(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 December 2013 (27.12.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/192143 A1

(51) International Patent Classification:
H01L 41/08 (2006.01) *H04R 17/00* (2006.01)

(21) International Application Number:
PCT/US2013/046248

(22) International Filing Date:
18 June 2013 (18.06.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/660,887 18 June 2012 (18.06.2012) US

(71) Applicant: **BAYER INTELLECTUAL PROPERTY GMBH** [DE/DE]; Creative Campus Monheim, Alfred-nobel-strasse 10, 40789 Monheim (DE).

(72) Inventors; and
(71) Applicants : **YOO, Mikyong** [KR/US]; 1916 Louis Road, Palo Alto, CA 94303 (US). **MOUSAVI NAZARI, Hooman** [IR/US]; 134 Santa Barbara Avenue, Dale City, CA 94014 (US). **QUAN, Xina** [US/US]; 19100 Brook Lane, Saratoga, CA 95070 (US).

(74) Agents: **WHALEN, Lyndanne, M.** et al.; Bayer Materialscience LLC, 100 Bayer Road, Pittsburgh, PA 15205-9741 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,

[Continued on next page]

(54) Title: STRETCH FRAME FOR STRETCHING PROCESS

(57) Abstract: An apparatus comprising a frame and a pressure sensitive adhesive applied to at least a portion of the frame, where the pressure sensitive adhesive is arranged to bond a pre-strained film to the frame is disclosed. A method of making the apparatus also is disclosed. Also disclosed is a method of preparing a stretch frame for manufacturing electroactive polymer devices thereon.

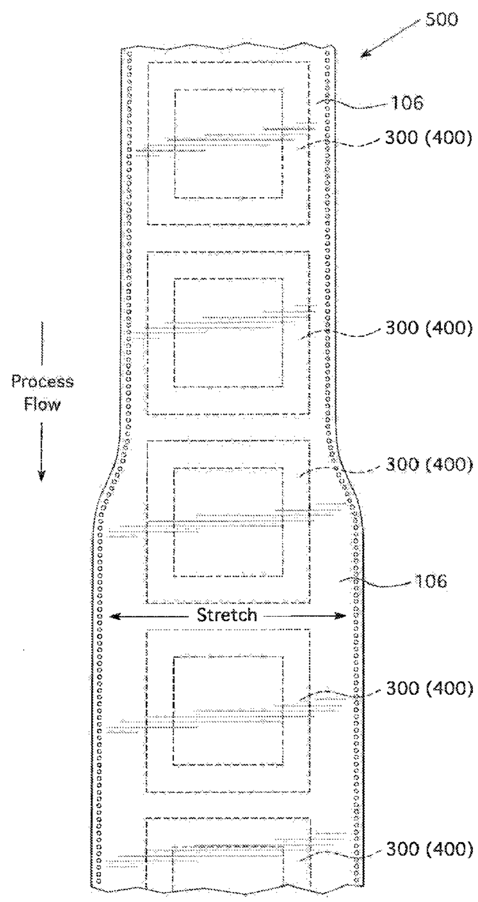

FIG. 12

WO 2013/192143 A1

MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

STRETCH FRAME FOR STRETCHING PROCESS

RELATED APPLICATIONS

This application claims the benefit, under 35 USC § 119(e), of U.S. Provisional Application No.: 61/660,887 filed June 18, 2012 entitled "STRETCH FRAME CONCEPT FOR RE-ENGINEERED STRETCHING PROCESS" the entirety of which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention is directed in general to a stretch frame for a stretching process during manufacturing and more specifically, to a stretch frame for a stretching process during high volume manufacturing processes for producing electroactive polymer cartridges and transducers.

BACKGROUND OF THE INVENTION

A tremendous variety of devices used today rely on actuators of one sort or another to convert electrical energy to mechanical energy. Conversely, many power generation applications operate by converting mechanical action into electrical energy. Employed to harvest mechanical energy in this fashion, the same type of device may be referred to as a generator. Likewise, when the structure is employed to convert physical stimulus such as vibration or pressure into an electrical signal for measurement purposes, it may be characterized as a sensor. Yet, the term "transducer" may be used to generically refer to any of the devices.

A number of design considerations favor the selection and use of advanced dielectric elastomer materials, also referred to as "electroactive polymers", for the fabrication of transducers. These considerations include potential force, power density, power conversion/consumption, size, weight, cost, response time, duty cycle, service requirements, environmental impact, etc. As such, in many applications, electroactive polymer technology offers an ideal replacement for piezoelectric, shape-memory alloy and electromagnetic devices such as motors and solenoids.

An electroactive polymer transducer comprises two electrodes having deformable characteristics and separated by a thin elastomeric dielectric material.

When a voltage difference is applied to the electrodes, the oppositely charged electrodes attract each other thereby compressing the polymer dielectric layer therebetween. As the electrodes are pulled closer together, the dielectric polymer film becomes thinner (the Z-axis component contracts) as it expands in the planar directions (along the X- and Y-axes), i.e., the displacement of the film is in-plane. The electroactive polymer film may also be configured to produce movement in a direction orthogonal to the film structure (along the Z-axis), i.e., the displacement of the film is out-of-plane. U.S. Pat. No. 7,567,681 discloses electroactive polymer film constructs which provide such out-of-plane displacement – also referred to as surface deformation or as thickness mode deflection.

The material and physical properties of the electroactive polymer film may be varied and controlled to customize the deformation undergone by the transducer. More specifically, factors such as the relative elasticity between the polymer film and the electrode material, the relative thickness between the polymer film and electrode material and/or the varying thickness of the polymer film and/or electrode material, the physical pattern of the polymer film and/or electrode material (to provide localized active and inactive areas), the tension or pre-strain placed on the electroactive polymer film as a whole, and the amount of voltage applied to or capacitance induced upon the film may be controlled and varied to customize the features of the film when in an active mode.

Numerous applications exist that benefit from the advantages provided by such electroactive polymer films whether using the film alone or using it in an electroactive polymer actuator. One of the many applications involves the use of electroactive polymer transducers as actuators to produce haptic, tactile, vibrational feedback (the communication of information to a user through forces applied to the user's body), and the like, in user interface devices. There are many known user interface devices which employ such feedback, typically in response to a force initiated by the user. Examples of user interface devices that may employ such feedback include keyboards, keypads, game controller, remote control, touch screens, computer mice, trackballs, stylus sticks, joysticks, etc. The user interface surface can comprise any surface that a user manipulates, engages, and/or observes regarding feedback or information from the device. Examples of such interface surfaces include, but are not limited to, a key (e.g., keys on a keyboard), a game pad or buttons, a display screen, etc.

The feedback provided by these types of interface devices is in the form of physical sensations, such as vibrations, pulses, spring forces, etc., which a user senses either directly (e.g., via touching of the screen), indirectly (e.g., via a vibrational effect such as when a cell phone vibrates in a purse or bag) or otherwise sensed (e.g., via an action of a moving body that creates a pressure disturbance sensed by the user). The proliferation of consumer electronic media devices such as smart phones, personal media players, portable computing devices, portable gaming systems, electronic readers, etc., can create a situation where a sub-segment of customers would benefit or desire an improved haptic effect in the electronic media device. However, increasing feedback capabilities in every model of an electronic media device may not be justified due to increased cost or increased profile of the device. Moreover, customers of certain electronic media devices may desire to temporarily improve the haptic capabilities of the electronic media device for certain activities.

Use of electroactive polymer materials in consumer electronic media devices as well as the numerous other commercial and consumer applications highlights the need to increase production volume while maintaining precision and consistency of the films.

Present techniques for stretching and laminating films to produce electroactive polymer devices require many steps and require that the stretch frame is cleaned after each use, which is very labor intensive. The present disclosure provides various stretch frames for producing electroactive polymer devices as described herein in the detailed description of the invention section of the present disclosure. The present disclosure also provides various stretching processing techniques for producing electroactive polymer devices as described herein in the detailed description of the invention section of the present disclosure.

SUMMARY OF THE INVENTION

Electroactive polymer devices that can be used with these designs include, but are not limited to planar, diaphragm, thickness mode, roll, and passive coupled devices (hybrids) as well as any type of electroactive polymer device described in the commonly assigned patents and applications cited herein.

In one embodiment, an apparatus comprising a frame and a pressure sensitive adhesive (PSA) applied to at least a portion of the frame is provided. The pressure sensitive adhesive is arranged to bond a pre-strained film to the frame.

In some variations, a method comprising providing a stretch frame, applying a pressure sensitive adhesive on at least a portion of the stretch frame, providing a film, stretching the film, and laminating the pre-strained film onto the pressure sensitive adhesive coating of the stretch frame is provided.

In other variations, a method of making a stretch frame is provided. The method comprises providing a frame and applying a pressure sensitive adhesive on at least a portion of the frame. In one embodiment, the method further comprises the use of a release layer between the frame and the adhesive.

As noted above, there remains a need to mass produce such electroactive polymer devices while maintaining the performance characteristics obtained through batch production or lower volume manufacturing processes.

The present disclosure provides stretch frames and stretching processes for producing electroactive polymer devices and reducing manufacturing cycle time, waste, and labor for cleaning conventional stretch frames after uses. Other benefits include cost reduction, improvement in lamination integrity, enabling the use of narrower frames, providing efficient use of silicone film, increasing throughput, and the film printing process after the film lamination process is made easier with thinner stretch frames.

These and other features, objects and advantages of the invention will become apparent to those persons skilled in the art upon reading the details of the invention as more fully described below. In addition, variations of the processes and devices described herein include combinations of the embodiments or of aspects of the embodiments where possible are within the scope of this disclosure even if those combinations are not explicitly shown or discussed.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is best understood from the following detailed description when read in conjunction with the accompanying drawings. To facilitate understanding, the same reference numerals have been used (where practical) to designate similar elements are common to the drawings. Included in the drawings are the following:

Figs. 1A and 1B illustrate a top perspective view of a transducer before and after application of a voltage in accordance with one embodiment of the present invention;

Fig. 2A illustrates an exemplary electroactive polymer cartridge in accordance with one embodiment of the present invention;

Fig. 2B illustrates an exploded view of an electroactive polymer actuator, inertial mass and actuator housing in accordance with one embodiment of the present invention;

Fig. 3 illustrates a conventional stretch frame used in a conventional process;

Fig. 4 illustrates a sectional view of the conventional stretch frame shown in Fig. 3 taken along section 4—4;

Fig. 5 illustrates a flow diagram of a conventional process for stretching and laminating film onto the conventional stretch frame shown in Fig. 4;

Fig. 6 illustrates an exploded view of a reusable stretch frame according to one embodiment of the present invention;

Fig. 7 illustrates a sectional view of the reusable stretch frame shown in Fig. 6 taken along section 7—7;

Fig. 8 illustrates a pre-strained film laminated onto a pressure sensitive adhesive coating applied to the reusable stretch frame shown in Figs. 6 and 7 according to one embodiment of the present invention;

Fig. 9 illustrates an exploded view of a disposable stretch frame according to one embodiment of the present invention;

Fig. 10 illustrates a sectional view of the disposable stretch frame shown in Fig. 8 taken along section 10—10;

Fig. 11 illustrates a pre-strained film laminated onto a pressure sensitive adhesive coating applied to the disposable stretch frame shown in Figs. 9 and 10 according to one embodiment of the present invention;

Fig. 12 illustrates a schematic diagram of a stretcher for stretching film and laminating the pre-strained film on stretch frames according to one embodiment of the present invention;

Fig. 13 illustrates a flow diagram of a film stretching and laminating process according to one embodiment of the present invention;

Fig. 14 illustrates one embodiment of a semiautomatic stretcher being used to stretch film and to laminate the stretched film onto a stretch frame according to one embodiment of the present invention; and

Fig. 15 illustrates one embodiment of a semiautomatic stretcher for stretching film and laminating the stretched film onto a stretch frame according to one embodiment of the present invention.

