ELECTROCHROMIC SEPARATOR

ABSTRACT

[0001] The present disclosure relates to a separator for an electroactive device, such as an electrochromic device.

BACKGROUND

[0002] An electroactive device can include an electrochromic stack on a glass pane or two glass panes 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] Manufacturing electroactive devices can take place in various steps and/or in various facilities at different locations. Handling and transporting the delicate electroactive devices during manufacturing, shipping, and installation ensures the devices accurate performance once installed, and thus, proper transporting and handling tools and methods are required. However, mis-handling or improper transporting may damage the electrochromic device. As such, improvements are needed to address handling and transporting of electroactive devices during the various stages of their manufacturing.

DESCRIPTION

[0004] Proper handling of electroactive devices during manufacturing, transport, and installation helps ensure the devices perform as expected. Typically, an electroactive device that is finished and ready for installation is not as vulnerable as one still in the process of manufacturing. However, finished electroactive devices, or insulated glazing units still require more care than a simple pane of glass. The electroactive device can be an insulated glazing unit ready to be installed or could be a substrate with various electroactive layers deposited thereon. An insulated glazing unit, according to one embodiment can include an electroactive device, a support lite, a first pane, and a second pane. In one embodiment, 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. 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 poly(3,4-ethylenedioxythiophene), or the like and other polymers such as polyaniline and polypyrrole or the like can be sulfonated and used. 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 the antireflection layer can have 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] An electroactive device can include some or all of the layers described above when it is transported. In other words, an electroactive device may be transported as a finished or unfinished device. Whether finished or unfinished, the electroactive device is susceptible to damage during transport without proper handling. Accordingly, a separator 100, as seen in FIG. 1, can aid in transport of an electroactive device—whether finished or unfinished—and ensure the device is not damaged while in transit. In one embodiment, the separator 100 has a creep resistance that is able to withstand the load of the electroactive device. The separator 100 will not deform or lose its grip on the device under the applied load. In another embodiment, the separator 100 can include materials that are able to withstand shipping temperatures of between -21°F to 150°F. The separator 100 can be used in conjunction with other packing material, such as crates, sealants, cages, containers, and the like.

[0011] As seen in FIG. 1, the separator 100 for securing an electroactive device, as described above, can include a body 102 defining an electroactive device engagement portion 105 adapted to engage the electroactive device and a tool engagement portion 110. In an embodiment, the electroactive device engagement portion 105 can be pivotally coupled with the tool engagement portion 110. In a particular instance, the tool engagement portion 110 can be adapted to receive a biasing force from an operator, a tool, or a combination thereof, to decrease a dimension, D_C, of the tool engagement portion 110. Decreasing the dimension, D_C, of the tool engagement portion 110 can increase a corresponding dimension, D_O, of the electroactive device engagement portion 105. In other words, as D_C is decreased, D_O is increased to accommodate entry of an electroactive device into the electroactive device engagement portion 105.

[0012] In an embodiment, the electroactive device engagement portion 105 can include a receiving area 108 disposed between a first sidewall 106 and a second sidewall 104. The receiving area 108 can be adapted to receive at least one of the electroactive devices, described above. In certain instances, the dimension, D_O, of the electroactive device engagement portion 105 can be greater than a thickness, of the electroactive device. In one embodiment, the first sidewall 106 can be parallel to the second side wall 104.

