INSULATED GLAZING UNIT WITH EQUALIZED PRESSURE

ABSTRACT

[0001] The present disclosure relates to an electroactive device, such as an insulated glazing unit, and methods of manufacturing the device. Specifically, the insulated glazing unit can include multiple panes with equalized pressure.

BACKGROUND

[0002] An electrochemical device can include an electrochromic stack where transparent conductive layers are used to provide electrical connections for the operation of the stack. Electrochromic (EC) devices employ materials capable of reversibly altering their optical properties following electrochemical oxidation and reduction in response to an applied potential. The optical modulation is the result of the simultaneous insertion and extraction of electrons and charge compensating ions in the electrochemical material lattice. EC devices have a composite structure through which the transmittance of light can be modulated.

[0003] Electroactive devices are often included in multi-pane insulated glazing units. However, since the various panes of glass can absorb different amounts of light, the variations in absorption cause variations in pressure within the entire system and it increases the stress on the glass panes. As such, improvements are needed to address electrochromic devices within systems containing multiple panes of glass.

DESCRIPTION

[0004] An insulated glazing unit, according to one embodiment can include an electroactive device, a support lite, a first pane, and a second pane. The electroactive device can be laminated to the support lite. For purposes of illustrative clarity, the electroactive device is a variable transmission device. In one embodiment, the electroactive device can be an electrochromic device. In another embodiment, the electroactive device can be a thin-film battery. However, it will be recognized that the present disclosure is similarly applicable to other types of described electroactive devices, electrochemical devices, as well as other electrochromic devices with different stacks or film structures (e.g., additional layers). The electroactive device may include a substrate, a first transparent conductor layer, a cathodic electrochemical layer, an anodic electrochemical layer, and a second transparent conductor layer.

[0005] In an embodiment, the substrate can include a glass substrate, a sapphire substrate, an aluminum oxynitride substrate, or a spinel substrate. In another embodiment, the substrate can include a transparent polymer, such as a polyacrylic compound, a polyalkene, a polycarbonate, a polyester, a polyether, a polyethylene, a polyimide, a polysulfone, a polysulfide, a polyurethane, a polyvinylacetate, another suitable transparent polymer, or a co-polymer of the foregoing. The substrate may or may not be flexible. In a particular embodiment, the substrate can be float glass or a borosilicate glass and have a thickness in a range of 0.5 mm to 12 mm thick. The substrate may have a thickness no greater than 16 mm, such as 12 mm, no greater than 10 mm, no greater than 8 mm, no greater than 6 mm, no greater than 5 mm, no greater than 3 mm, no greater than 2 mm, no greater than 1.5 mm, no greater than 1 mm, or no greater than 0.01 mm. In another particular embodiment, the substrate can include ultra-thin glass that is a mineral glass having a thickness in a range of 50 microns to 300 microns. In a particular embodiment, the substrate may be used for many different electrochemical devices being formed and may be referred to as a motherboard.

[0006] Transparent conductive layers can include a conductive metal oxide or a conductive polymer. Examples can include a tin oxide or a zinc oxide, either of which can be doped with a trivalent element, such as Al, Ga, In, or the like, a fluorinated tin oxide, or a sulfonated polymer, such as polyaniline, polypyrrole, poly(3,4-ethylenedioxythiophene), or the like. In another embodiment, the transparent conductive layers can include gold, silver, copper, nickel, aluminum, or any combination thereof. The transparent conductive layers can include indium oxide, indium tin oxide, doped indium oxide, tin oxide, doped tin oxide, zinc oxide, doped zinc oxide, ruthenium oxide, doped ruthenium oxide and any combination thereof. The transparent conductive layers can have the same or different compositions. The transparent conductive layers can have a thickness between 10 nm and 600 nm. In one embodiment, the transparent conductive layers can have a thickness between 200 nm and 500 nm. In one embodiment, the transparent conductive layers can have a thickness between 320 nm and 460 nm. In one embodiment the first transparent conductive layer can have a thickness between 10 nm and 600 nm. In one embodiment, the second transparent conductive layer can have a thickness between 80 nm and 600 nm.

