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(71) Applicant *(for all designated States except US)*: **3M INNOVATIVE PROPERTIES COMPANY** [US/US]; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **PETERSON, Mary, M.** [US/US]; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(74) Agents: **CAPAN, Elizabeth S.** et al.; 3M Center Office of Intellectual Property Counsel, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

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(54) **Title**: ADHESIVE ARTICLE FOR THREE-DIMENSIONAL APPLICATIONS

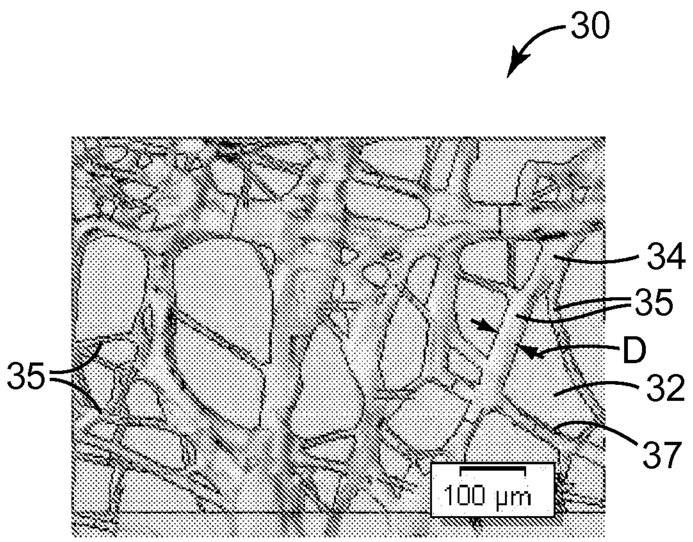

FIG. 3

(57) **Abstract**: The present disclosure relates to an adhesive article comprising a heat-bondable adhesive layer having a first surface, and a first discontinuous pressure sensitive adhesive layer disposed upon a first portion of the first surface of the heat-bondable adhesive layer. Methods for making such adhesive articles are also described.

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ADHESIVE ARTICLE FOR THREE-DIMENSIONAL APPLICATIONS

Technical Field

[0001] The present disclosure relates to adhesive articles comprising a heat-bondable adhesive film with one or more layer(s) of pressure sensitive adhesive on one or both surfaces of the heat-bondable adhesive film. The adhesive articles are primarily intended for fabric or textile bonding, but are also suitable for many other substrates, particularly porous or textured substrates.

Background

[0002] Although heat-bondable adhesive films provide good strength and durability, they are typically not tacky at room temperature. This makes pre-assembly of parts difficult and often causes movement and/or misalignment during the bonding process, which can result in poor quality of the finished product and waste. The lack of adherence to the substrate prior to heat bonding also limits the use of such heat-bondable adhesive films to flat or substantially two-dimensional bonding processes that rely on gravity to maintain placement of the bonding film and substrates. This limitation restricts the applications in which heat-bondable adhesive films can be used, particularly in footwear and apparel manufacturing, thus also limiting the designs and types of footwear and apparel that can be manufactured.

[0003] Attempts have been made to use a pressure sensitive adhesive (PSA) alone or as a continuous layer on a heat-bondable adhesive film to remedy these difficulties. The room temperature tack of a PSA layer allows for pre-assembly of parts and assures alignment throughout the production process. However, both the PSA alone and the continuous PSA layer on heat-bondable adhesive films present problems as well.

[0004] PSA materials alone typically have neither sufficient cohesive strength nor adequate water resistance for the demanding applications of textile bonding in which water resistance is a common requirement and the flexibility of the substrates typically results in mixed stresses, such as peel and shear. In the case of a heat-bondable film with a continuous layer of PSA, the continuous PSA layer prevents the heat-bondable adhesive film layer from adequately contacting the substrate and, therefore, these constructions are not able to provide a strong or durable bond. Additionally, the PSA may ooze out of the seam line or penetrate through the fabric creating a tacky fabric surface. Such effects are very undesirable, particularly for textile applications where use of PSA alone or a continuous PSA layer on a heat-bondable adhesive film can result in uncomfortable or unsightly apparel and textiles that collect lint or debris.

[0005] Attempts have also been made to apply a discontinuous PSA layer to heat-bondable adhesive films, but such attempts remain imperfect because most do not provide sufficient bond strength in the finished article, particularly in fabric applications.

[0006] Accordingly, there is still a need for adhesive films that can provide room temperature tack to allow adequate positioning of materials during manufacture and reduce waste while also providing sufficient bond strength in the finished product. Specifically, there is a need for adhesive films that provide these characteristics when bonding articles other than hard surfaces. For instance, there is a need for adhesive films with these characteristics that can bond flexible materials, including, but not limited to, textiles, leather, fabrics, nonwovens, foams, and films.

Summary

[0007] In one aspect, the present disclosure provides an adhesive article comprising a heat-bondable adhesive layer having a first surface, and a first discontinuous pressure sensitive adhesive layer disposed upon a first portion of the first surface of the heat-bondable adhesive layer. In some embodiments, the first portion of the first surface comprises from about 12% to less than 100% of the first surface. In some embodiments, the adhesive article comprises a heat-bondable adhesive layer having a first surface, and a first discontinuous pressure sensitive adhesive layer disposed upon a first portion of the first surface of the heat-bondable adhesive layer; wherein the first discontinuous pressure sensitive adhesive layer comprises a web of pressure sensitive adhesive microfibers having an average diameter of from about 10 μm to about 200 μm.