FIG. 16 illustrates a side view of the semiautomatic stretcher shown in Fig. 15.

Variation of the invention from that shown in the figures is contemplated.

DETAILED DESCRIPTION OF THE INVENTION

Examples of electroactive polymer devices and their applications are described, for example, in U.S. Pat. Nos. 6,343,129; 6,376,971; 6,543,110; 6,545,384; 6,583,533; 6,586,859; 6,628,040; 6,664,718; 6,707,236; 6,768,246; 6,781,284; 6,806,621; 6,809,462; 6,812,624; 6,876,135; 6,882,086; 6,891,317; 6,911,764; 6,940,221; 7,034,432; 7,049,732; 7,052,594; 7,062,055; 7,064,472; 7,166,953; 7,199,501; 7,199,501; 7,211,937; 7,224,106; 7,233,097; 7,259,503; 7,320,457; 7,362,032; 7,368,862; 7,378,783; 7,394,282; 7,436,099; 7,492,076; 7,521,840; 7,521,847; 7,567,681; 7,595,580; 7,608,989; 7,626,319; 7,750,532; 7,761,981; 7,911,761; 7,915,789; 7,952,261; 8,183,739; 8,222,799; 8,248,750; and in U.S. Patent Application Publication Nos.; 2007/0200457; 2007/0230222;

2011/0128239; and 2012/0126959, the entireties of which are incorporated herein by reference.

In various embodiments, the present invention provides a stretch frame for stretching film and / or laminating the stretched film onto the stretch frame. In various embodiments, the present invention provides a stretching process employing the stretch frame for stretching and / or laminating the stretched film. In one embodiment, a polymer film is stretched and / or laminated using the stretch frame and process according to the present disclosure to manufacture electroactive polymer devices. Embodiments of the stretch frame and stretching process according to the present disclosure can be used to stretch and laminate film to reduce manufacturing costs relative to conventional techniques by eliminating numerous processing steps and preclude the need for cleaning the stretch frames after each use, which can be labor intensive. Various embodiments of the present invention employ a unique coating stack to hold a pre-strained film tightly during manufacturing of electroactive polymer devices and to enable easy removal of film remnants left on the stretch frame after the devices are removed, e.g., cut out, from the stretch frame. In one embodiment, the stretch frames are disposable. In another embodiment, at least a portion of the stretch frame can be incorporated permanently into the transducer.

In one embodiment, a pressure sensitive adhesive (PSA) and release coat are applied to the stretch frame to hold a pre-strained film on the stretch frame and to enable easy removal of any pressure sensitive adhesive and / or film remnants from the stretch frame after each use, respectively. In addition to reducing manufacturing costs by decreasing the number of stretching and laminating steps and labor costs of cleaning stretch frames after each use, embodiments of the present invention also enable the use of narrower stretch frames, which provides additional printing area for an equally sized frame with the same outside dimensions, leading to increased manufacturing throughput.

For some electroactive polymer device configurations, the adhesives can be printed after film-to-film lamination. Conventional stretch frames that employ two aluminum stretch frames, it is difficult to build more than two layers of film in a lamination due to the thickness of the stretch frames. Embodiments of the present invention provide thinner single stretch frames to simplify the stretching and / or lamination processes.

Films useful in embodiments of the present invention include, but are not limited to those made from polymers such as silicone, polyurethane, acrylate, hydrocarbon rubber, olefin copolymer, polyvinylidene fluoride copolymer, fluoroelastomer styrenic copolymer, and adhesive elastomer.

Prior to describing the stretch frame and stretch / laminating process according to various embodiments of the present invention, the description now turns to Figs. 1A and 1B, which illustrate an example of an electroactive polymer film or membrane **10** structure. A thin elastomeric dielectric film or layer **12** is sandwiched between compliant or stretchable electrode plates or layers **14** and **16**, thereby forming a capacitive structure or film. The length "l" and width "w" of the dielectric layer, as well as that of the composite structure, are much greater than its thickness "t". Preferably, the dielectric layer has a thickness in the range from about 10 μm to about 100 μm, with the total thickness of the structure in the range from about 15 μm to about 10 cm. The thickness of the dielectric layer in the transducer can be reduced during fabrication by stretching (or pre-straining) the dielectric film. The stretching can be uniaxial or biaxial. In biaxial pre-strain, the stretch ratio may be equal in all directions or it can be anisotropic with stretching in one axis greater than in another.

It is additionally desirable to select the elastic modulus, thickness, and/or the geometry of electrodes **14**, **16** such that the additional stiffness they contribute to the actuator is generally less than the stiffness of the dielectric layer **12**, which has a relatively low modulus of elasticity, i.e., less than about 100 MPa and more preferably less than about 10 MPa, but is likely thicker than each of the electrodes. Electrodes suitable for use with these compliant capacitive structures are those capable of withstanding cyclic strains greater than about 1% without failure due to mechanical fatigue.

As seen in Fig. 1B, when a voltage is applied across the electrodes, the unlike charges in the two electrodes **14**, **16** are attracted to each other and these electrostatic attractive forces compress the dielectric film **12** (along the Z-axis). The dielectric film **12** is thereby caused to deflect with a change in electric field. As electrodes **14**, **16** are compliant, they change shape with dielectric layer **12**. In the context of the present disclosure, "deflection" refers to any displacement, expansion, contraction, torsion, linear or area strain, or any other deformation of a portion of dielectric film **12**. Depending on the architecture, e.g., a frame, in which capacitive structure **10** is employed (collectively referred to as a "transducer"), this deflection may be used to produce mechanical work. Various different transducer architectures are disclosed and described in the above-identified patent references.

With a voltage applied, the transducer film **10** continues to deflect until mechanical forces balance the electrostatic forces driving the deflection. The mechanical forces include elastic restoring forces of the dielectric layer **12**, the compliance or stretching of the electrodes **14**, **16** and any external resistance provided by a device and/or load coupled to transducer **10**. The resultant deflection of the transducer **10** as a result of the applied voltage may also depend on a number of other factors such as the dielectric constant of the elastomeric material and its size and stiffness. Removal of the voltage difference and the induced charge causes the reverse effects.

In some cases, the electrodes **14** and **16** may cover a limited portion of dielectric film **12** relative to the total area of the film. This may be done to prevent electrical breakdown around the edge of the dielectric or achieve customized deflections in certain portions thereof. Dielectric material outside an active area (the latter being a portion of the dielectric material having sufficient electrostatic force to enable deflection of that portion) may be caused to act as an external spring force on the active area during deflection. More specifically, material outside the active area may resist or enhance active area deflection by its contraction or expansion.

The dielectric film **12** may be pre-strained using the various embodiments of the stretch frame and process according to the present invention described herein. The pre-strain improves conversion between electrical and mechanical energy, i.e., the pre-strain allows the dielectric film **12** to deflect more and provide greater mechanical work. Pre-strain of a film may be described as the change in dimension in a direction after pre-straining relative to the dimension in that direction before pre-straining. The pre-strain may include elastic deformation of the dielectric film and be formed, for example, by stretching the film in tension and fixing one or more of the edges while stretched, as indicated in Fig. 10. The pre-strain may be imposed at the boundaries of the film or for only a portion of the film and may be implemented by using a rigid frame or by stiffening a portion of the film.

The transducer structure of Figs. 1A and 1B and other similar compliant structures and the details of their constructs are more fully described in many of the referenced patents and publications disclosed herein.

Fig. 2A illustrates an exemplary electroactive polymer cartridge **12** having an electroactive polymer transducer film **26** placed between rigid frame **8** where the electroactive polymer film **26** is exposed in openings of the frame **8**. The exposed portion of the film **26** includes two working pairs of thin elastic electrodes **32** on either side of the cartridge **12** where the electrodes **32** sandwich or surround the exposed portion of the film **26**. The electroactive polymer film **26** can have any number of configurations. However, in one example, the electroactive polymer film **26** comprises a thin layer of elastomeric dielectric polymer (e.g., made of acrylate, silicone, urethane, thermoplastic elastomer, hydrocarbon rubber, fluoroelastomer, styrenic copolymer elastomer, or the like). When a voltage difference is applied across the oppositely-charged electrodes **32** of each working pair (i.e., across paired electrodes that are on either side of the film **26**), the opposed electrodes attract each other thereby compressing the dielectric polymer layer **26** therebetween. The area between opposed electrodes is considered the active area. As the electrodes are pulled closer together, the dielectric polymer **26** becomes thinner (i.e., the Z-axis component contracts) as it expands in the planar directions (i.e., the X- and Y-axes components expand) (See Figs. 1B for axis references).

Furthermore, in variations where the electrodes contain conductive particles, like charges distributed across each electrode may cause conductive particles embedded within that electrode to repel one another, thereby contributing to the expansion of the elastic electrodes and dielectric films. In alternate variations, electrodes do not contain conductive particles (e.g., textured sputtered metal films). The dielectric layer **26** is thereby caused to deflect with a change in electric field. As the electrode material is also compliant, the electrode layers change shape along with dielectric layer **26**. As stated hereinabove, deflection refers to any displacement, expansion, contraction, torsion, linear or area strain, or any other deformation of a portion of dielectric layer **26**. This deflection may be used to produce mechanical work. As shown, the dielectric layer **26** can also include one or more mechanical output bars **34**. The bars **34** can optionally provide attachment points for either an inertial mass (as described below) or for direct coupling to a substrate in the electronic media device.

In fabricating a transducer, an elastic film **26** can be stretched and held in a pre-strained condition usually by a rigid frame or stretch frame **8**. In those variations employing a four-sided frame, the film can be stretched bi-axially. It has been observed that pre-strain improves the dielectric strength of the polymer layer **26**, thereby enabling the use of higher electric fields and improving conversion between electrical and mechanical energy, i.e., the pre-strain allows the film to deflect more and provide greater mechanical work. Preferably, the electrode material is applied after pre-straining the polymer layer, but may be applied beforehand. The two electrodes provided on the same side of layer **26**, referred to herein as same-side electrode pairs, i.e., electrodes on the top side of dielectric layer **26** and electrodes on a bottom side of dielectric layer **26**, can be electrically isolated from each other. The opposed electrodes on the opposite sides of the polymer layer form two sets of working electrode pairs, i.e., electrodes spaced by the electroactive polymer film **26** form one working electrode pair and electrodes surrounding the adjacent exposed electroactive polymer film **26** form another working electrode pair. Each same-side electrode pair can have the same polarity, whereas the polarity of the electrodes of each working electrode pair is opposite each other. Each electrode has an electrical contact portion configured for electrical connection to a voltage source.

Examples of electroactive polymer films can be found in the commonly assigned patents and patent applications disclosed and incorporated by reference herein.