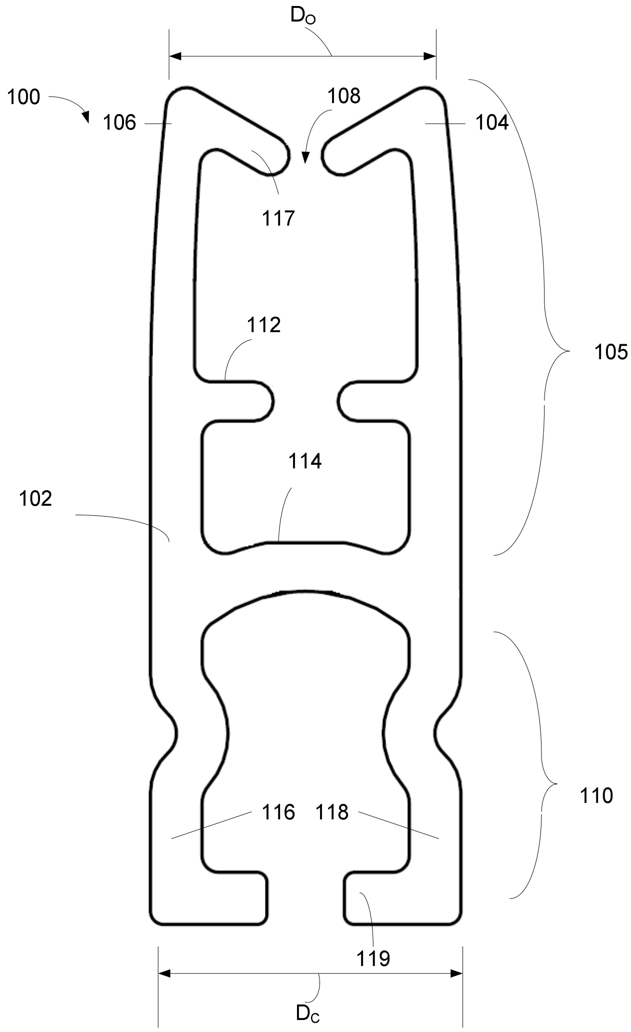

FIG. 1

[0013] In an embodiment, at least one of the first and second sidewalls 106 and 104 of the electroactive device engagement portion 105 can include a flange 117 disposed at or adjacent to a distal end of the separator 100. In a particular embodiment, the first and second sidewalls 104 and 106 can both include a flange 117 disposed at or adjacent to the distal end. In an embodiment, the flange 117 of the first sidewall 106 can extend radially inward. The flange 117 of the second sidewall 104 can extend radially inward. In a more particular embodiment, the flange 117 can be canted relative to the first sidewall 106. In another embodiment, the flange 117 can be canted relative to the second wall 104. As the dimension D_O increases, the flange 117 can be canted away from the receiving area 108 as the separator 100 receives an electroactive device. In an embodiment, the flange 117 can be adapted to guide the electroactive device into the receiving area 108. In an embodiment, the flange 117 can include a rounded end, a tapered end, or any combination thereof.

[0014] In an embodiment, the electroactive device engagement portion 105 can include one or more projections 112 extending into the receiving area 108. In an embodiment, at least one of the one or more projections 112 can extend from the first sidewall 106 and at least one of the one or more projections 112 can extend from the second sidewall 104. In a particular embodiment, the first and second sidewalls 106 and 104 can include different numbers of projections 112 as compared to one another. In another particular embodiment, the first and second sidewalls 106 and 104 can include the same number of projections 112 as compared to one another. In a particular instance, the projections 112 can be similarly positioned along the first and second sidewalls 106 and 104. In one embodiment, at least one of the one or more projections 112 can be canted relative to the first or second sidewall 106 or 104. In another embodiment, at least one of the one or more projections 112 can be perpendicular to the first and second sidewalls 106 and 104, as seen in FIG. 1. In an embodiment, the angle of the projection 112 can be different than the angle of the flange 117. In another embodiment, the angle of the projection 112 can be different than the angle of the flange 117. In an embodiment, all of the one or more projections 112 can be disposed at the angle that is less than 90°, such as less than 85°, or less than 80°, or less than 75°, or less than 70°, or less than 65°, or less than 60°, as seen in FIG. 2. In one embodiment, the one or more projections 112 can extend inward toward the receiving area 108 and then project downward such that the one or more projections 112 are parallel to the first and second sidewalls 106 and 104.