[0008] In some embodiments, the first discontinuous pressure sensitive adhesive layer comprises a web of pressure sensitive adhesive strands. In some embodiments, the adhesive strands have an average diameter of from about 10 μm to about 200 μm. In some embodiments, the first discontinuous pressure sensitive adhesive layer comprises a perforated sheet of pressure sensitive adhesive comprising a plurality of voids. In some embodiments, the discontinuous pressure sensitive adhesive layer comprises a plurality of independent pressure sensitive adhesive islands. In some embodiments, the adhesive article has, after bonding, a fabric lap shear bond strength resulting in fabric failure or a fabric lap shear bond strength of at least 1.0 MPa, when measured on polyester substrates at room temperature according to ASTM D1002-10the Fabric Lap Shear Test. In some embodiments, the adhesive article has, after bonding, a T-peel bond strength resulting in fabric failure or a reduction in T-peel bond strength, as compared to the bare heat-bondable adhesive without PSA, of 25% or less, as measured on fabric substrates at room temperature according to ASTM D1876-01the 180 Degree T-Peel Test.

[0009] In another aspect, the adhesive article further comprises a second surface, wherein the first surface and the second surface are on opposite faces of the heat-bondable adhesive layer. In some embodiments, the adhesive article may comprise a second discontinuous pressure sensitive adhesive disposed upon a first portion of the second surface of the heat-bondable adhesive layer.

[0010] In some embodiments, the adhesive article may comprise at least one finished layer disposed upon at least a portion of the layer selected from the group consisting of the first discontinuous pressure sensitive adhesive layer, the heat-bondable adhesive layer, the second discontinuous pressure sensitive

adhesive layer, and combinations thereof. In some embodiments, the at least one finished layer is selected from the group consisting of a fabric, a foam, a nonwoven, a film, and combinations thereof.

[0011] In some embodiments, the heat-bondable adhesive layer may comprise one or more heat-bondable adhesive layers. In some embodiments, the first and second discontinuous pressure sensitive adhesive layers may each independently comprise one or more pressure sensitive adhesive layers. In some embodiments, the pressure sensitive adhesive is repositionable. In some embodiments, the invention comprises a footwear article comprising the adhesive article. In some embodiments the footwear article comprises a seam bonded by the adhesive article. In some embodiments, the invention comprises a fabric article comprising the adhesive article. In some embodiments the fabric article comprises a seam bonded by the adhesive article. In some embodiments, the invention comprises an article comprising (i) the adhesive article of claim 1; and (ii) a substrate selected from the group comprising a fabric, a foam, a non-woven, a film, and combinations thereof; wherein the adhesive article contacts the substrate or is bonded to the substrate. In some embodiments, the article is a footwear article or an apparel article.

[0012] In yet another aspect, the present disclosure relates to processes for producing adhesive articles of the present disclosure. In some embodiments, a process for producing an adhesive article comprises attaching a first portion of a first surface of a heat-bondable adhesive layer to a first discontinuous pressure sensitive adhesive layer. In some embodiments, the attaching comprises laminating a discontinuous pressure sensitive adhesive layer to the first portion of the first surface of the heat-bondable adhesive layer, wherein the heat-bondable adhesive layer and the discontinuous pressure sensitive adhesive layer are each independently preformed. In some embodiments, the attaching comprises forming the discontinuous pressure sensitive adhesive layer directly on the first portion of the first surface of the heat-bondable adhesive layer, and wherein the heat-bondable adhesive layer is preformed. In some embodiments, the attaching comprises forming the first portion of the first surface of the at least one heat-bondable adhesive layer directly on the discontinuous pressure sensitive adhesive layer, and wherein the discontinuous pressure sensitive adhesive layer is preformed.

[0013] In some embodiments, the process further comprises attaching a second discontinuous pressure sensitive adhesive layer to a second portion of a second surface of the heat-bondable adhesive layer, wherein the first surface and the second surface are on opposite faces of the heat-bondable adhesive layer. In some embodiments, the process further comprises attaching at least one finished layer to at least a portion of a layer selected from the group consisting of the first discontinuous pressure sensitive adhesive layer, the second discontinuous pressure sensitive adhesive layer, the heat-bondable adhesive layer, and the combination thereof. In some embodiments, the at least one finished layer is selected from the group consisting of a fabric, a foam, a nonwoven, a film, and combinations thereof.

Brief Description of Drawings

[0014] FIG. 1A is a side cross section schematic of an exemplary adhesive article according to some embodiments of the present disclosure.

[0015] FIG. 1B is a top view schematic of the adhesive article of **FIG. 1A**.

[0016] FIG. 2A is a side cross section schematic of an exemplary adhesive article of another embodiment of the present disclosure.

[0017] FIG. 2B is a top view schematic of the adhesive article of **FIG. 2A**.

[0018] FIG. 3 is a top view photomicrograph of an exemplary adhesive article according to some embodiments of the present disclosure.

[0019] FIG. 4 is a side cross section schematic of a finished adhesive article according to some embodiments of the present disclosure.

Detailed Description

[0020] Generally, the adhesive articles of the present disclosure comprise a layer of a heat-bondable adhesive and discontinuous layer of a pressure sensitive adhesive. Examples of such adhesive articles include the following.