[0007] The electroactive device can include electrode layers, wherein one of the layers may be a cathodic electrochemical layer, and the other of the layers may be an anodic electrochromic layer (also referred to as a counter electrode layer). In one embodiment, the cathodic electrochemical layer is an electrochromic layer. The cathodic electrochemical layer can include an inorganic metal oxide material, such as WO_3, V_2O_5, MoO_3, Nb_2O_5, TiO_2, CuO, Ni_2O_3, NiO, Ir_2O_3, Cr_2O_3, Co_2O_3, Mn_2O_3, mixed oxides (e.g., W-Mo oxide, W-V oxide), or any combination thereof and can have a thickness in a range of 40 nm to 600 nm. In one embodiment, the cathodic electrochemical layer can have a thickness between 100 nm to 400 nm. In one embodiment, the cathodic electrochemical layer can have a thickness between 350 nm to 390 nm. The cathodic electrochemical layer can include lithium, aluminum, zirconium, phosphorus, nitrogen, fluorine, chlorine, bromine, iodine, astatine, boron; a borate with or without lithium; a tantalum oxide with or without lithium; a lanthanide-based material with or without lithium; another lithium-based ceramic material; or any combination thereof.

[0008] The anodic electrochromic layer can include any of the materials listed with respect to the cathodic electrochromic layer or Ta_2O_5, ZrO_2, HfO_2, Sb_2O_3, or any combination thereof, and may further include nickel oxide (NiO, Ni_2O_3, or combination of the two), and Li, Na, H, or another ion and have a thickness in a range of 40 nm to 500 nm. In one embodiment, the anodic electrochromic layer can have a thickness between 150 nm to 300 nm. In one embodiment, the anodic electrochromic layer can have a thickness between 250 nm to 290 nm. In some embodiments, lithium may be inserted into at least one of the first electrode or second electrode.

[0009] In another embodiment, the device may include a plurality of layers between the substrate and the first transparent conductive layer. In one embodiment, an antireflection layer is between the substrate and the first transparent conductive layer. The antireflection layer can include SiO_2, NbO_2, and can be a thickness between 20 nm to 100 nm. The device may include at least two bus bars. The first bus bar can be electrically connected to the first transparent conductive layer and the second bus bar can be electrically connected to the second transparent conductive layer.

[0010] As seen in FIG. 1, the insulated glazing unit can be a triple glazing unit containing multiple panes of glass. In one embodiment, the insulated glazing unit contains more than two cavities, such as three cavities, four cavities, or even five cavities. More specifically, the insulated glazing unit can include a first pane, a second pane, a third pane, and an EC lite with the electrochromic device thereon, a first spacer between the first pane and the EC lite, a second spacer between the EC lite and the second pane, a pressure equalizing conduit, a first cavity, and a second cavity. In one embodiment, the EC lite can be on the first pane. In another embodiment, as seen in FIG. 2, the EC lite can be on the second pane. The EC lite can include a substrate, a first transparent conductor layer, a cathodic electrochemical layer, an anodic electrochemical layer, and a second transparent conductor layer. The first spacer, the second spacer, and the sealant can maintain a gas impermeable enclosed space between each pane and the EC lite forming the first cavity and the second cavity. The first cavity and the second cavity can include gas, such as helium, nitrogen, oxygen, or other inert gases, or other insulating gas. In an insulated glazing unit containing multiple cavities, the pressure between the cavities can vary, such that one cavity has higher pressure than the other, depending on changes in temperature and transmission of light. In a closed system, it can become difficult to equalize the pressure within the various cavities without affecting the electrochromic device.