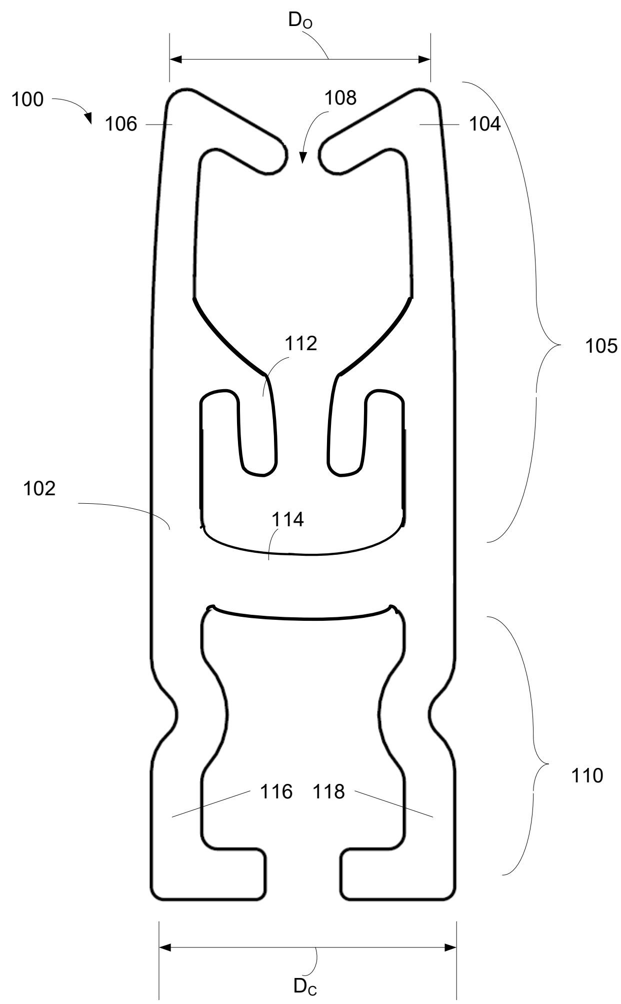

FIG. 2

[0015] In an embodiment, at least one of the one or more projections 112 can extend the same distance into the receiving area 108, as measured from the first or second sidewalls 106 or 104 when the separator 100 is not coupled with an electroactive device. The separator 100 can include one or more sets of projections. A set of projections can be a first projection extending from the first sidewall 106 and a second projection extending from the second sidewall 104, where the two projections face each other. In one embodiment, the sets of projections can be like rungs on a ladder where each set include two projections, one on each of the first sidewall 106 and second sidewall 104. In another embodiment, at least one set of the projections 112 can extend a different distance into the receiving area 108 than a second set of projections 112. In another embodiment, at least one set of projections 112 can include a first projection of the set extending a different distance into the receiving area 108 than a second projection of the set. In a more particular embodiment, all of the one or more projections 112 can extend the same distance into the receiving area 108. In another embodiment, the flange 117 can extend farther into the receiving area 108 than the one or more projections 112.

[0016] In one embodiment, the separator 100 can be manufactured as a single monolithic piece. In one embodiment, the separator 100 can be manufactured as separate components made of the same material. In another embodiment, the separator 100 can be manufactured as separate components made of different material. The separator 100 and/or components such as one or more projections 112, flange 117, 119, or body 102 can include a deformable material, such as an elastomer, adapted to deform upon insertion of the electroactive device into the receiving area 108. In an embodiment, at least one of the projections 112 can include a material selected from the group consisting of ethylene propylene diene monomer (EPDM), silicone, butyl, isoprene, styrene-butadiene (SBR), butadiene, isobutylene, fluorocarbon, fluoroelastomer (FKM), natural rubber, butyl rubber, isobutylene isoprene rubber (IIR), acrylonitrile butadiene rubber (NBR), chloroprene rubber (CR), chlorosulfonated polyethylene (CSM), a nylon, a polyether ether ketone (PEEK), polyether sulfone (PES), polytetrafluoroethylene (PTFE), polyimide, or an organic or inorganic composite, fluorinated ethylene-propylene (FEP), polyvinylidenfluoride (PVDF), polychlorotrifluoroethylene (PCTFE), ethylene chlorotrifluoroethylene (ECTFE), perfluoroalkoxy alkane (PFA), polypropylene (PP), polyethylene terephthalate glycol (PETG), polyphenylene oxide (PPO), polyphenylene ether (PPE), polyvinyl chloride (PVC), polyacetal, polybutylene terephthalate (PBT), polyethylene terephthalate (PET), polyimide (PI), polyetherimide, polyethylene (PE), polysulfone, polyamide (PA), polyphenylene oxide, polyphenylene sulfide (PPS), polyurethane, polyester, liquid crystal polymers (LCP), or any combination thereof.