[0021] FIG. 1A is a side cross section schematic of a first exemplary adhesive article **10** according to some embodiments of the present disclosure. Adhesive article **10** comprises heat-bondable adhesive layer **12** with first surface **18** and second surface **19**. Discontinuous pressure sensitive adhesive (PSA) layer **14** is disposed upon first portion **16** of first surface **18** of heat-bondable adhesive layer **12**. First portion **16** corresponds to the area of first surface **18** of heat-bondable adhesive layer **12** that is covered by the PSA. As shown in the top view of adhesive article **10** (**FIG. 1B**), discontinuous PSA layer **14** comprises voids **17** through which the heat-bondable adhesive layer **12** on which the PSA layer is disposed is exposed.

[0022] FIG. 2A is a side cross section schematic of a second exemplary adhesive article **20**. Adhesive article **20** comprises heat-bondable adhesive layer **22** with first surface **28** and second surface **29**. Discontinuous PSA layer **24** is disposed upon first portion **26** of first surface **28** of heat-bondable adhesive layer **22**. As shown in the top view of adhesive article **20** (**FIG. 2B**), discontinuous PSA layer **24** comprises islands of the PSA separated by exposed (i.e., uncovered) regions of heat-bondable adhesive layer **22**.

[0023] FIG. 3 is a top view photomicrograph of a third exemplary adhesive article **30** comprising discontinuous PSA layer **34** comprising voids **37** through which heat-bondable adhesive layer **32** is exposed. Discontinuous PSA layer **34** comprises a web of pressure sensitive adhesive fibers **35** having a diameter **D**.

[0024] Heat-bondable Adhesive Layer. The heat-bondable adhesive layer can be any suitable film comprising heat-bondable adhesive materials. As used herein, “heat-bondable” means that the adhesive layer forms a bond to one or more surfaces when heated and that the bond formed can be released upon subsequent heating. As opposed to PSAs, generally, heat-bondable adhesives have insufficient room temperature tack to bond to substrates. In addition, unlike thermosetting adhesives, the bond formed by a heat-bondable adhesive is reversible.

[0025] Heat-bondable adhesives are known to those skilled in the art and include, e.g., thermoplastics. Generally, the heat-bondable adhesive can be selected for the particular application intended. Suitable heat-bondable adhesives include fabric bonding films such as those available from 3M Company (St. Paul, MN), Bemis Associates (Shirley, MA), Framis Italia (Gaggiano, Italy), and Sealon (Seoul, Korea). Exemplary materials suitable for use as a heat-bondable layer include polyurethanes, nylons (polyamides), polyesters, vinyls, ethylene vinyl acetates, and polyolefins

[0026] In some embodiments, the heat-bondable adhesive is flexible and creates a flexible bond upon heating. In some embodiments the final bond created by the heat-bondable adhesive layer exhibits elastic or stretch characteristics. In some embodiments, the heat-bondable adhesive layer is capable of being melted such that it can flow into substrates such as textiles, non-wovens, and foams while bonding.

[0027] In some embodiments the heat-bondable adhesive layer can comprise multiple heat-bondable layers. The multiple heat-bondable layers can each comprise the same or different heat-bondable compositions. In some embodiments, the heat-bondable layer can comprise an additional non-adhesive layer depending upon the needs of the intended application. The additional non-adhesive layer can comprise, e.g., an elastic layer or a structural layer (e.g., a polymeric film, a foil, or scrim).

[0028] Pressure Sensitive Adhesive (PSA) Layer. The PSA layer can comprise any suitable pressure sensitive adhesive material. In some embodiments, the PSA layer comprises pressure sensitive adhesives which exhibit room temperature (e.g., about 20 °C to about 25 °C) tack, as can be determined by a finger tack test or by conventional measurement devices. In some embodiments, the pressure sensitive adhesives can easily form a useful adhesive bond with the application of light pressure and can be applied in a discontinuous manner (either directly or indirectly with secondary lamination to the bonding film).

[0029] An acceptable quantitative description of a pressure-sensitive adhesive is given by the Dahlquist criterion line (as described in the Handbook of Pressure Sensitive Adhesive Technology, Second Edition, D. Satas, ed., Van Nostrand Reinhold, New York, NY 1989, pages 171-176), which typically indicates that materials having a storage modulus (G’) of less than about $3x10^5$ Pascals (measured at 10 radians/second at a temperature of about 20 °C to about 22 °C) have PSA properties while materials having G’ in excess of this value do not.

[0030] Suitable pressure sensitive adhesive materials may comprise those known in the art, such as acrylics, natural or synthetic rubber-based materials, poly(alpha-olefins), and silicones. In some embodiments, the pressure sensitive adhesive material is selected such that, upon contact with a bondable adhesive layer, the pressure sensitive adhesive characteristics of the pressure sensitive adhesive layer and the heat-bondable adhesive characteristics of the bondable adhesive layer are each retained as described above.

[0031] The pressure sensitive adhesive layers of the adhesive articles of the present disclosure are discontinuous. The term "discontinuous" as used herein means that the PSA layer comprises voids such that the layer under the PSA layer (usually the heat-bondable adhesive layer) is not completely covered by the PSA layer. In some embodiments the PSA layer may take the form of islands of PSA disposed upon the heat-bondable adhesive layer. Such islands of PSA may have a specific shape (round dots, stripes, triangles, etc.) or irregular shapes. In other embodiments, the discontinuous PSA layer may be in the form of a sheet of PSA comprising voids through which the heat-bondable adhesive layer is exposed. In some embodiments, the sheet of PSA may be microperforated or microstructured. In still other embodiments, the discontinuous PSA layer may be in the form of a web of pressure sensitive adhesive fibers defining voids through which the heat-bondable adhesive layer is exposed. In some embodiments, the PSA web may be a web of melt-blown, non-woven microfibers.

