa or greater, or about 85 MPa or greater.

[0069] Suitable glass compositions for use in glass sheet **42** include soda lime glass, aluminosilicate glass, borosilicate glass, boroaluminosilicate glass, alkali-containing aluminosilicate glass, alkali-containing borosilicate glass, and alkali-containing boroaluminosilicate glass.

[0070] In one or more embodiments, the glass composition may include SiO.sub.2 in an amount in a range from about 66 mol % to about 80 mol %, Al.sub.2O.sub.3 in an amount in a range from about 4 mol % to about 15 mol %, B.sub.2O.sub.3 in an amount in a range from about 0 mol % to about 5 mol %, P.sub.2O.sub.5 in an amount in a range from about 0 mol % to about 2 mol %, R.sub.2O in an amount in a range from about 8 mol % to about 20 mol %, RO in an amount in a range of from about 0 mol % to about 2 mol %, ZrO.sub.2 in an amount in a range of from about 0 mol % to about 0.2 mol %, and SnO.sub.2 in an amount in a range from about 0 mol % to about 0.2 mol %. In the foregoing composition, R.sub.2O refers to the total amount of alkali metal oxides, such as Li.sub.2O, Na.sub.2O, K.sub.2O, Rb.sub.2O, and Cs.sub.2O). In particular, Na.sub.2O may be present in an amount in a range from about from about 8 mol % to about 20 mol %, and K.sub.2O may be present in an amount in a range from about 0 mol % to about 4 mol %,. Further, in the foregoing composition, RO refers to the total amount of alkaline earth metal oxide such, as CaO, MgO, BaO, ZnO and SrO. In particular, CaO may be present in an amount in a range of from about 0 mol % to about 1 mol %, and MgO may be present in an amount in a range of from about 0 mol % to about 7 mol %.

[0071] In embodiments, the glass composition may include other oxides of such metals as Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Ce, W, and Mo. In particular, Fe in the form of Fe.sub.2O.sub.3 may be present in an amount in a range of from about 0 mol % to about 1 mol %, and TiO.sub.2 may be present in an amount of in a range of about 0 mol % to about 5 mol %.

[0072] An exemplary glass composition includes SiO.sub.2 in an amount in a range from about 65 mol % to about 75 mol %, Al.sub.2O.sub.3 in an amount in a range from about 8 mol % to about 14 mol %, Na.sub.2O in an amount in a range from about 12 mol % to about 17 mol %, K.sub.2O in an amount in a range of about 0 mol % to about 0.2 mol %, and MgO in an amount in a range from about 1.5 mol % to about 6 mol %. Optionally, SnO.sub.2 may be included in the amounts otherwise disclosed herein.

[0073] Aspect (1) of this disclosure pertains to a glass article, comprising: a glass sheet comprising a first major surface and a second major surface opposite to the first major surface; a hinge mechanism disposed on the second major surface of the glass sheet, the hinge mechanism dividing the glass sheet into a first side and a second side; a bendable display unit bonded to the second major surface of the glass sheet and disposed between the glass sheet and the hinge mechanism; an adhesive material disposed on the second major surface of the glass sheet around the display; wherein the first side is bendable about the hinge mechanism relative to the second side; and wherein the bendable display unit is hermetically sealed within the adhesive material.

[0074] Aspect (2) of this disclosure pertains to the glass article of Aspect (1), wherein the bendable display unit comprises a front display surface, a rear surface, and a peripheral surface connecting the front display surface and the rear surface and wherein the adhesive material is bonded to the peripheral surface and to the rear surface.

[0075] Aspect (3) of this disclosure pertains to the glass article of Aspect (2), wherein the front display surface is bonded to the second major surface of the glass sheet with an optically clear adhesive.

[0076] Aspect (4) of this disclosure pertains to the glass article of Aspect (2) or Aspect (3), further

comprising at least one frame disposed on the second major surface of the glass sheet on a side of the hinge mechanism, wherein the adhesive material bonds the frame to the second major surface of the glass sheet and wherein the adhesive material is not bonded to the hinge mechanism in a region between the hinge mechanism and the bendable display unit.