[0017] In certain instances, at least one of the projections 112 can include a filler. Fillers can include a material selected from the group consisting of glass fibers, carbon fibers, silicon, PEEK, aromatic polyester, carbon particles, bronze, fluoropolymers, thermoplastic fillers, aluminum oxide, polyamidimide (PAI), PPS, polyphenylene sulfone (PPSO2), LCP, aromatic polyesters, molybdenum disulfide, tungsten disulfide, graphite, grapheme, expanded graphite, boron nitrade, talc, calcium fluoride, or any combination thereof, alumina, silica, titanium dioxide, calcium fluoride, boron nitride, mica, Wollastonite, silicon carbide, silicon nitride, zirconia, carbon black, pigments, or any combination thereof.

[0018] In certain instances, the separator 100 can further include a separating feature 114 adapted to separate the electroactive device engagement portion 105 from the tool engagement portion 110. In an embodiment, the separating feature 114 can be disposed at a proximal end of the receiving area 108. In one embodiment, the separating feature 114 can also provide a pivot point between the electroactive device engagement portion 105 and the tool engagement portion 110. In one embodiment, the separating feature 114 can provide a path for the holding the electroactive device and further act as a shock absorption for the electroactive device.

[0019] In an embodiment, the tool engagement portion 110 can include a first biasing surface 116 and a second biasing surface 118. The first and second biasing surfaces 116 and 118 can be adapted to engage with a tool (not illustrated) adapted to compress the biasing surfaces 116 and 118 together. As illustrated, in an embodiment, the first and second biasing surfaces 116 and 118 can extend from the pivot point 114 in directions generally parallel with respect to one another.

[0020] In an embodiment, at least one of the biasing surfaces 116 or 118 can include a flange 119 disposed adjacent to a distal end of the at least one biasing surface 116 or 118. In one embodiment, the flanges 119 can extend inward, toward one another. In another embodiment, at least one of the flanges 119 can extend outward, away from the other flange 119.

[0021] While in use, the separator 100 can engage with an electroactive device that has either been fully formed or is in the midst of the manufacturing process and has not yet been fully formed. The electroactive device can pass through an opening of the separator 100 into the receiving area 108. In a particular embodiment, the electroactive device can be guided into the receiving area 108 by one or both flanges 117. Upon entry, the electroactive device can deform the one or more projections 112, such as to bend and compress at least one of the projections 112. In certain instances, at least one of the sidewalls 104 and 106 can deform outward as the electroactive device is inserted into the receiving area 108. In a more particular instance, the sidewalls 104 and 106 can deform outward as the electroactive device is inserted into the receiving area 108. The separator 100 can help protect and support the electroactive device during transport without damaging the deposited layers in a partially finished device during manufacturing between or within a facility and/or transport of a finished device.

[0022] While in use with an electroactive device 301, the separator 100 can be placed along the edge of the electroactive device 301, as seen in FIG. 3.