[0032] The percent coverage of a discontinuous PSA layer can be selected depending on the intended use of the adhesive article. In some embodiments, coverage may be selected to optimize the final bond strength of the finished adhesive article while also providing sufficient adhesive characteristics of the PSA layer to hold the adhesive article in place prior to bonding. In some embodiments, the final bond strength may be comparable to or the same as that provided by the heat bonding layer alone. In some embodiments, the surface coverage of the discontinuous PSA layer is from about 12% to less than 100%, more preferably from about 12% to about 85%, and most preferably from about 30% to about 70%.

[0033] In some embodiments, where the PSA layer comprises a web of fibers of pressure sensitive adhesive, the fiber size can be selected depending on the intended use and the desired final heat bond characteristics. In some embodiments, the pressure sensitive adhesive fibers will have an average diameter of from about 5 micrometers (μm) to about 200 μm, e.g., about 10 to about 200 μm, about 10 to about 100 μm, about 10 to about 50 μm, or even about 10 to 25 μm. In some embodiments, the pressure sensitive adhesive fibers will have an average diameter of no greater than 100 μm, e.g., no greater than 50 μm, or even no greater than 25 μm. Without being bound by theory, it is believed that these diameters of the microfibers allow the use of less overall PSA, while also allowing a greater surface area of PSA to contact the fibers of fabrics, textiles, nonwovens, and other flexible materials that are ordinarily difficult to bond with PSA. This increased contact surface area is believed to result in better room temperature tack for positioning of materials prior to heat-bonding. Further, the ability to use less overall PSA is believed to allow more of the heat-bondable adhesive to participate in the final bond after heat bonding. This is believed to result in strong final bond strengths after bonding, particularly T-peel bond strengths resulting in fabric failure or a reduction in T-peel bond strength, as compared to the bare heat-bondable adhesive without PSA, of 25% or less, 17% or less, 14% or less, 8% or less, and even 0%, as measured on fabric substrates at room temperature according to the 180 Degree T-Peel Test. The use of less overall PSA is also believed to result in strong fabric lap shear bond strengths after bonding, particularly a fabric lap shear bond strength resulting in fabric failure or a fabric lap shear bond strength of at least 1.0 MPa, when measured on polyester substrates at room temperature according to the Fabric Lap Shear Test. Finally, the use of less overall PSA is also believed to result in only small reductions in aluminum lap shear bond strength as compared to the bare heat-bondable adhesive without PSA, with final bond strengths after bonding ranging from 0.60 MPa to less than 1 MPa, 0.64 to less than 1 MPa, 0.71 MPa to less than 1 MPa, 0.74 MPa to less than 1 MPa, 0.75 MPa to less than 1 MPa, or even 0.79 to less than 1 MPa, as measured on aluminum substrates at room temperature according to the Aluminum Lap Shear Test. The use of less overall PSA is also believed to result in fewer problems with remaining room-temperature tack after bonding.

[0034] In some embodiments, the discontinuous PSA layer can be a single layer of pressure sensitive adhesive. In other embodiments, the discontinuous PSA layer can comprise more than one discontinuous PSA layer. In some embodiments, the PSA layer(s) of the present disclosure may, independently, comprise a combination of pressure sensitive adhesive materials, e.g., blends, layers, sheath-core structures, or “island in the sea” type structures. In some embodiments, the PSA layer(s) may, independently, include fibers, such as staple fibers; particulates; non-PSA materials, fillers, tackifiers, and other known additives. Generally, the PSA components will provide at least a portion of the exposed outer surface of a multi-component conjugate structure.

[0035] In some embodiments the PSA layer is unpatterned, meaning that the voids in the PSA layer and the PSA layer itself take on no single, repeated pattern, but instead are randomly placed. **FIG. 3** shows an adhesive article embodiment of the present disclosure comprising a PSA layer with an unpatterned structure. In embodiments where the discontinuous PSA layer comprises islands of PSA, the islands of PSA may also be distributed in a patterned or unpatterned manner.

[0036] The room temperature tack of the adhesive article is affected by the properties and relative surface areas of the PSA layer and the bondable adhesive layer. Generally, these parameters can be selected to meet the needs of the intended use of the adhesive article. In most bonding applications, the tack should be sufficient to hold the adhesive article in place prior to heat bonding. Preferably, the room temperature tack of the adhesive article is at least 4 g, as measured by the tack test described in the examples below.

[0037] In some embodiments, nonwoven or fibrous PSA layers may be preferable as they provide porosity and high PSA surface area and because they possess the desirable characteristics of conformability and good adhesion to irregular surfaces (such as fabrics or textiles). In some embodiments, a fibrous PSA layer is created through melt processes. Melt processes for the preparation of fibers are well-known in the art. For example, such processes are disclosed in Wente, Van A., “Superfine Thermoplastic Fibers,” Industrial Engineering Chemistry, Vol. 48, pp 1342 – 1346 and in Wente, Van A. et al., “Manufacture of Superfine Organic Fibers,” Report No. 4364 of the Naval Research Laboratories, published May 25, 1984, and United States Patent Nos. 3,338,992 (Kinney); 3,502,763 (Hartmann); 3,692,618 (Dorschner et al.); 3,825,379 (Lohkamp et al.); 3,849,241 (Butin et al.); 4,295,809 (Mikami et al.); 4,375,718 (Wadsworth et al.); 4, 405,297 (Appel et al.); 4,818,463 (Buehning); and 4,986,743 (Buehning).