Now turning to Fig. 3, where a conventional stretch frame **100** used in a conventional process is illustrated. As shown, the conventional stretch frame **100** includes a top frame element **102** and a bottom frame **104** element. The top frame element **102** is slightly smaller than the bottom frame element **104**. With reference now to both Figs. 3 and 4, a pre-strained dielectric film **106** is sandwiched between the top and bottom frame elements **102**, **104** of the stretch frame **100**. An adhesive tape **108** may be employed to bond the top and bottom frame elements **102**, **104** together. This holds the pre-strained film **108** in place for subsequent lamination and printing processes. Once the printing process is completed, the individual electroactive polymer devices are removed, e.g., cut out (singulated), from the film **108** and removed from the stretch frame **100**. The tape **108** and any film remnants must then be removed the stretch frame **100** before the stretch frame **100** can be reused. Removing the tape **108** and film remnants increases the manufacturing cycle time and adds labor costs for cleaning the stretch frame after each use. Although the top and bottom stretch frame elements **102**, **104** can be made of any suitable materials such as metals and rigid plastics, generally these components are made of aluminum.

Fig. 5 illustrates a flow diagram **200** of a conventional process for stretching and laminating film onto the conventional stretch frame shown in Fig. 4. This process **200** will now be described in conjunction with Figs. 3 and 4. The process **200** starts by providing **202** the bottom frame element **104**. The film **106** is stretched **204** and laminated **206** onto the bottom frame element **104**. The top frame element **102** is then provided and placed above the stretched film **106** and the bottom frame element **104**. The tape **108** is applied to bond the top and bottom frame elements **102**, **104** to hold the pre-strained film **108** during the manufacturing steps. The electroactive polymer devices are manufactured using the stretch frame **100**. The devices are then removed **216** from the film **108**. The excess film **108** is removed **218** and the tape **108** is removed and cleaned from the stretch frame **100**.

Having described the film stretching and laminating process for manufacturing electroactive polymer devices using a conventional stretch frame **100** and process **200**, the disclosure now turns to Fig. 6, which illustrates an exploded view of a reusable stretch frame **300** according to one embodiment of the present invention and Fig. 7, which illustrates a sectional view of the stretch frame shown in Fig. 6 taken along section 7—7. As shown in Figs. 6 and 7, the reusable stretch frame **300** according to one embodiment of the present invention comprises a bottom stretch frame element **302**, a permanent, or long term, release coating **304** applied to a top portion of the stretch frame element **302**, and a pressure sensitive adhesive **306** applied to the release coating **304**. The release coating **304** is reusable and generally is applied once to the stretch frame element **302**. Although the stretch frame element **302** can be made of any suitable material, the stretch frame element **302** is generally made of aluminum.

The reusable stretch frame **300** can be manufactured with thinner, narrower, stretch frame elements **302**, which provides the additional advantage of increasing the pre-strained film **106** area available for printing the electroactive polymer components, for example. In other words, thinner or narrower stretch frame elements **302** increase the ratio of print area over the overall area defined by the stretch frame element **302**.

As shown in Fig. 8, the pre-strained film **106** is laminated onto the pressure sensitive adhesive material **306**, which will hold the pre-strained film **106** during the electroactive polymer device manufacturing steps. Since the pre-strained film **106** is bonded to the stretch frame element **302** by the pressure sensitive adhesive **306**, there is no need for a top stretch frame element **102** and tape **108** or other method to bond the top and bottom stretch frame elements **102**, **104** as shown and described in connection with Figs. 3 and 4.

Fig. 9 illustrates an exploded view of a disposable stretch frame **400** according to one embodiment of the present invention. Fig. 10 illustrates a sectional view of the stretch frame shown in Fig. 8 taken along section 10—10. The disposable stretch frame **400** comprises a stretch frame element **402** made of relatively inexpensive material (e.g., plastic) to make it economically feasible to make it disposable. A pressure sensitive adhesive **404** coating is applied to a top portion of the stretch frame element **402** but no release coating is necessary since the disposable stretch frame **400** will not be reused. Fig. 11 illustrates a pre-strained film **106** laminated onto the pressure sensitive adhesive **404** coating applied to the stretch frame element **402**.

Another embodiment of this invention is that at least a portion of the disposable stretch frame can be incorporated into the structure of the transducer cartridge. For example, an adhesive coated polyethylene terephthalate (PET) film with apertures could be laminated onto a pre-strained dielectric film, processed through printing stations to add electrodes, and singulated into individual transducers by die-cutting through the entire materials stack. Using the disposable stretch frame material in the final product could reduce product cost by eliminating the steps used to print a frame in an electroactive polymer cartridge.

Although the reusable and disposable stretch frames **300**, **400** are illustrated as having a generally rectilinear shape, the shape of these stretch frames **300**, **400** should not be limited as such. In general, the stretch frames **300**, **400** may be implemented using any suitable triangular, square, rectangular, rhomboidal, polygonal, circular, oval, irregular, or other suitable shape.

Fig. 12 illustrates a schematic diagram of a stretcher **500** for stretching film and laminating the pre-strained film on the stretch frames **300**, **400** according to one embodiment of the present invention. The film **106** is initially rolled out and clamped on either side. As the film **106** advanced the clamps follow a track that widens and stretches the film **106**. During the process, after the film **106** has been stretched, the film **106** is laminated onto the pressure sensitive adhesive coating applied to the reusable stretch frame **300** or the disposable stretch frame **400**. After the pre-strained film **106** is laminated onto the stretch frames **300** (**400**), the frames are removed, e.g., cut out, from the film web and routed to an electroactive polymer device manufacturing stage, where the various components of the electroactive polymer device are printed or applied to the pre-strained film **106** bonded to the stretch frame **300** (**400**).

The cleaning process is simple. After the device or plurality of devices is removed from the pre-strained film **106**, the pressure sensitive adhesive **306** and film remnants are peeled easily from the release coating **304**. The reusable stretch frame **300** with the release coating **304** is reusable. For materials selection, consideration is given to the tack and peel adhesion properties of the pressure sensitive adhesive **306** as well as the release properties of the pressure sensitive adhesive **306**. In other words, the pressure sensitive adhesive **306** should not be too easily released from the release coating **304** so it will remain during the manufacturing process, but should be easily released for the cleaning process. For making the release coating **306** permanent, an adhesion promoter can be applied to a portion of the stretch frame **300** prior to applying the release coating **304** thereon.

Various materials can be employed for the pressure sensitive adhesive **306** and the release coating **304**. In one embodiment the pressure sensitive adhesive **306** is a Dow Corning 2013 (a solvent-free silicone pressure sensitive adhesive that, when used with SYL-OFF 4000 catalyst (a blend of platinum catalyst and vinyl functional silicone polymer), offers the ability to prepare pressure sensitive constructions at low curing temperatures) material, among other materials, for example; the release coating **304** is a Dow Corning SYL-OFF Q2-7785 (an 88% active solids dispersion of fluorofunctional silicone polymer in heptane), among other materials, for example; and optionally, an adhesion promoter for the release coating **304** to aluminum stretch frame **302** is NuSil CF2-135 (silicone primer), among other materials, for example.

Other materials that may be employed for the pressure sensitive adhesive **304** include: Dow Corning 280A (a dispersion of polydimethylsiloxane gum and resin diluted with xylene to 55% silicone solids content.), Dow Corning 282 (a dispersion of polydimethyldisiloxane gum and resin diluted with xylene to 55% silicone solids content), Dow Corning 7355 (a dispersion of polydimethylsiloxane gum and resin diluted with xylene and toluene to an average 56.5 percent silicone solids content.), Dow Corning 7358 (a dispersion of polydimethylsiloxane gum and resin diluted with xylene and toluene to an average 56.5 percent silicone solids content), Dow Corning 7388 (a dispersion of polydimethylsiloxane gum and resin diluted with xylene to 55% to 58% silicone solids content), Dow Corning 7651, 7652, 7657, Dow Corning SYL-OFF Q2-7566 (a dispersion of polydimethylsiloxane gum and resin diluted with xylene to 55% silicone solids content), Dow Corning SYL-OFF Q2-7735 (a peroxide-curable silicone pressure sensitive adhesive designed to provide low, stable release from liners made with Dow Corning SYL-OFF Q2-7785 Release Coating, while maintaining high subsequent tack and adhesion properties; the adhesive is a dispersion of siloxane gum and silicone resin diluted with xylene to 55% silicone solids content), Dow Corning SYL-OFF Q2-7406 (a polydimethylsiloxane gum and resin dispersion), Momentive SILGRIP PSA529 (silicone pressure sensitive adhesive), Momentive SILGRIP PSA590 (a silicone pressure sensitive adhesive based on a toluene solution of polysiloxane gum and resin and supplied at 60% silicone solids and may be further diluted with aromatic, aliphatic or chlorinated solvents), Momentive SILGRIP PSA595 (a silicone pressure sensitive adhesive based on a xylene solution of polysiloxane gum and resin and supplied at 55% silicone solids and may be further diluted with aromatic, aliphatic or chlorinated solvents), Momentive SILGRIP PSA6573A (a silicone pressure sensitive adhesive based on a toluene solution of polysiloxane gum and resin and supplied at 60% silicone solids and may be further diluted with aromatic, aliphatic or chlorinated solvents), Momentive SILGRIP PSA6574 (a silicone pressure sensitive adhesive based on a toluene solution of phenyl based polysiloxane gum and resin supplied at 55% silicone solids and may be further diluted with aromatic, aliphatic or chlorinated solvents), NuSil PSA-1170 (a silicone based pressure sensitive adhesive), among other materials, for example. Other adhesives may also be employed that are not pressure sensitive adhesives such as hot-melt, liquid, thermal curing, UV curing, and B-staged adhesives. A wide range of adhesives can be used including silicones, fluorosilicones, acrylates, polyurethanes, olefins, hydrocarbon rubbers, styrene copolymers, epoxies, hot-melt adhesives, pressure sensitive adhesives, thermal curing adhesives, UV curing adhesives, liquid adhesives, and any combinations thereof, among other materials.

Materials that may be employed for the release coating **304** include: Momentive FSR2000 (a fluorosilicone polymer containing platinum catalyst), epoxy silicone, fluoropolymer, fluorosilicone, among other materials, for example. The choice of the release coating is highly dependent on the materials used for the stretch frame, adhesive, and stretched dielectric film.

Additional materials that have been tested but have not performed as well as the above listed materials for a silicone film design include, for the release coating **304**: Magnaplate coatings including polymer-based LECTROFLUOR, TUFRAM surface enhancement coating, and TEFLON (polytetrafluoroethylene (PTFE) synthetic fluoropolymer of tetrafluoroethylene), mold release, EASE RELEASE 200, among other materials. These materials may find utility for other chemistries, however.

Portions of the surface of the stretch frame may be pre-treated prior to the application of the release coating to improve the formation and adhesion of a strong, durable release coating. Treatment agents include solvents, primers, coupling agents, and etchants. An exemplary adhesion promoter for a fluorosilicone release coating **304** to the aluminum stretch frame **302** is NuSil MED1-161 (silicone primer specially formulated primer designed for use with platinum-cured systems where conventional silicone primers are insufficient.

Fig. 13 illustrates a flow diagram **600** of a film stretching and laminating process according to one embodiment of the present invention. As shown in Fig. 13, a stretch frame **300** (**400**) is provided **602** and a pressure sensitive adhesive **306** is applied thereto. In one embodiment, the reusable stretch frame **300** is made of aluminum, or other reusable material. The release coating **304** is applied to the aluminum reusable stretch frame **300** prior to its introduction into the process depicted in the flow diagram **600**. When a disposable stretch frame **400** is employed, then the pressure sensitive adhesive **306** can be applied directly to the disposable stretch frame **400** material. Once the pressure sensitive adhesive **306** coating is applied, the film **106** stretched and the pre-strained film **106** is laminated onto the stretch frame **300** (**400**). After lamination the stretch frame **300** (**400**) with the pre-strained film **106** is employed to manufacture **610** the electroactive polymer devices as described in connection with Figs 1A, 1B, 2A, 2B. The devices are then removed, e.g., cut **612**, from the pre-strained film **106** bonded to the stretch frame **300** (**400**) by the pressure sensitive adhesive **306**. When a reusable stretch frame **300** is employed, the excess film **106** and the pressure sensitive adhesive **306** are simply peeled away from the release coating **304**, making clean up easy and preparation of the stretch frame **300** for the next process run more efficient. When a disposable stretch frame **400** is employed, the entire stretch frame **400** is disposed of.