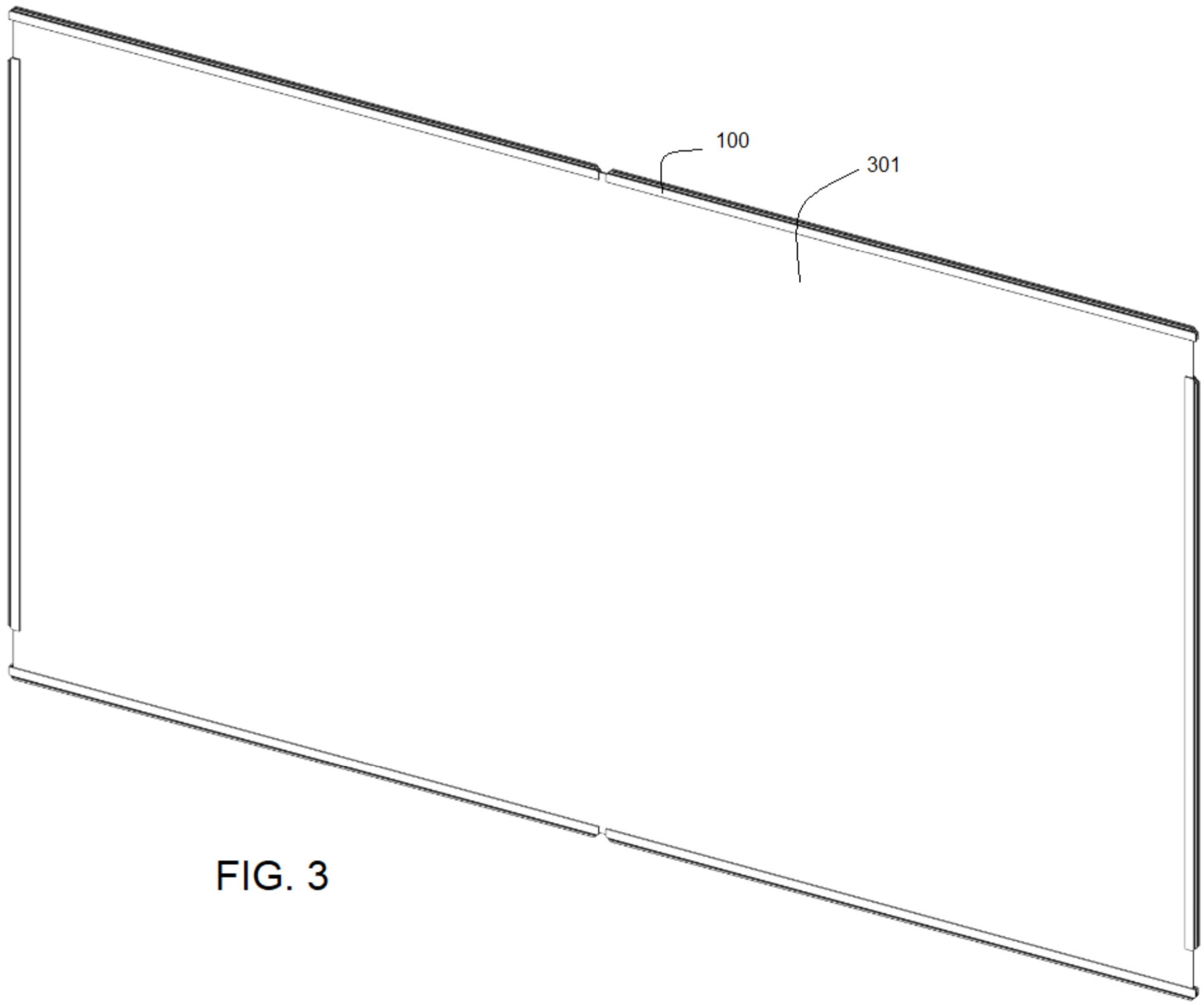

FIG. 3

[0023] In one embodiment, the separator 100 can be placed along any edge of the electroactive device 301. In one embodiment, one or more separators 100 can be placed on the electroactive device 301. In one embodiment, each side of the electroactive device 301 can have one or more separators 100. In another embodiment, one or more sides of the electroactive device 301 can have one or more separators 100. In one embodiment, the separator 100 can run along the entire edge of the electroactive device 301. In another embodiment, the separator 100 can run along a portion of the edge of the electroactive device 301.