[0038] Such processes include both spunbond processes and melt-blown processes. In some embodiments, a preferred method for the preparation of fibers, particularly microfibers, and nonwoven webs thereof, is a melt-blown process. For example, nonwoven webs of multi-layer microfibers and melt-blown processes for producing them are disclosed in US Patent Nos. 5,176,952 (Joseph et al.); 5,232,770 (Joseph),; 5,238,733 (Joseph et al.); 5,258,220 (Joseph); 5,248,455 (Joseph et al.); and 6,083,856 (Joseph et al.). These and other melt processes can be used in the formation of the nonwoven webs of the present disclosure.

[0039] Melt-blown processes use hot (e.g., about 20 °C to about 30 °C higher than the polymer melt temperature), high-velocity air to draw out and attenuate extruded polymeric material from a die. Generally, the polymeric material solidifies after traveling a relatively short distance from the die. The resultant fibers are termed melt-blown fibers and are generally substantially continuous. They form into a coherent web between the exit of the die orifice and a collecting surface by entanglement of the fibers due in part to the turbulent air stream in which the fibers are entrained.

[0040] The solidified or partially solidified fibers form an inter-locking network of entangled fibers, which are collected as a coherent web. The collecting surface can be a solid or perforated surface in the form of a flat surface or a drum, a moving belt, or the like. If a perforated surface is used, the backside of the collecting surface can be exposed to a vacuum, or low-pressure region to assist in the deposition of the fibers. The collector distance is generally about 7 centimeters (cm) to about 130 cm from the die face. Moving the collector closer to the die face, e.g., about 7 cm to about 30 cm, will result in stronger inter-fiber bonding and a less lofty web.

[0041] The size of the polymeric fibers formed depends to a large extent on the velocity and temperature of the attenuating airstream, the orifice diameter, the temperature of the melt stream, and the overall flow rate per orifice. In some embodiments, the fiber size is from about 10 μm to about 200 μm. In some embodiments, the thickness of the PSA layer may be greater than the diameter of a single PSA fiber, particularly in embodiments where more than one PSA layer (stacking) is utilized. The webs formed can be of any suitable thickness for the desired and intended end use.

[0042] In some embodiments, the PSA layer can be formed by hot melt, aqueous, or solvent spray coating. In some embodiments, handheld can or bulk spray equipment can be used to produce the discontinuous PSA layers of the present disclosure. Continuous, automated spray coating methods such as those enabled by Nordson Corporation (Duluth, GA) adhesive spray equipment may also be used in some embodiments to provide a method for manufacturing discontinuous PSA layers of the present disclosure. In other embodiments, the discontinuous PSA layer may be formed by ink jet printing, screen printing, or coating processes, however, these processes require the use of solvents or water. Also, in utilizing these processes, care must be taken to maintain the particular parameters required for the desired final bond strength.

[0043] The discontinuous PSA layer may be manufactured/applied a substantial time ahead of use with a "permanent" tack PSA or may be applied more immediate to use with a PSA that has a time-limited "open" tack time. Preferred methods would be those that would allow the manufacturing and sale of the discontinuous PSA / bonding film rather than requiring PSA application at the bonding film use location. The step of combining the pressure-sensitive adhesive and the heat-bonding film can occur by directly forming the discontinuous PSA layer on the bonding film (using, e.g., melt blown, spun bond, spray coating, screen printing or the like), by forming the bonding film directly on a preformed discontinuous PSA layer, or by forming the discontinuous PSA layer on a transfer liner and secondarily laminating the PSA to the bonding film.

[0044] Various embodiments of the adhesive articles of the present disclosure can be combined with other substrates to from composite multi-layer structures. Exemplary substrates include webs, nonwoven webs of spun bond, staple and/or melt-blown fibers, fabrics or textiles, such as woven and knit fabrics, as well as films of elastic, semi-permeable, and/or impermeable materials. These other substrates can be selected for a variety of reasons including for increasing the rigidity or strength of the article, providing surface texture, adjusting elasticity, etc. The substrates can be attached to or incorporated in the adhesive articles of the present disclosure using conventional techniques such as laminating, heat bonding, coating, mechanical entanglement, etc. In some embodiments, binders or adhesives may be used to attach adjacent layers.

[0045] Webs or composite structures including the webs of the disclosure can be further processed after collection or assembly, such as by calendaring or point embossing to increase web strength, increase cohesive strength between layers, provide a patterned surface, or fuse fibers at contact points in a web structure or the like to increase internal PSA layer cohesive strength; by orientation to provide increased web strength and/or uniformity; by heat and/or by molding operations; by coating, such as with adhesives or films; or the like.

[0046] In some embodiments, other layers, such as a primer layer, may be interposed between the PSA layer and the heat-bondable adhesive layer, but such layers should also be discontinuous or permeable to the heat bonding layer when it is heated.

[0047] Some embodiments of the present disclosure also include finished articles comprising the adhesive article. In some embodiments, finished articles may include the adhesive article bonded, on one or both sides, to a finished layer. In some embodiments, the finished layer is selected from a fabric, foam, non-woven, film, or combinations thereof. Other finished layers may include elastic, reflective, or decorative materials, or materials that impart desired structural properties such as stiffness.