[0077] Aspect (5) of this disclosure pertains to the glass article of Aspect (4), wherein the bendable display extends over the at least one frame.

[0078] Aspect (6) of this disclosure pertains to the glass article of Aspect (1), wherein the bendable display unit comprises a front display surface, a rear surface, and a peripheral surface connecting the front display surface and the rear surface and wherein a gap is provided between the adhesive material and the peripheral surface and the rear surface.

[0079] Aspect (7) of this disclosure pertains to the glass article of Aspect (6), further comprising an anti-splinter film bonded to the second major surface of the glass sheet around the bendable display unit.

[0080] Aspect (8) of this disclosure pertains to the glass article of Aspect (6) or Aspect (7), further comprising a spacer disposed on the rear surface of the bendable display unit.

[0081] Aspect (9) of this disclosure pertains to the glass article of Aspect (6) or Aspect (7), further comprising a spacer disposed around the peripheral surface of the bendable display unit.

[0082] Aspect (10) of this disclosure pertains to the glass article of Aspect (8) or Aspect (9), wherein the spacer comprises at least one of a rubber gasket, a honeycomb structure, or an air bladder.

[0083] Aspect (11) of this disclosure pertains to the glass article of any one of Aspects (6) through (10), wherein the bendable display unit extends past at least one side of the hinge mechanism.

[0084] Aspect (12) of this disclosure pertains to the glass article of any one of Aspects (6) through (11), further comprising a backing sheet disposed between the adhesive material and the hinge mechanism.

[0085] Aspect (13) of this disclosure pertains to the glass article of Aspect (12), wherein the backing plate comprises an aluminum alloy or a steel alloy.

[0086] Aspect (14) of this disclosure pertains to the glass article of any one of Aspects (6) through (13), further comprising at least one frame on a side of the hinge mechanism, wherein the adhesive material bonds to the at least one frame and to the second major surface of the glass sheet.

[0087] Aspect (15) of this disclosure pertains to the glass article of Aspect (14), wherein

[0088] hinge mechanism comprises a protrusion, wherein the bendable display unit is in contact with the protrusion of the hinge mechanism.

[0089] Aspect (16) of this disclosure pertains to the glass article of Aspect (14), wherein the hinge mechanism comprises a recess, wherein the at least a portion of the peripheral surface of the bendable display unit is surrounded by the recess.

[0090] Aspect (17) of this disclosure pertains to the glass article of any one of Aspects (1) through (16), wherein the adhesive material comprises a polyurethane, a polyvinylchloride, or a reaction injection molding material.

[0091] Aspect (18) of this disclosure pertains to the glass article of any one of Aspects (1) through (17), wherein the hinge mechanism comprises an aluminum alloy or a steel alloy.

[0092] Aspect (19) of this disclosure pertains to the glass article of any one of Aspects (1) through (18), wherein the bendable display unit comprises at least one of an organic light emitting diode display, an organic liquid crystal display, or a micro-light emitting diode display.

[0093] Aspect (20) of this disclosure pertains to the glass article of any one of Aspects (1) through (19), wherein the first side is bendable from a planar configuration with respect to the second side to a bent configuration in which the first side bends 10° to 180° from planar.

[0094] Aspect (21) of this disclosure pertains to an interior system of a vehicle, comprising: a dashboard base positioned across a center line axis of the vehicle, the center line axis dividing the vehicle longitudinally into a driver side and a passenger side; a glass article attached to the

dashboard base, the glass article comprising: a glass sheet comprising a first major surface and a second major surface opposite to the first major surface, wherein the first glass sheet comprises a first side and a second side, the first side being located on the driver side of the center line axis; a hinge mechanism disposed on the second major surface of the glass sheet, the hinge mechanism dividing the glass sheet between the first side and the second side; and a bendable display unit bonded to the second major surface of the glass sheet and disposed between the hinge mechanism and the glass sheet; an adhesive material disposed on the second major surface of the glass sheet around the bendable display unit; wherein the display is hermetically sealed between the adhesive material and the glass sheet; wherein the bendable display unit is configured to transition between a curved configuration and a planar configuration when the second side of the glass sheet bends about the hinge mechanism.