Fig. 14 illustrates one embodiment of a semiautomatic stretcher **700** being used to stretch film **106** and to laminate the stretched film **106** onto a stretch frame **300** (**400**) according to one embodiment of the present invention. The semiautomatic stretcher **700** is being used to stretch the film **106** and for film-frame lamination on the film stretcher **500** (as shown in Fig. 12). As shown in Fig. 14, an operator **702** is in the process of laminating the film **106** onto the frames **300** (**400**) that were coated with the pressure sensitive adhesive **306**, as described in connection with Figs. 6-8. Although a manual lamination process is shown, embodiments of the present invention encompass a fully automatic process where a roller or other means are employed to perform the lamination function. Also, the film **106** stretcher **500** can be advanced continuously or indexed by a single frame **300** (**400**) or a predetermined number of frames **300** (**400**).

Fig. 15 illustrates one embodiment of a semiautomatic stretcher **800** for stretching film **106** with the film stretcher **500** (as shown in Fig. 12) and laminating the stretched film **106** onto a stretch frame **300** (**400**) according to one embodiment of the present invention. FIG. 16 illustrates a side view of the semiautomatic stretcher **800**. With reference now to Figs. 15, and 16, the semiautomatic stretcher **800** comprises a base material roll **802**, a machine direction orientation roll **808**, a first scrap winder **810**, and a second scrap winder **812**. The base material roll **802** comprises a dielectric film **106** layer sandwiched between a polyethylene terephthalate layer **804** and a polyethylene (PE) interleave layer **806**. In operation, as the base material roll **802** rotates the polyethylene terephthalate layer **804** is wound by the first scrap winder **810** and the PE interleave layer **806** is wound by the second scrap winder **812**. The dielectric film layer **106** is advanced to the film stretcher **500** portion. A tape unwind spool **814** can be employed to apply tape **816** to the edges of the edges of the dielectric film **106** to reinforce the film **106** during the stretching phase.

As previously discussed, the various embodiments of the stretch frames **300** (**400**) and process **600** for stretching and laminating the film **106** onto the stretch frames **300** (**400**) provide several advantages over the conventional stretch frame **100** and process **200**. Such advantages include, without limitation, cost reduction, improved lamination integrity, enables use of narrower frames to increase the film area available for printing, efficient use of silicone film, and increase throughput. Also, printing after the lamination process becomes easier with thinner stretch frames.

As for other details of the present invention, materials and alternate related configurations may be employed as within the level of those with skill in the relevant art. The same may hold true with respect to process-based aspects of the invention in terms of additional acts as commonly or logically employed. In addition, though the invention has been described in reference to several examples, optionally incorporating various features, the invention is not to be limited to that which is described or indicated as contemplated with respect to each variation of the invention. Various changes may be made to the invention described and equivalents (whether recited herein or not included for the sake of some brevity) may be substituted without departing from the true spirit and scope of the invention. Any number of the individual parts or subassemblies shown may be integrated in their design. Such changes or others may be undertaken or guided by the principles of design for assembly.

Also, it is contemplated that any optional feature of the inventive variations described may be set forth and claimed independently, or in combination with any one or more of the features described herein. Reference to a singular item, includes the possibility that there are plural of the same items present. More specifically, as used herein and in the appended claims, the singular forms “a,” “an,” “said,” and “the” include plural referents unless the specifically stated otherwise. In other words, use of the articles allow for “at least one” of the subject item in the description above as well as the claims below. It is further noted that the claims may be drafted to exclude any optional element. As such, this statement is intended to serve as antecedent basis for use of such exclusive terminology as “solely,” “only” and the like in connection with the recitation of claim elements, or use of a “negative” limitation. Without the use of such exclusive terminology, the term “comprising” in the claims shall allow for the inclusion of any additional element – irrespective of whether a given number of elements are enumerated in the claim, or the addition of a feature could be regarded as transforming the nature of an element set forth in the claims. Stated otherwise, unless specifically defined herein, all technical and scientific terms used herein are to be given as broad a commonly understood meaning as possible while maintaining claim validity.

WHAT IS CLAIMED IS:

1. An apparatus comprising:

a frame; and

an adhesive applied to at least a portion of the frame,

wherein the adhesive is arranged to bond a pre-strained film to the frame.

2. The apparatus according to Claim 1, wherein the adhesive is a pressure sensitive adhesive.

3. The apparatus according to one of Claims 1 and 2, wherein the adhesive comprises a material selected from the group consisting essentially of silicones, fluorosilicones, acrylates, polyurethanes, olefins, hydrocarbon rubbers, styrenic copolymers, epoxies, hot-melt adhesives, pressure sensitive adhesives, thermal curing adhesives, UV curing adhesives, liquid adhesives, and any combinations thereof.

4. The apparatus according to Claim 1, further comprising a release coating applied to at least a portion of the frame, wherein the adhesive is applied on top of the release coating.

5. The apparatus according to Claim 4, wherein the release coating comprises a material selected from the group consisting essentially of epoxy silicone, fluoropolymer, fluorosilicone, polymer, and polytetrafluoroethylene, mold release, and any combinations thereof.

6. The apparatus according to Claim 4, further comprising an adhesion promoter, coupling agent, solvent, or etchant to improve the adhesion of release coating to the frame.

7. The apparatus according to Claim 6, wherein the adhesion promoter comprises a silicone based primer.

8. A method of fabricating a polymer film device, the method comprising:

providing the apparatus according to any one of Claims 1 to 7;

providing a film;

stretching the film; and

laminating or bonding the pre-strained film onto the adhesive coating of the frame.

9. The method according to Claim 8, further comprising manufacturing the electroactive polymer device on the pre-strained film.

10. The method according to Claim 9, further comprising removing the electroactive polymer devices from the pre-strained film bonded to the frame by the adhesive.

11. The method according to Claim 10, further comprising incorporating at least a portion of the frame into the electroactive polymer device.

12. The method according to Claim 8, further comprising applying a release coating onto at least a portion of the frame and applying the adhesive coating on top of the release coating.

13. The method according to Claim 12, further comprising applying an adhesion promoter to at least a portion of the stretch frame prior to applying the release coating thereon.

14. The method according to Claim 12, further comprising reusing the stretch frame by removing at least a portion of the pre-strained film from the release coating.

15. A method of making a stretch frame, the method comprising:

providing a frame; and

applying a pressure sensitive adhesive on at least a portion of the frame.

16. The method according to Claim 15, further comprising applying a release coating on at least a portion of the frame prior to applying the pressure sensitive adhesive thereon.

17. The method according to Claim 16, further comprising applying an adhesion promoter on at least a portion of the frame prior to applying the release coating thereon.