[0048] **FIG. 4** is a side cross section schematic of exemplary finished adhesive article **40** comprising heat-bondable adhesive layer **42** with first surface **48** and second surface **49**. Discontinuous pressure sensitive adhesive (PSA) layer **44** is disposed upon first portion **46** of first surface **48** of heat-bondable adhesive layer **42**. Finished layer **43** is disposed upon second surface **49** of heat-bondable adhesive layer **42**.

[0049] In some embodiments, one or more additional discontinuous PSA layer(s), discontinuous primer layer(s), or other discontinuous layers may be disposed between the adhesive article and the finished layer. A backing may be used on one or both sides of the adhesive article, attached directly to the heat-bondable adhesive layer, attached directly to the PSA layer, or combinations thereof. Suitable backings metallic foils, polymer films, and releasable materials.

[0050] A release material may be coated onto at least one layer of the adhesive article, such as the heat-bondable adhesive layer or the discontinuous PSA layer, to form a low adhesion backing (LAB). Alternatively, a release liner having differential release characteristics may be employed on one or both sides of the adhesive article. Suitable materials for use as LAB and release liners are well known to those skilled in the art and include silicones and fluoropolymeric materials. The thickness of the release material, as well as the release value of an adhesive to the release material, may be varied depending upon the intended application

[0051] Some embodiments of the disclosure also include a finished tape comprising an adhesive article attached to a releasable backing, comprising a finished article comprising an adhesive article and one or more finished layers as described above, or comprising a finished article comprising an adhesive article and one or more finished layers as described above attached to a releasable backing.

[0052] The articles of the present disclosure can be particularly useful in fabric and textile bonding applications, such as in apparel or footwear seam bonding. However, the articles of the present disclosure are also useful in other bonding applications, particularly in three-dimensional, non-flat bonding applications and in applications for bonding porous or textured surfaces, or applications requiring flexibility or stretchibility of the final adhesive bond.

Examples

[0053] The following examples are merely for illustrative purposes and are not meant to limit in any way the scope of the appended claims. Advantages and embodiments of this disclosure are further illustrated by the following examples, but the particular materials and amounts thereof recited in these examples, as well as other conditions and details, should not be construed to unduly limit this disclosure.

[0054] Samples were cut from the fabric materials listed in Table 1A.

Table 1A: Fabric descriptions.

Fabric	Description	Composition	Orientation
1	PET Felt	100% recycled polyester (Ecofi)	face-to-face
2	Synthetic leather to 3-dimensional polyester mesh	Leather: 100% polyurethane Mesh: 100% polyester	back-to-face
3	Grey olefin nonwoven	100% olefin	face-to-face
4	Pink print interlock knit	100% cotton	face-to-face
5	WHITESTAR #442	82.62% nylon / 17.38% spandex	face-to-face
6	#7857 (Elastic Fabrics America)	74% polyester, 26% spandex	face-to-face
7	Beige striped woven	74% rayon / 22% nylon / 4% spandex	face-to-face (printed)
8	Blue plaid flannel	100% cotton	face-to-face
9	Blue plaid woven shirt fabric	100% cotton	face-to-face
10	Denim	100% cotton, distressed finish	face-to-face (darker blue)
11	Green satin	100% acetate	face-to-face (shiny surface)
12	Red plaid woven	65% polyester / 35% rayon	face-to-face
13	Red woven	81% polyester / 15% rayon / 4% spandex	face-to-face
14	Aluminum coated	100% cotton / aluminum vapor coating	face-to-face (silver side)
15	Wool felt	35% wool / 65% rayon	face-to-face
16	AT3828AKS (polyester 3-layer)	Face: PE taffeta; 100% polyester Waterproof membrane: 100% polyurethane Lining: Tricot, 100% nylon	face-to-face
17	MAXKIN synthetic leather	60 - 70% polyester / 30 -40% spandex, polyurethane coated	face-to-face
18	Mocha color, coated fabric	PVC / PP back	face-to-face (coated)
19	Red, black plaid wool	100% wool	face-to-face
20	AT3660AX (nylon 3-layer)	Face: FT rip stop; 100% nylon Waterproof membrane: 100% polyurethane Lining: Tricot, 100% nylon	face-to-face
21	AL3822AKY (polyester 2-layer)	Face: PE micro taffeta; 100% polyester Waterproof membrane: 100% polyurethane	face-to-face
22			back-to-back
23	SUNBRELLA white woven	100% acrylic	face-to-face

[0055] An adhesive film was layered between fabric samples and bonded with a heated platen press. The temperature of the top and bottom platens, pressure applied, and length of time were all controlled and recorded. First, bonding conditions for each fabric combination were optimized using 3M 7016 bonding film (a heat-bondable layer without a PSA) to maximize bond strength while minimizing heat effects upon the fabrics. The optimal bonding conditions for each fabric are shown in Table 1B. These optimal bonding conditions for each specific fabric combination were then used to bond all exemplary adhesive materials to those fabrics and the results were compared directly to the results obtain using the 3M 7016 bonding film alone.

[0056] Table 1B: Optimal bonding conditions.