[0095] Aspect (22) of this disclosure pertains to the interior system of Aspect (21), wherein the bendable display unit comprises a front display surface, a rear surface, and a peripheral surface connecting the front display surface and the rear surface and wherein the adhesive material is bonded to the peripheral surface and to the rear surface.

[0096] Aspect (23) of this disclosure pertains to the interior system of Aspect (22), further comprising at least one frame disposed on the second major surface of the glass sheet on a side of the hinge mechanism, wherein the adhesive material bonds the frame to the second major surface of the glass sheet and wherein the adhesive material is not bonded to the hinge mechanism in a region between the hinge mechanism and the bendable display unit.

[0097] Aspect (24) of this disclosure pertains to the interior system of Aspect (23), wherein the bendable display extends over the at least one frame.

[0098] Aspect (25) of this disclosure pertains to the interior system of Aspect (22), wherein the bendable display unit comprises a front display surface, a rear surface, and a peripheral surface connecting the front display surface and the rear surface and wherein a gap is provided between the adhesive material and the peripheral surface and the rear surface.

[0099] Aspect (26) of this disclosure pertains to the interior system of Aspect (25), further comprising a spacer disposed on the rear surface of the bendable display unit.

[0100] Aspect (27) of this disclosure pertains to the interior system of Aspect (25), further comprising a spacer disposed around the peripheral surface of the bendable display unit.

[0101] Aspect (28) of this disclosure pertains to the interior system of any one of Aspects (25) through (27), wherein the bendable display unit extends past at least one side of the hinge mechanism.

[0102] Aspect (29) of this disclosure pertains to the interior system of any one of Aspects (25) through (28), further comprising a backing sheet disposed between the adhesive material and the hinge mechanism.

[0103] Aspect (30) of this disclosure pertains to the interior system of any one of Aspects (25) through (29), further comprising at least one frame on a side of the hinge mechanism, wherein the adhesive material bonds to the at least one frame and to the second major surface of the glass sheet.

[0104] Aspect (31) of this disclosure pertains to the interior system of Aspect (30), wherein hinge mechanism comprises a protrusion, wherein the bendable display unit is in contact with the protrusion of the hinge mechanism.

[0105] Aspect (32) of this disclosure pertains to the interior system of Aspect (30), wherein the hinge mechanism comprises a recess, wherein the at least a portion of the peripheral surface of the bendable display unit is surrounded by the recess.

[0106] 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 in no way intended that any particular order be inferred. In addition, as used herein, the article

“a” is intended to include one or more than one component or element, and is not intended to be construed as meaning only one.
[0107] It will be apparent to those skilled in the art that various modifications and variations can be made without departing from the spirit or scope of the disclosed embodiments. Since modifications, combinations, sub-combinations and variations of the disclosed embodiments incorporating the spirit and substance of the embodiments may occur to persons skilled in the art, the disclosed embodiments should be construed to include everything within the scope of the appended claims and their equivalents.