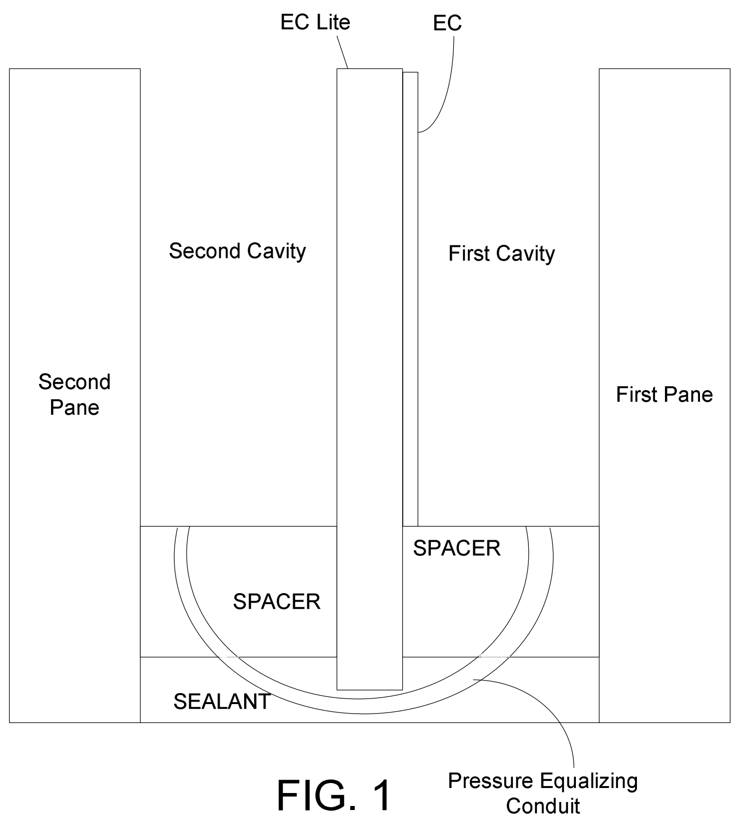
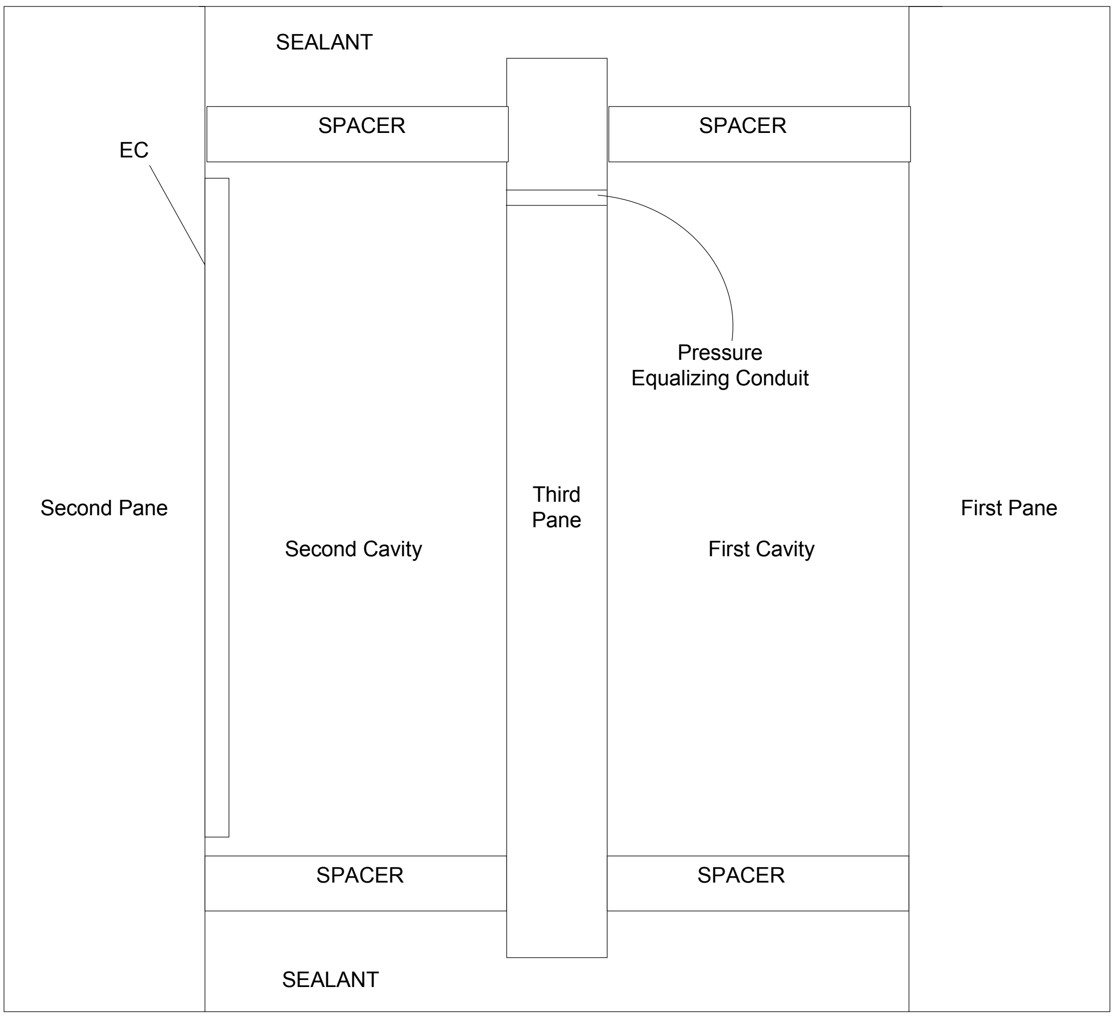