Fabric #	**Platen Temp.**		**Dwell (sec.)**
	Top	Bottom	
1	135 °C	149 °C	5
2	141 °C	Off	40
3	149 °C	163 °C	5
4	149 °C	163 °C	10
5	149 °C	163 °C	10
6	149 °C	163 °C	20
7	149 °C	163 °C	20
8	149 °C	163 °C	20
9	149 °C	163 °C	20
10	149 °C	163 °C	20
11	149 °C	163 °C	20
12	149 °C	163 °C	20
13	149 °C	163 °C	20
14	149 °C	163 °C	20
15	149 °C	163 °C	30
16	149 °C	163 °C	60
17	149 °C	163 °C	60
18	149 °C	163 °C	60
19	149 °C	163 °C	60
20	149 °C	163 °C	60
21	149 °C	163 °C	60
22	149 °C	163 °C	60
23	149 °C	163 °C	60

[0057] **Example 1 (EX-1).** A discontinuous PSA web on a heat-bondable adhesive film was prepared using a melt blowing process similar to that described, for example, in Wente, Van A., "Superfine Thermoplastic Fibers," Industrial Engineering Chemistry, Vol. 48, pp 1342 – 1346 or in Wente, Van A. et al., "Manufacture of Superfine Organic Fibers," Report No. 4364 of the Naval Research Laboratories, published May 25, 1954, except that the apparatus utilized a single extruder which fed its extrudate to a gear pump that controlled the polymer melt flow. The gear pump fed a stream of 3M™ High Tack Pressure Sensitive Adhesive 3794 [3M 3794] (a 100% solids, styrene block copolymer hot melt pressure-sensitive adhesive [PSA] available from 3M, St. Paul, MN) to a feedblock assembly which was connected to a melt-blowing die having circular smooth surface orifices (10/centimeter [cm]) with a 5:1 length to diameter ratio.

[0058] The gear pump intermediate of the extruder and the feedblock assembly was adjusted to deliver the 3M 3794 melt stream to the die, which was maintained at 195 °C, at a rate of 179 grams/hour/centimeter (g/hr/cm) die width. The primary air was maintained at 255 °C and the airflow rate was regulated at 3.5 cubic meters / minute with a 0.076 cm gap width, to produce a uniform web. The PSA web was collected on 3M™ Stitchless Bonding Film 7016 [3M 7016] (a 150 micron thick, polyurethane heat-activated fabric bonding film), which passed around a rotating drum collector at a collector to die distance of 20.3 cm. The resulting PSA web, comprising PSA microfibers having an average diameter of 10 micrometers, had a basis weight of about 74 grams/square meter.

[0059] Example 2 (EX-2). A discontinuous PSA web on a heat-bondable adhesive film was prepared using the melt blowing process as described in Example 1 except that the rotating drum collector was sped up to provide a lighter coating of pressure-sensitive adhesive and the airflow rate was regulated at 2.4 cubic meters per minute to provide larger PSA microfibers. The resulting PSA web, comprising PSA microfibers having an average diameter of 15 μm, has a basis weight of about 53 g/m^2.

[0060] Example 3 (EX-3). A discontinuous PSA web on a heat-bondable adhesive film was prepared using the melt blowing process as described in Example 1 except that the rotating drum collector was sped up to provide a lighter coating of PSA. The resulting PSA web, comprising PSA microfibers having an average diameter of 11 μm, has a basis weight of about 53 g/m^2.

[0061] Example 4 (EX-4). A discontinuous PSA web on a heat-bondable adhesive film was prepared by spraying 3M™ Pressure Sensitive Spray Adhesive 72 [Spray 72] (an aerosol, solvent-based styrene block copolymer pressure-sensitive adhesive available from 3M, St. Paul, MN) directly onto 3M 7016 bonding film. Spray Adhesive 72 is provided in aerosol can format with a variable controlled lace spray actuator which results in a discontinuous or fibrous "lacy" pattern of adhesive. A uniform speed and sweeps from left to right were used to coat approximately 30 cm x 60 cm pieces of film resulting in lanes of essentially uniform, though discontinuous, adhesive on top of the bonding film. The resulting discontinuous PSA layer has a basis weight of about 4 g/m^2.

[0062] Example 5 (EX-5). A discontinuous PSA web on a heat-bondable adhesive film was produced using a handheld hot melt adhesive spray applicator, Pam Powerline 700 Hot Melt Spray Hand Gun (available from Ellsworth Adhesives, Germantown, WI), Temperature – 177 °C, Spray Setting - #3, Extruding Pressure – 276 kPa. 3M 3794 was sprayed in a discontinuous, lace pattern directly onto 3M 7016 bonding film. A uniform speed and a back and forth motion was used to coat an approximately 30 cm x 60 cm piece of film. Samples were then directly cut from the lanes of PSA/film. The resulting PSA web, comprising PSA fibers having an average diameter of 120 μm, has a basis weight of about 60 g/m^2.

[0063] Example 6 (EX-6). A discontinuous PSA web on a heat-bondable adhesive film was produced using the method as described in Example 5 except that two passes were made (a second layer of lace adhesive was applied on top of the first layer of lace adhesive) to provide a double weight coating of the discontinuous PSA. The resulting PSA web has a basis weight of about 120 g/m^2.

[0064] Example 7 (EX-7). A discontinuous PSA web on a heat-bondable adhesive film was prepared using the melt blowing process as described in Example 2 except that a double coated silicone release paper (available from Loparex LLC, Willowbrook, IL) was passed around the rotating drum collector in place of the bonding film and the rotating drum collector was sped up to provide a lighter coating of PSA. The resulting PSA web, comprising PSA microfibers having an average diameter of 11 μm, has a basis weight of about 9 g/m^2. The PSA web was then hand laminated to 3M 7016 bonding film.