Claims

1. A glass article, comprising: a glass sheet comprising a first major surface and a second major surface opposite to the first major surface; an adhesive material disposed on the second major surface of the glass sheet; a hinge mechanism configured to cooperate with the second major surface of the glass sheet; and a bendable display unit bonded to the second major surface of the glass sheet and disposed between the glass sheet and the hinge mechanism, the hinge mechanism defining a bend axis about which the glass sheet and the bendable display unit are configured to bend; wherein the adhesive material is disposed around the bendable display unit such that the bendable display unit is hermetically sealed by the adhesive material.
2. The glass article of claim 1, wherein the bendable display unit comprises a front display surface, a rear surface, and a peripheral surface connecting the front display surface and the rear surface, and wherein the adhesive material is bonded to the peripheral surface and to the rear surface.
3. The glass article of claim 2, further comprising at least one frame configured to cooperate with the second major surface of the glass sheet on a side of the hinge mechanism, wherein the adhesive material bonds the frame to the second major surface of the glass sheet, and wherein the adhesive material is not bonded to the hinge mechanism in a region between the hinge mechanism and the bendable display unit.
4. The glass article of claim 3, wherein the bendable display extends over the at least one frame.
5. The glass article of claim 1, wherein the bendable display unit comprises a front display surface, a rear surface, and a peripheral surface connecting the front display surface and the rear surface, and wherein a gap is provided between the adhesive material and the peripheral surface and the rear surface.
6. The glass article of claim 5, further comprising an anti-splinter film bonded to the second major surface of the glass sheet around the bendable display unit.
7. The glass article of claim 5, further comprising a spacer disposed on the rear surface of the bendable display unit or around the peripheral surface of the bendable display unit.
8. The glass article of claim 5, further comprising a backing sheet disposed between the adhesive material and the hinge mechanism, wherein the backing plate comprises an aluminum alloy or a steel alloy.
9. The glass article of claim 5, further comprising at least one frame on a side of the hinge mechanism, wherein the adhesive material bonds to the at least one frame and to the second major surface of the glass sheet.
10. The glass article of claim 9, wherein: the hinge mechanism comprises a protrusion that is in contact with the bendable display unit; or the hinge mechanism comprises a recess, wherein the at least a portion of the peripheral surface of the bendable display unit is surrounded by the recess.
11. The glass article of claim 1, wherein the hinge mechanism divides the glass sheet into a first side and a second side, and wherein the first side is bendable from a planar configuration with respect to the second side to a bent configuration in which the first side bends 10° to 180° from planar.
12. An interior system of a vehicle, comprising: a dashboard base positioned across a center line

axis of the vehicle; and a glass article attached to the dashboard base, the glass article comprising: a glass sheet comprising a first major surface and a second major surface opposite to the first major surface; an adhesive material disposed on the second major surface of the glass sheet; a hinge mechanism configured to cooperate with the second major surface of the glass sheet via the adhesive material; and a bendable display unit bonded to the second major surface of the glass sheet and disposed between the hinge mechanism and the glass sheet, the hinge mechanism defining a bend axis about which the glass sheet and the bendable display unit are configured to bend; wherein the bendable display unit is hermetically sealed between the adhesive material and the glass sheet.

13. The interior system of claim 12, wherein the bendable display unit comprises a front display surface, a rear surface, and a peripheral surface connecting the front display surface and the rear surface, and wherein the adhesive material is bonded to the peripheral surface and to the rear surface.

14. The interior system of claim 13, further comprising at least one frame disposed on the second major surface of the glass sheet on a side of the hinge mechanism, wherein the adhesive material bonds the frame to the second major surface of the glass sheet, and wherein the adhesive material is not bonded to the hinge mechanism in a region between the hinge mechanism and the bendable display unit.

15. The interior system of claim 14, wherein the bendable display extends over the at least one frame.

16. The interior system of claim 13, wherein the bendable display unit comprises a front display surface, a rear surface, and a peripheral surface connecting the front display surface and the rear surface, and wherein a gap is provided between the adhesive material and the peripheral surface and the rear surface.

17. The interior system of claim 16, further comprising a spacer disposed on the rear surface of the bendable display unit or around the peripheral surface of the bendable display unit.

18. The interior system of claim 16, further comprising at least one frame on a side of the hinge mechanism, wherein the adhesive material bonds to the at least one frame and to the second major surface of the glass sheet.

19. The interior system of claim 18, wherein: hinge mechanism comprises a protrusion that is in contact with the bendable display unit; or the hinge mechanism comprises a recess, wherein the at least a portion of the peripheral surface of the bendable display unit is surrounded by the recess.

20. The interior system of claim 12, wherein: the center line axis divides the vehicle longitudinally into a driver side and a passenger side, the hinge mechanism divides the glass sheet between a first side and a second side, the first side of the glass sheet is located on the driver side of the center line axis, and the bendable display unit is configured to transition between a curved configuration and a planar configuration when the second side of the glass sheet bends about the hinge mechanism.