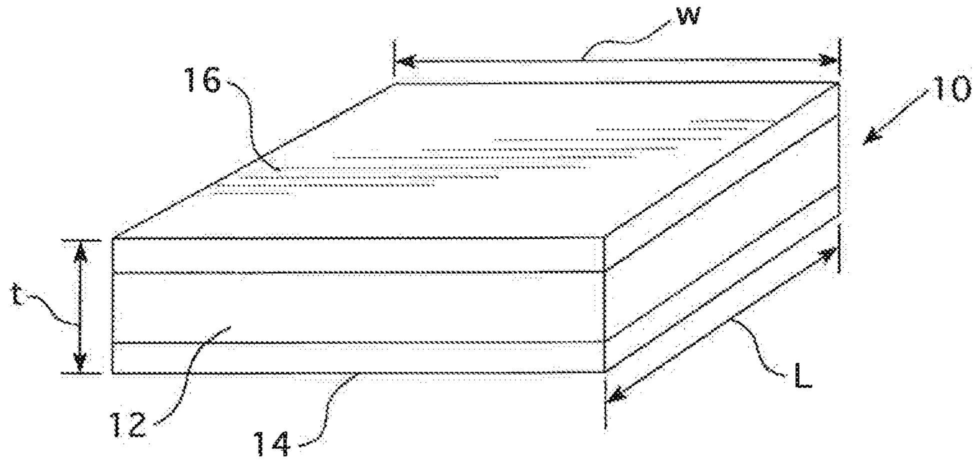

FIG. 1A

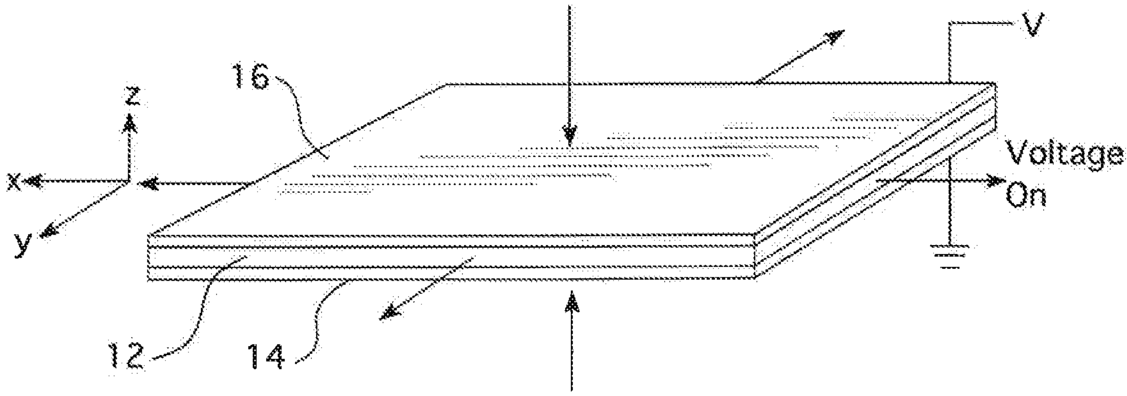

FIG. 1B

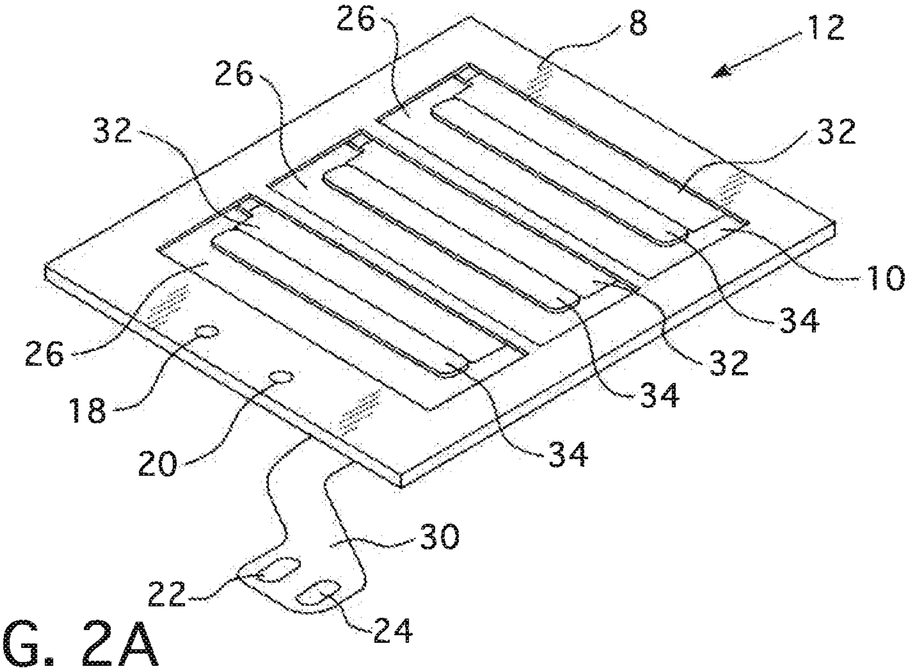

FIG. 2A

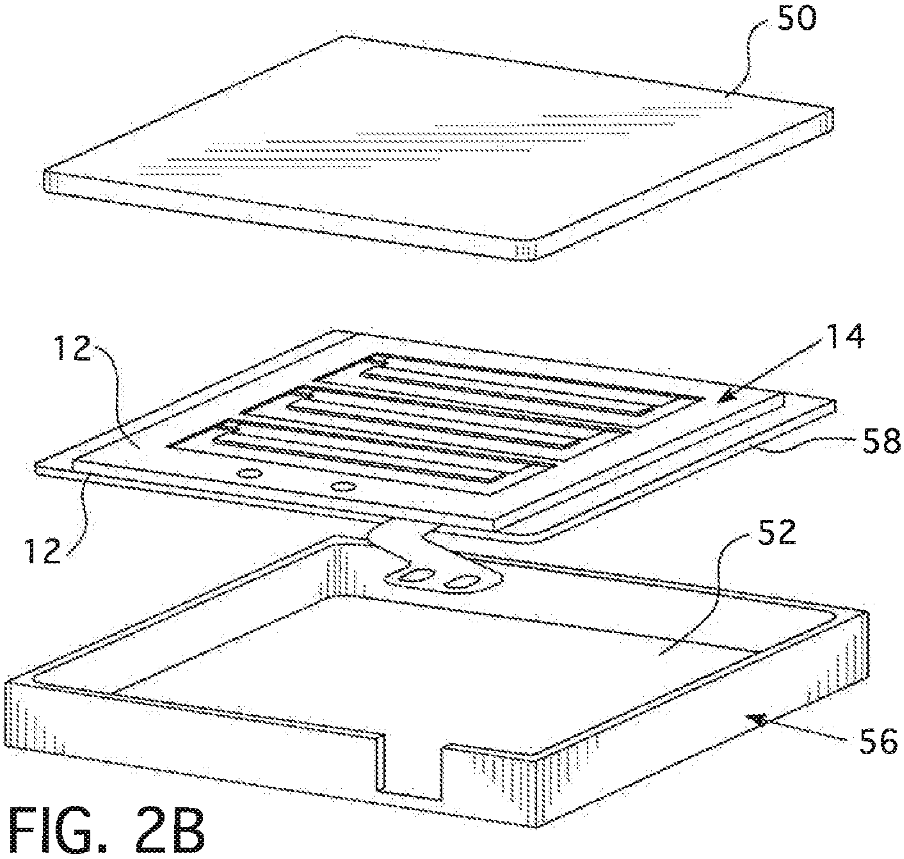

FIG. 2B

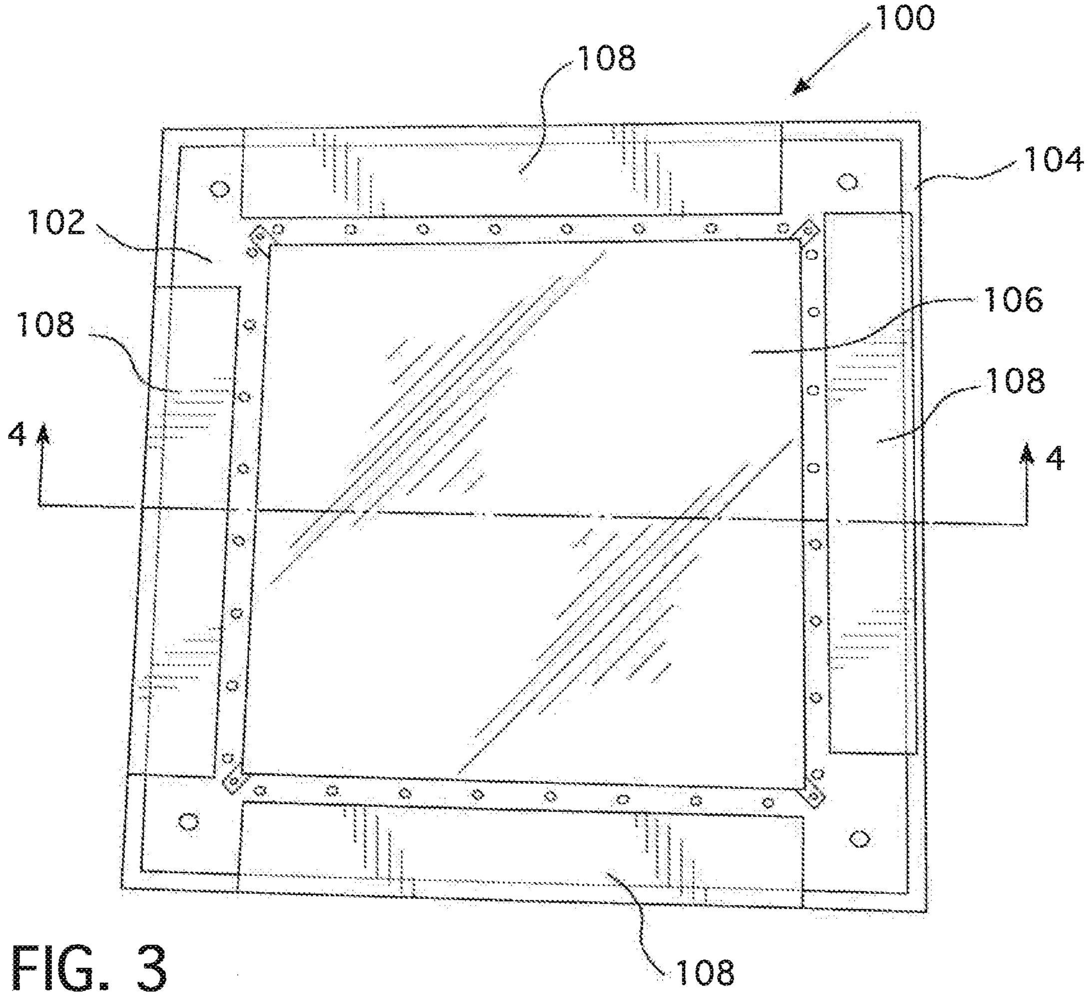
100
108
104
102
106
108
108
4
4
108

FIG. 3

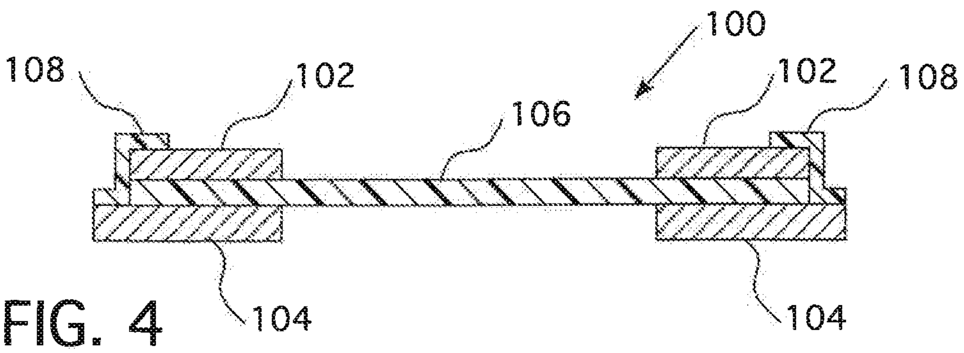
100
108
102
106
102
108
104
104

FIG. 4

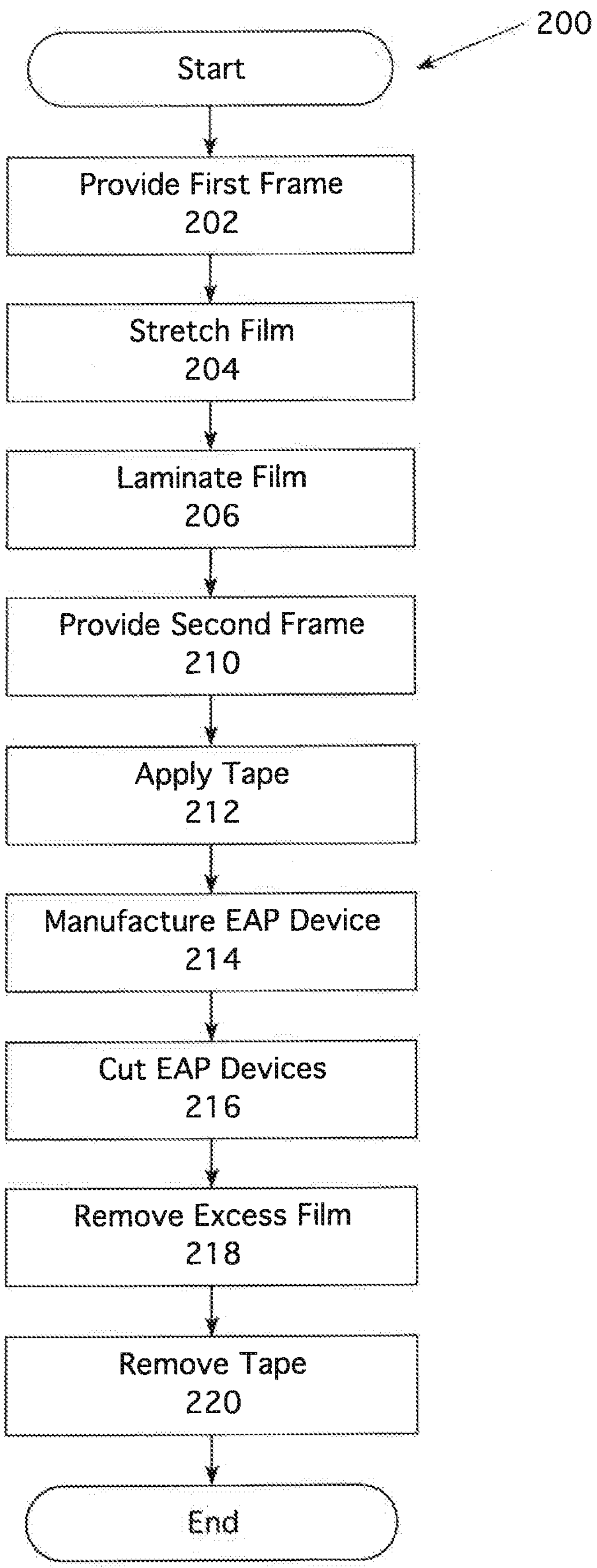
200
Start
Provide First Frame
202
Stretch Film
204
Laminate Film
206
Provide Second Frame
210
Apply Tape
212
Manufacture EAP Device
214
Cut EAP Devices
216
Remove Excess Film
218
Remove Tape
220
End