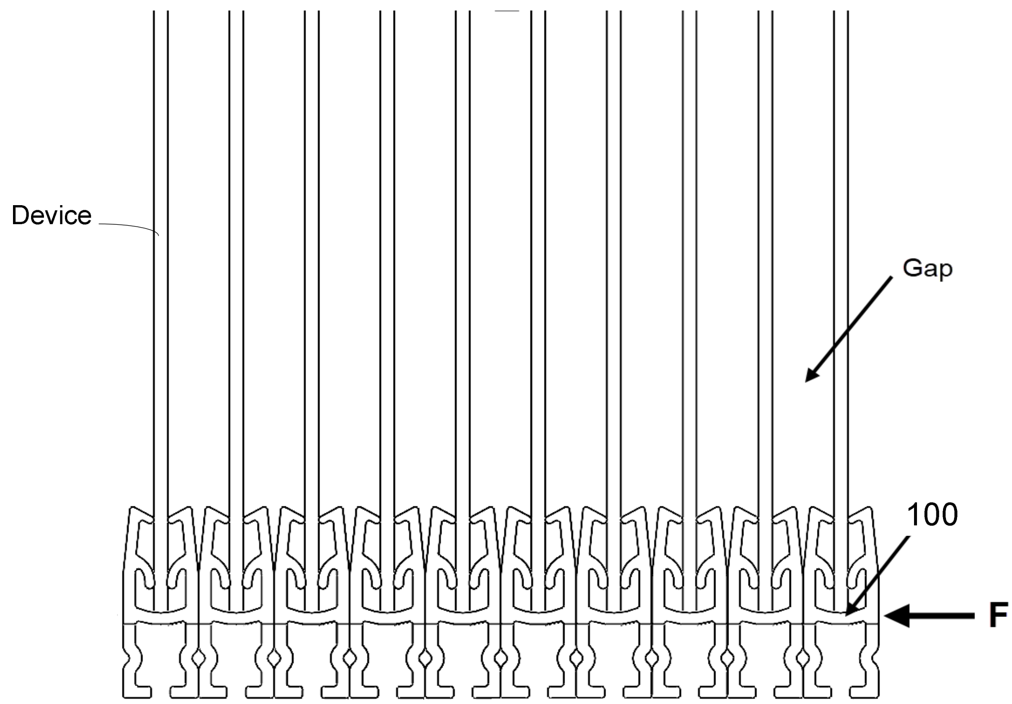

FIG. 4

[0024] While in use, the separators 100 can help maintain the electroactive device 301 in a vertical position, as seen in FIG. 4. FIG. 4 includes an illustration of a configuration for transporting more than one electroactive device 301 simultaneously. While not illustrated, the devices in FIG. 4 can then be used in conjunction with an enclosure, such as a crate, to transport the multiple electroactive devices simultaneously. When used in conjunction with a surrounding enclosure, such as a crate, the one or more separators 100 can help prevent the electroactive devices 301 from shifting, touching, or being damaged during transport. Additionally, within an enclosure, the separators can prevent relative motion of the more than one electroactive device 301 during transport and ensure that multiple electroactive devices can be transported simultaneously without damage to said devices. The separators 100 can act as a protective barrier to prevent mechanical damage to the one or more electroactive devices 301 during transport. In another embodiment, the separator 100 can act as a shock absorber for the electroactive device 301. Once transport is complete, the separators 100 can be removed from the electroactive device 301 and used for transport of a different device. As such, the separator 100 can have a good creep resistance under an applied load, be able to withstand the temperatures as set by shipping standards, maintain its grip on the device while in use, be able to maintain the device in a vertical position during transport, be able to protect the device from mechanical damage, be adaptable for use in conjunction with other packing materials, and be able to act as a shock absorber for the device.

Keywords: Electrochromic, electroactive, device, insulated glazing unit, preform, engagement, tool, separator, adapter, carrier, transport, container, support, protection