FIG. 1

[0011]

[0012] The pressure equalizing conduit can pass through the sealant and below the EC lite, as seen in FIG. 1, to connect the first cavity with the second cavity. In one embodiment, the pressure equalizing conduit can be porous. In another embodiment, the pressure equalizing conduit can be a channel within the sealant that connects to holes or openings within the first spacer and the second spacer. In another embodiment, the pressure equalizing conduit can be a hole or opening within the third pane, as seen in FIG. 2. In one embodiment, the third pane can be an EC lite, meaning the third pane can contain the EC device and still contain the pressure equalizing conduit as well. In one embodiment, the pressure equalizing conduit is on the periphery of the EC device.



[0013] In another embodiment, the pressure equalizing conduit can be a hollow cast or formed shape to connect openings within the spacers. In yet another embodiment, the IGU can contain more than one pressure equalizing conduit, such as more than two pressure equalizing conduits, or such as more than three pressure equalizing conduits. In one embodiment, the multiple pressure equalizing conduits can include a combination of holes, pass throughs, or conduits, as seen in FIGs. 3A-3D. In one embodiment, the EC device can be on the third pane, as seen in FIGs. 3A and 3B. In another embodiment, the EC device can be on the second pane, as seen in

FIG. 3C. In yet another embodiment, the EC device can be on the first pane, as seen in FIG. 3D. Although FIGs. 3A-3D show two conduits and two holes, it can be imagined that there can be an embodiment with one hole and two conduits, one conduits and one hole, one conduit and more than one hole or any combination therein.