FIG. 5

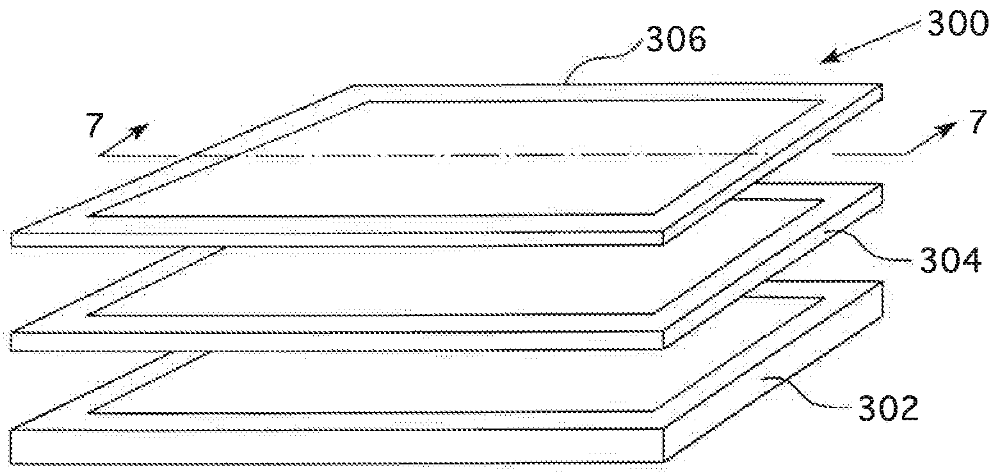

FIG. 6

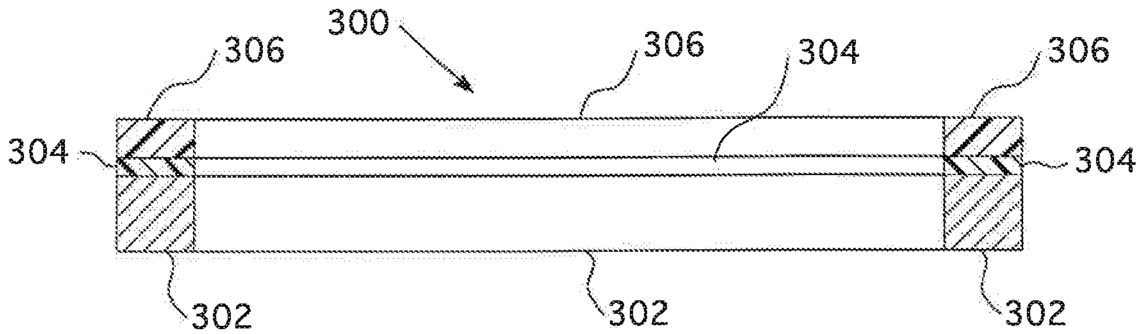

FIG. 7

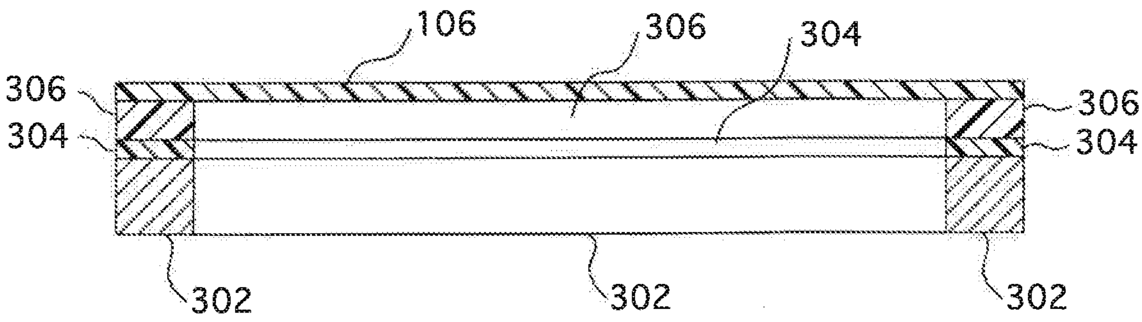

FIG. 8

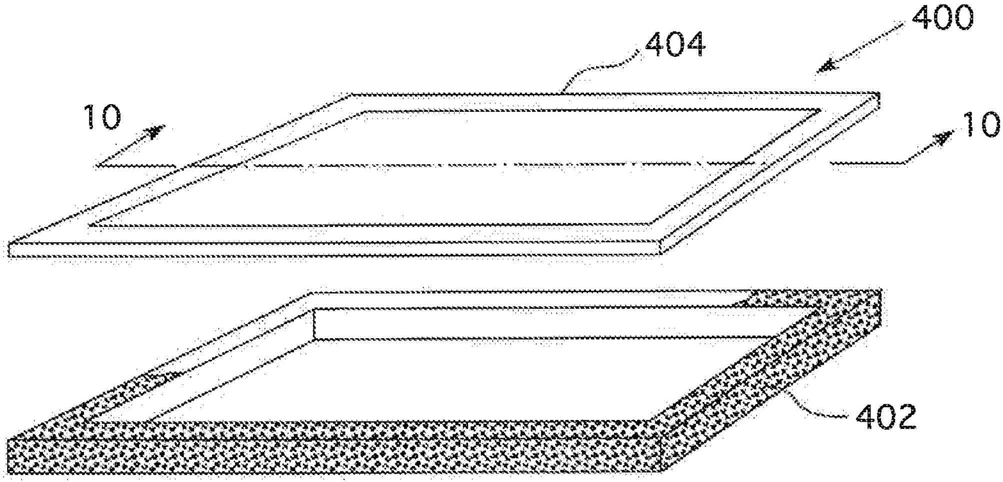

FIG. 9

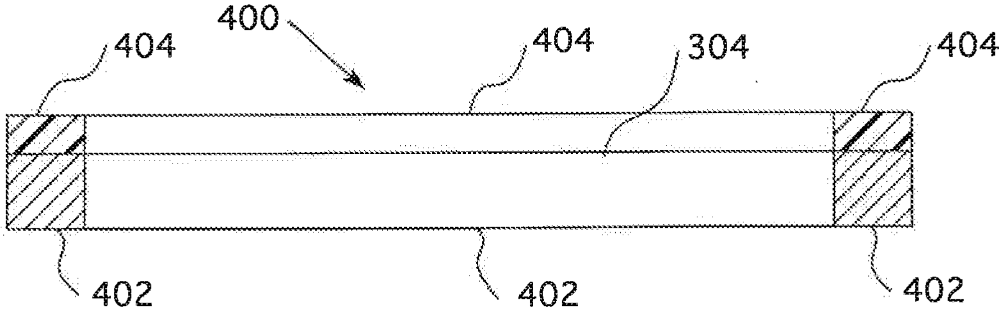

FIG. 10

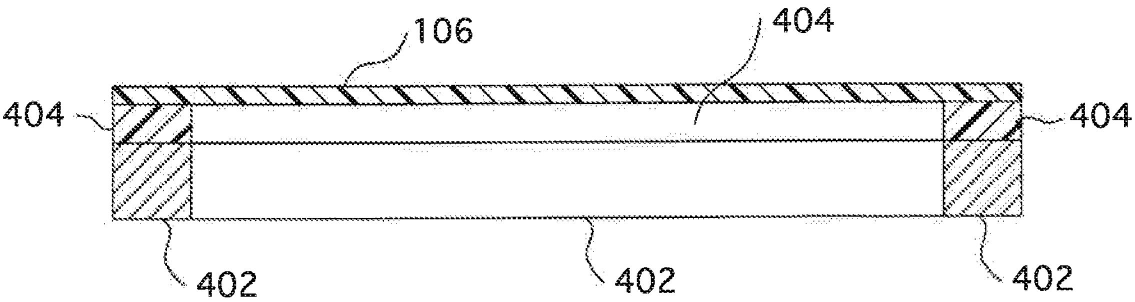

FIG. 11

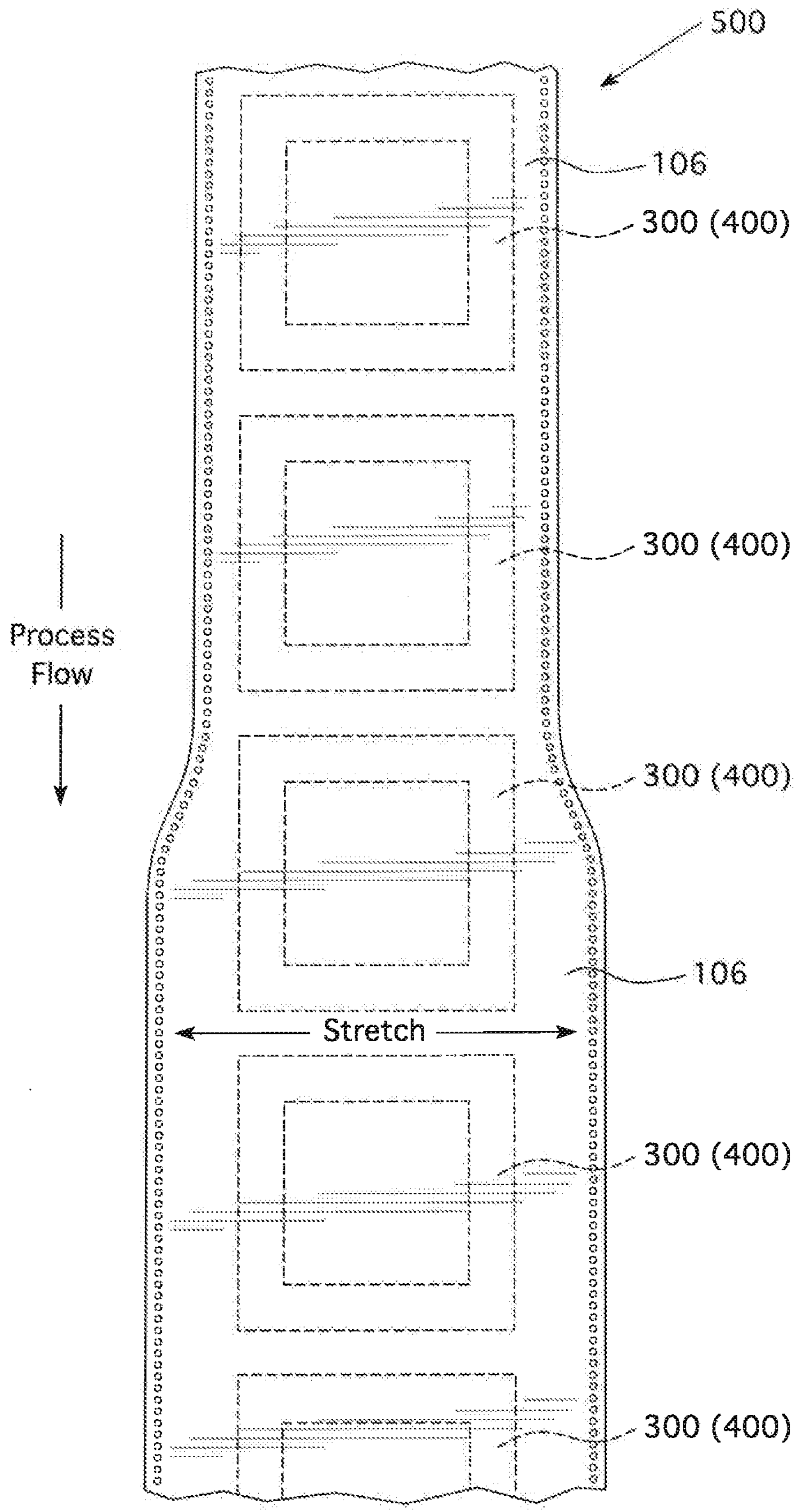
500
106
300 (400)
300 (400)
Process
Flow
300 (400)
106
Stretch
300 (400)
300 (400)