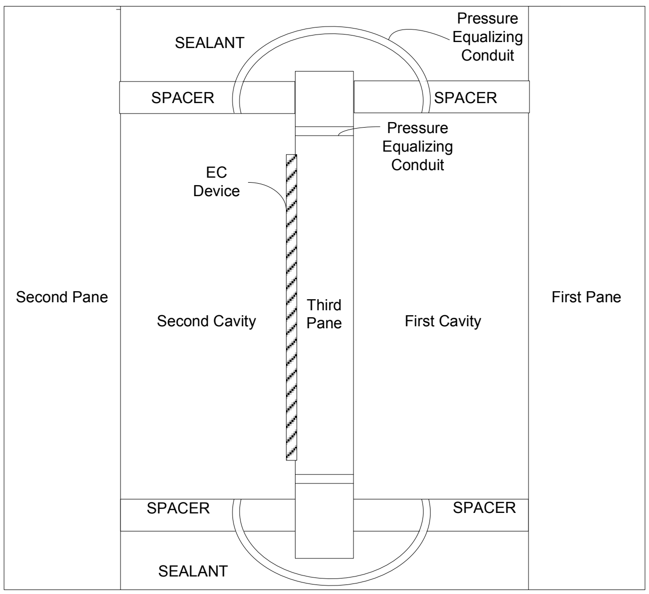


FIG. 3A

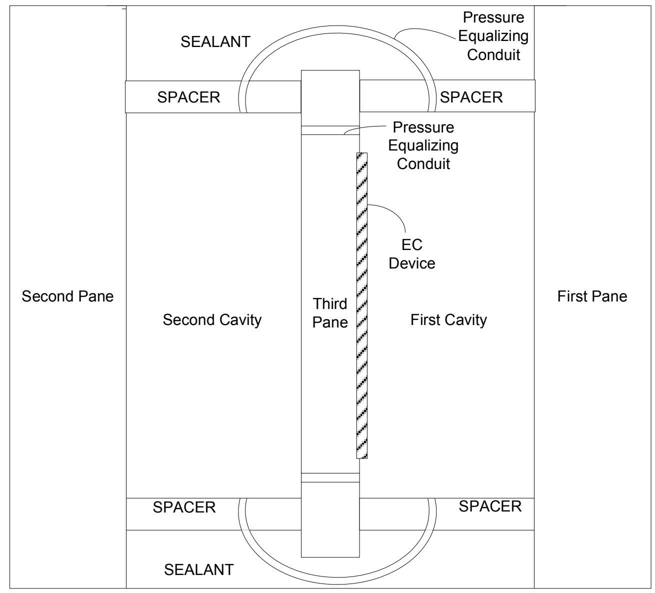


FIG. 3B

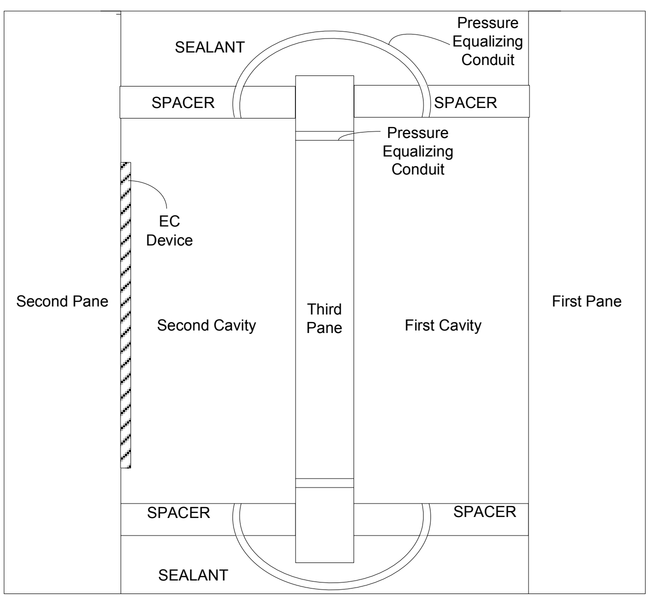


FIG. 3C

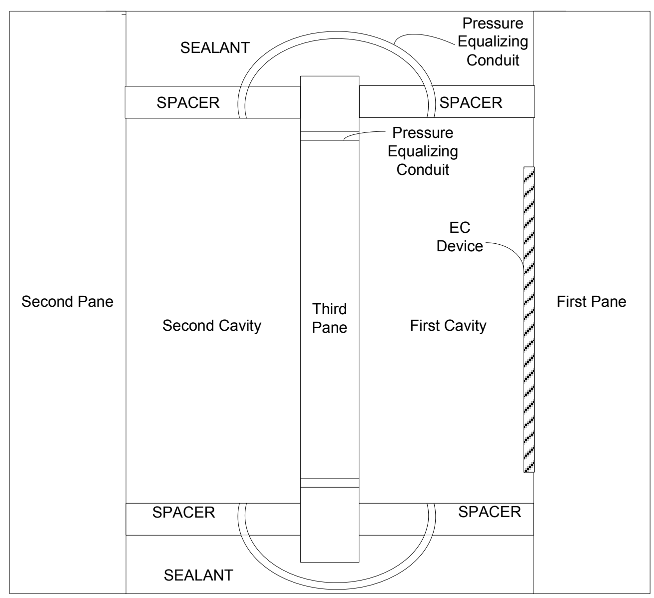


FIG. 3D

[0014] In yet another embodiment, the pressure equalizing conduit can pass through the first spacer, the third pane, and the second spacer. In another embodiment, the pressure equalizing conduit can be sealed to the first spacer and/or the second spacer. The pressure equalizing conduit can include a valve. In another embodiment, the pressure equalizing conduit can include a desiccant to reduce moisture within the cavities. The pressure equalizing conduit can be made of a flexible material. In another embodiment, the pressure equalizing conduit can include a mixture of flexible and stiff material; for example, a first portion may be flexible while a second portion may be stiff. In one embodiment, the pressure equalizing conduit may include silicone, rubber, steel, stainless steel, aluminum, iron, copper, or a mixture thereof. In one embodiment, the pressure equalizing conduit can be within the sealant and below the EC lite. In one embodiment, the pressure equalizing conduit does not directly contact the EC device. In one embodiment, the pressure equalizing conduit is below the EC device. In another embodiment, the pressure equalizing conduit is above the EC device. In yet another embodiment, the pressure equalizing conduit is on the periphery of the EC device.

[0015] In fact, by equalizing the pressure between the first cavity and the second cavity, the pressure, and thus visual distortion, around the EC light is reduced. Moreover, since the system is a closed system, the first cavity and the second cavity, while equalized, can still in fact be pressurized with respect to the outside environment and the hermetic seal of the IGU maintained. The pressure equalizing conduit can also prevent condensation within the cavities by including a desiccant. Additionally, the pressure equalizing conduit maintains an equalized pressure even as conditions, such as temperature changes, occur throughout the day or through the changes in seasons.

Key Words: Electrochromic, equalized pressure, triple glazing unit, insulated glazing unit, conduit, multi-cavity