FIG. 12

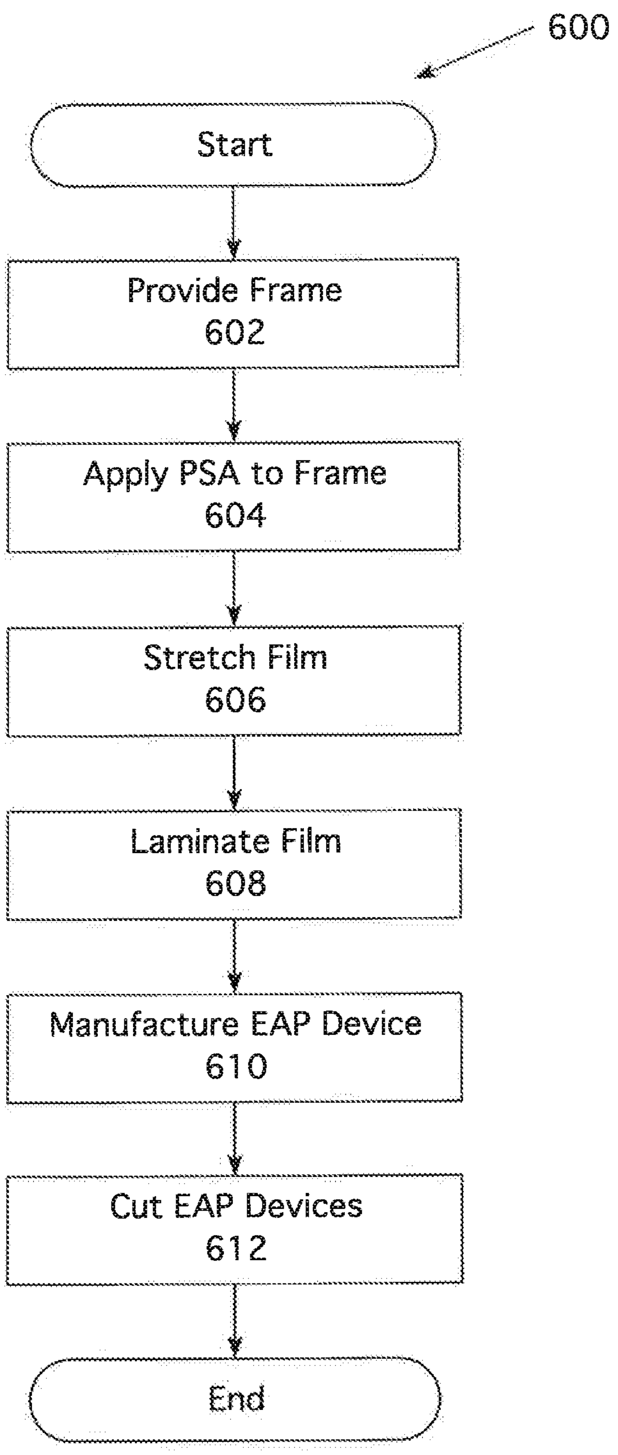
600
Start
Provide Frame
602
Apply PSA to Frame
604
Stretch Film
606
Laminate Film
608
Manufacture EAP Device
610
Cut EAP Devices
612
End

FIG. 13

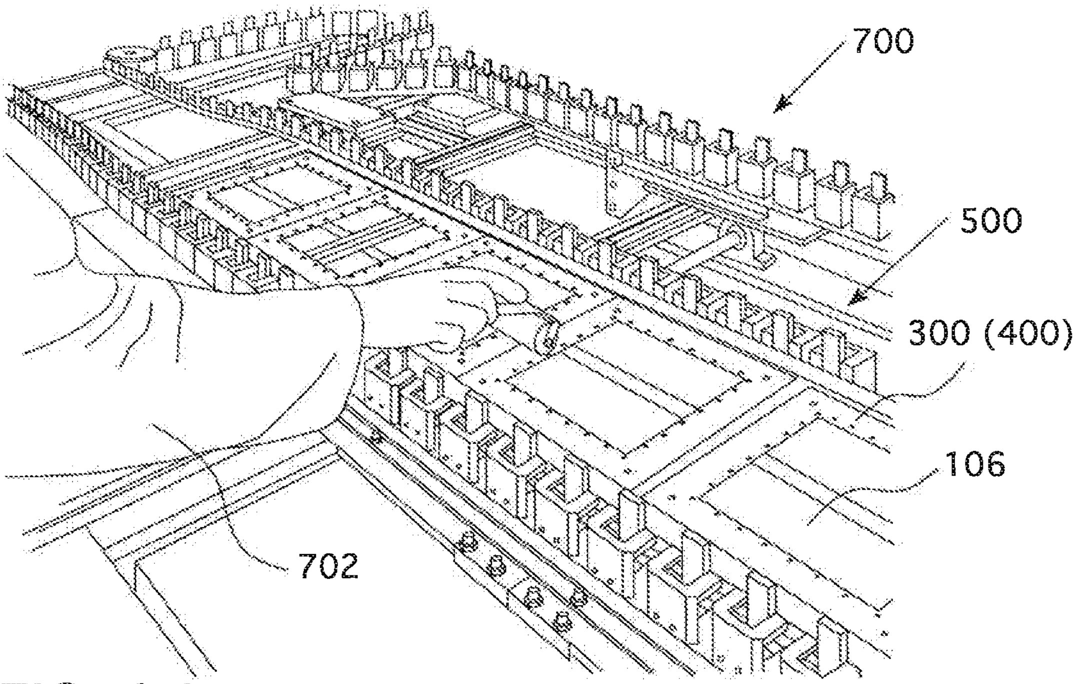

FIG. 14

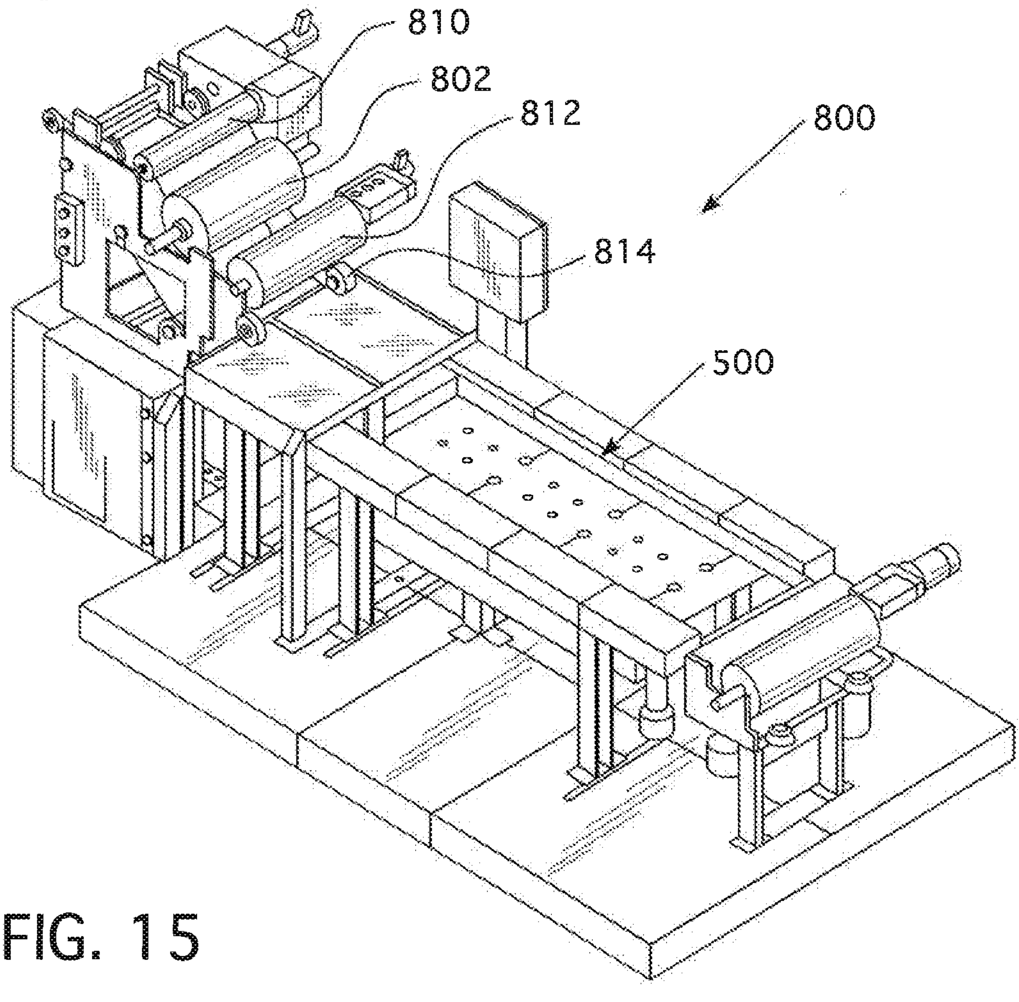

FIG. 15

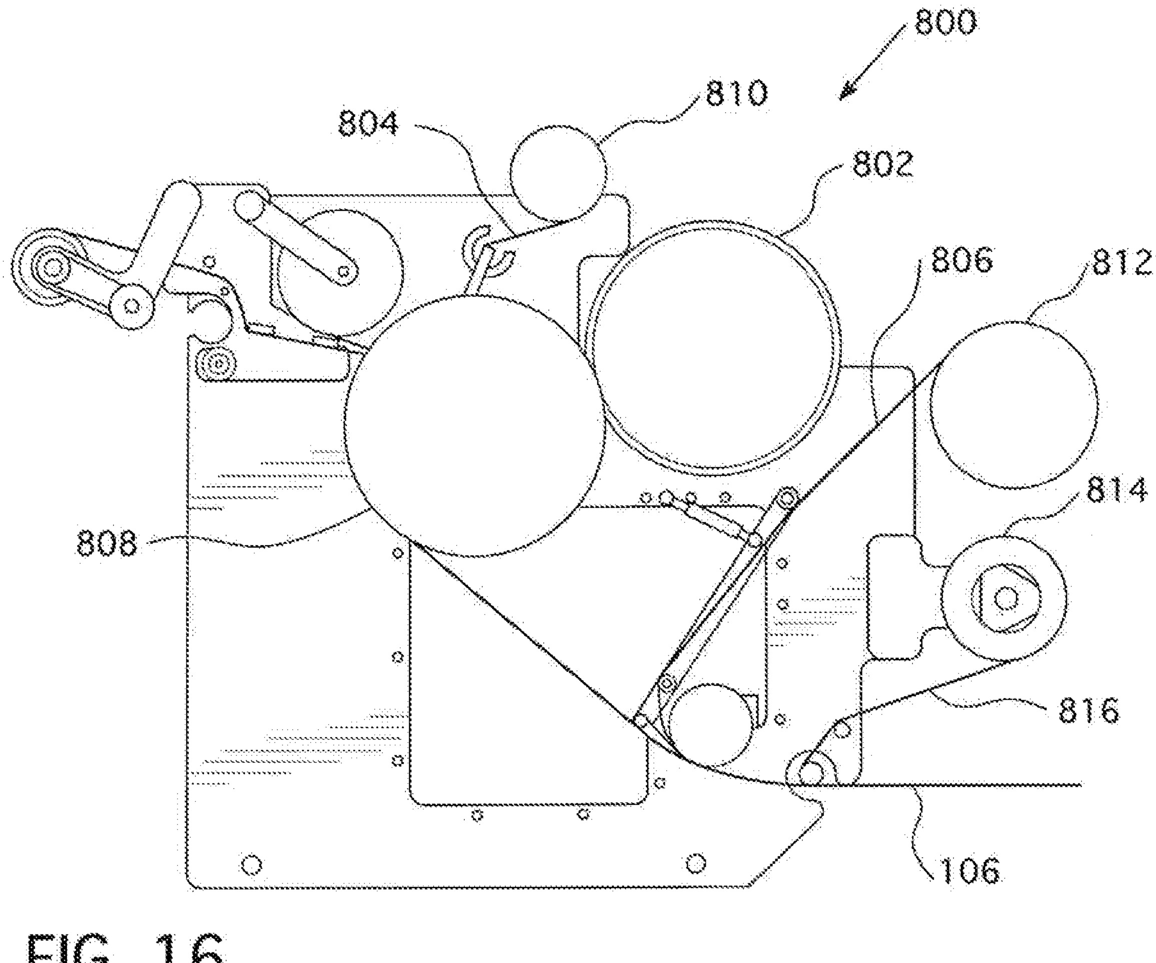

FIG. 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/046248

A. CLASSIFICATION OF SUBJECT MATTER

H01L 41/08(2006.01)i, H04R 17/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L 41/08; H04R 25/00; G03F 1/00; G03F 9/00; B32B 37/02; B32B 38/12; G03F 1/14; H04R 17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: frame, adhesive, pre-strained, film, pressure sensitive adhesive, release coating, electroactive polymer device

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009-0246646 A (YUICHI HAMADA) 01 October 2009	1-3,15
	See abstract; claim 1; paragraph [0028]; and figure 1.	
A		4-7,16,17
A	US 2011-0155307 A1 (RONALD E. PELRINE et al.) 30 June 2011 See abstract; claims 1, 10; paragraph [0113]; and figure 2J.	1-7,15-17
A	US 2010-0330466 A1 (TORU SHIRASAKI et al.) 30 December 2010 See claim 12; paragraph [0035]; and figure 1.	1-7,15-17
A	US 7567681 B2 (RONALD E. PELRINE et al.) 28 July 2009 See abstract; claim 1; and figures 1A, 1B.	1-7,15-17
A	JP 2006-178434 A (ASAHI KASEI ELECTRONICS CO., LTD.) 06 July 2006 See abstract; claims 1, 2; and figures 1, 2.	1-7,15-17

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 November 2013 (13.11.2013)	**15 November 2013 (15.11.2013)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
LEE, Dong Yun
Telephone No. +82-42-481-8734

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/046248

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 9-14
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claims 9-14 are unclear because they refer to multiple dependent claim 8 which does not comply with PCT Rule 6.4(a).

3. ☒ Claims Nos.: 8
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0246646 A1	01/10/2009	CN 101551587 A	07/10/2009
		CN 101551587 B	15/02/2012
		EP 2107421 A2	07/10/2009
		EP 2107421 A3	17/03/2010
		HK 1132338 A1	14/09/2012
		JP 05134418 B2	30/01/2013
		JP 2009-251022 A	29/10/2009
		KR 10-2009-0105809 A	07/10/2009
		TW 200942964 A	16/10/2009
		TW I392958 B	11/04/2013
		US 8026023 B2	27/09/2011
US 2011-0155307 A1	30/06/2011	AU 2000-62308 A1	05/02/2001
		AU 2000-70520 A1	05/02/2001
		AU 2001-252883 A8	20/08/2001
		AU 2001-268027 A8	12/09/2001
		AU 2001-280428 A8	30/10/2001
		AU 2001-38675 A1	03/09/2001
		AU 2001-49058 A1	20/08/2001
		AU 2001-52883 A1	20/08/2001
		AU 2001-68027 A1	12/09/2001
		AU 2001-80428 A1	30/10/2001
		AU 2003-223231 A1	31/12/2003
		AU 2003-225913 A1	08/10/2003
		EP 1212800 A1	12/06/2002
		EP 1212800 B1	12/12/2007
		EP 1221180 A2	10/07/2002
		EP 1221180 B1	08/09/2010
		EP 1259992 A2	27/11/2002
		EP 1259992 B1	05/10/2011
		EP 1371130 A2	17/12/2003
		EP 1481467 A1	01/12/2004
		EP 1481467 B1	09/06/2010
		EP 1512215 A1	09/03/2005
		EP 1512215 B1	17/08/2011
		EP 1602135 A2	07/12/2005
		EP 1602135 B1	10/11/2010
		EP 1783843 A2	09/05/2007
		EP 1848046 A2	24/10/2007
		EP 1848046 A3	15/04/2009
		EP 1848046 B1	03/10/2012
		EP 2276163 A1	19/01/2011
		EP 2290721 A1	02/03/2011
		EP 2299585 A1	23/03/2011
		EP 2299585 B1	03/07/2013
		EP 2317639 A1	04/05/2011
		EP 2362458 A2	31/08/2011
		EP 2362458 A3	09/05/2012
		JP 04408415 B2	03/02/2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		JP 04939577 B2	30/05/2012
		JP 05022705 B2	12/09/2012
		JP 2003-505865 A	12/02/2003
		JP 2003-506858 A	18/02/2003
		JP 2003-526213 A	02/09/2003
		JP 2005-522162 A	21/07/2005
		JP 2005-527178 A	08/09/2005
		JP 2006-520180 A	31/08/2006
		JP 2009-267429 A	12/11/2009
		JP 2010-004736 A	07/01/2010
		JP 2010-226949 A	07/10/2010
		JP 2011-087460 A	28/04/2011
		JP 2011-236916 A	24/11/2011
		JP 2012-095527 A	17/05/2012
		JP 2013-102681 A	23/05/2013
		US 2001-0026165 A1	04/10/2001
		US 2001-0032663 A1	25/10/2001
		US 2001-0036790 A1	01/11/2001
		US 2002-0008445 A1	24/01/2002
		US 2002-0050769 A1	02/05/2002
		US 2002-0122561 A1	05/09/2002
		US 2002-0130673 A1	19/09/2002
		US 2002-0175594 A1	28/11/2002
		US 2002-0175598 A1	28/11/2002
		US 2002-0185937 A1	12/12/2002
		US 2003-0006669 A1	09/01/2003
		US 2003-0141473 A1	31/07/2003
		US 2003-0214199 A1	20/11/2003
		US 2004-0008853 A1	15/01/2004
		US 2004-0124738 A1	01/07/2004
		US 2004-0217671 A1	04/11/2004
		US 2004-0263028 A1	30/12/2004
		US 2006-0113878 A1	01/06/2006
		US 2006-0113880 A1	01/06/2006
		US 2006-0119225 A1	08/06/2006
		US 2006-0158065 A1	20/07/2006
		US 2006-0238079 A1	26/10/2006
		US 2006-0290241 A1	28/12/2006
		US 2007-0164641 A1	19/07/2007
		US 2007-0200467 A1	30/08/2007
		US 2007-0222344 A1	27/09/2007
		US 2007-0290577 A1	20/12/2007
		US 2008-0022517 A1	31/01/2008
		US 2008-0136052 A1	12/06/2008
		US 2008-0191585 A1	14/08/2008
		US 2008-0245985 A1	09/10/2008
		US 2008-0252176 A1	16/10/2008
		US 2009-0184606 A1	23/07/2009
		US 2009-0200501 A1	13/08/2009
		US 2010-0013356 A1	21/01/2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		US 2010-0026143 A1	04/02/2010
		US 2010-0176322 A1	15/07/2010
		US 2010-0263181 A1	21/10/2010
		US 2011-0025170 A1	03/02/2011
		US 2011-0154641 A1	30/06/2011
		US 6343129 B1	29/01/2002
		US 6376971 B1	23/04/2002
		US 6543110 B1	08/04/2003
		US 6545384 B1	08/04/2003
		US 6583533 B2	24/06/2003
		US 6586859 B2	01/07/2003
		US 6628040 B2	30/09/2003
		US 6664718 B2	16/12/2003
		US 6806621 B2	19/10/2004
		US 6809462 B2	26/10/2004
		US 6812624 B1	02/11/2004
		US 6882086 B2	19/04/2005
		US 6891317 B2	10/05/2005
		US 6911764 B2	28/06/2005
		US 7049732 B2	23/05/2006
		US 7052594 B2	30/05/2006
		US 7062055 B2	13/06/2006
		US 7064472 B2	20/06/2006
		US 7166953 B2	23/01/2007
		US 7199501 B2	03/04/2007
		US 7211937 B2	01/05/2007
		US 7224106 B2	29/05/2007
		US 7233097 B2	19/06/2007
		US 7259503 B2	21/08/2007
		US 7320457 B2	22/01/2008
		US 7362032 B2	22/04/2008
		US 7378783 B2	27/05/2008
		US 7394182 B2	01/07/2008
		US 7411332 B2	12/08/2008
		US 7456549 B2	25/11/2008
		US 7468575 B2	23/12/2008
		US 7537197 B2	26/05/2009
		US 7608989 B2	27/10/2009
		US 7703742 B2	27/04/2010
		US 7705521 B2	27/04/2010
		US 7761981 B2	27/07/2010
		US 7898159 B2	01/03/2011
		US 7911115 B2	22/03/2011
		US 7923064 B2	12/04/2011
		US 7971850 B2	05/07/2011
		US 8042264 B2	25/10/2011
		US 8093783 B2	10/01/2012
		US 8508109 B2	13/08/2013
		WO 01-06575 A1	25/01/2001
		WO 01-06579 A3	31/01/2002

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		WO 01-58973 A2	16/08/2001
		WO 01-58973 A3	26/04/2001
		WO 01-59852 A2	16/08/2001
		WO 01-59852 A3	21/02/2002
		WO 01-63738 A2	30/08/2001
		WO 01-63738 A3	21/02/2002
		WO 01-65615 A2	07/09/2001
		WO 01-65615 A3	06/06/2002
		WO 01-80284 A2	25/10/2001
		WO 01-80284 A3	20/02/2003
		WO 02-071592 A2	12/09/2002
		WO 02-071592 A3	23/10/2003
		WO 03-081762 A1	02/10/2003
		WO 03-107523 A1	24/12/2003
		WO 2004-079832 A2	16/09/2004
		WO 2004-079832 A3	21/10/2004
		WO 2007-100606 A2	07/09/2007
		WO 2007-100606 A3	02/05/2008
US 2010-0330466 A1	30/12/2010	CN 101930165 A	29/12/2010
		CN 101930165 B	15/05/2013
		EP 2267526 A2	29/12/2010
		EP 2267526 A3	16/01/2013
		JP 2011-007934 A	13/01/2011
		KR 10-2010-0138821 A	31/12/2010
		TW 201111906 A	01/04/2011
		US 8221944 B2	17/07/2012
US 7567681 B2	28/07/2009	AU 2004-315868 A1	01/09/2005
		AU 2004-315868 B2	28/05/2009
		CA 2537244 A1	01/09/2005
		DK 1665880 T3	25/02/2013
		EP 1665880 A2	07/06/2006
		EP 1665880 A4	11/05/2011
		EP 1665880 B1	05/12/2012
		ES 2398525 T3	19/03/2013
		JP 04875982 B2	15/02/2012
		JP 2007-534283 A	22/11/2007
		PT 1665880 E	04/02/2013
		US 2005-0157893 A1	21/07/2005
		US 2008-0289952 A1	27/11/2008
		US 7787646 B2	31/08/2010
		WO 2005-079187 A2	01/09/2005
		WO 2005-079187 A3	08/11/2007
JP 2006-178434 A	06/07/2006	None	