[0065] Example 8 (EX-8). A discontinuous PSA web on a heat-bondable film was prepared using the method described in Example 7 except that airflow was regulated at 3.5 cubic meters/min to provide smaller PSA microfibers. The PSA web, comprising PSA microfibers having an average diameter of 8 μm, has a basis weight of about 10 g/m^2.

[0066] Example 9 (EX-9). A discontinuous PSA web on a heat-bondable film was prepared using the melt blowing process as described in Example 2 except that the rotating drum collector was sped up to provide a lighter coating of PSA. The resulting PSA web, comprising PSA microfibers having an average diameter of 16 μm, has a basis weight of about 34 g/m^2.

[0067] Example 10 (EX-10). A discontinuous PSA web on a heat-bondable film was prepared using the melt blowing process as described in Example 1 except that the rotating drum collector was sped up to provide a lighter coating of PSA. The resulting PSA web has a basis weight of about 33 g/m^2.

[0068] Example 11 (EX-11). A discontinuous PSA web on a heat-bondable adhesive film was prepared using the melt blowing process as described in Example 1 except that the rotating drum collector was sped up to provide a lighter coating of PSA. The resulting PSA web, comprising PSA microfibers having an average diameter of 9 μm, has a basis weight of about 25 g/m^2.

[0069] Example 12 (EX-12). A discontinuous PSA web on a heat-bondable adhesive film was prepared using the melt blowing process as described in Example 2 except that the rotating drum collector was sped up to provide a lighter coating of PSA. The resulting PSA web has a basis weight of about 23 g/m^2.

[0070] Example 13 (EX-13). A discontinuous PSA web on a heat-bondable adhesive film was prepared using the melt blowing process as described in Example 7 except that the rotating drum collector was sped up to provide a lighter coating of PSA. The resulting PSA web, comprising PSA microfibers having an average diameter of 12 μm, has a basis weight of about 7 g/m^2.

[0071] Example 14 (EX-14). A discontinuous PSA web on a heat-bondable adhesive film was prepared using the melt blowing process as described in Example 2 except that the rotating drum collector was sped up to provide a lighter coating of PSA. The resulting PSA web, comprising PSA microfibers having an average diameter of 15 μm, has a basis weight of about 20 g/m^2.

[0072] Comparative Example 1 (CE-1). A discontinuous PSA web without a heat-bondable adhesive film layer was prepared using the method described in Example 1 except that a double coated silicone release paper was passed around the rotating drum collector in place of the bonding film. The resulting PSA web, comprising PSA microfibers having an average diameter of 13 μm, had a basis weight of about 56 g/m^2.

[0073] Comparative Example 2 (CE-2). A continuous film of PSA on a heat-bondable adhesive film was prepared by heat pressing a melt blown, fibrous PSA between silicone coated release liners to form a filmed PSA of the same composition as the discontinuous PSA examples. The discontinuous PSA was produced by the method described in Comparative Example C1. Two layers of the approximately 56 g/m2 PSA were placed between double-coated silicone paper liners and subsequently pressed in a heated platen press (149 °C top plate / 163 °C bottom plate [padded with a rubber pad], 345 kPa pressure for 1 minute). The filmed PSA was then hand laminated to the 3M 7016 bonding film. No void spaces exposing the 3M 7016 bonding film were evident.

[0074] Comparative Example 3 (CE-3). A continuous film of PSA on a heat-bondable adhesive film was prepared by spraying 3M™ Fastbond™ Insulation Adhesive 49 [Spray 49] (a water-based, high solids, acrylate pressure sensitive adhesive available from 3M, St. Paul, MN) directly onto 3M 7016 bonding film using a gravity fed, air atomizing spray gun (Binks Model 95G, fluid nozzle = 1.778 millimeters, air cap = 66SD, fluid control knob setting = wide open, fan control knob=1/2 turn [counter clockwise], and atomizing air = 176 kPa). A uniform speed and sweeps from left to right were used to coat approximately 30 cm x 60 cm pieces of film resulting in an essentially uniform, continuous layer of adhesive on top of the bonding film. The adhesive/film combination was allowed to air dry at ambient conditions before testing. No voids exposing the 3M 7016 bonding film were evident when examined microscopically.

[0075] Comparative Example 4 (CE-4). A continuous film of PSA on a heat-bondable adhesive film was prepared by spraying 3M™ Repositionable 75 Spray Adhesive [Spray 75] (an aerosol, solvent-based acrylate pressure-sensitive adhesive available from 3M, St. Paul, MN) directly onto 3M 7016 bonding film. 3M Spray 75 adhesive is provided in aerosol can format with a mist spray actuator which results in a continuous layer of adhesive. A uniform speed and sweeps from left to right were used to coat approximately 30 cm x 60 cm pieces of film resulting in lanes of essentially uniform, continuous, adhesive on top of the bonding film. No void spaces exposing the 3M 7016 bonding film were evident.

[0076] Comparative Example 5 (CE-5). An essentially continuous PSA web on a heat-bondable adhesive film was prepared using the melt blowing process as described in Example 2 except that the rotating drum collector was slowed down to provide a heavier coating of PSA and the airflow rate was regulated at 2.4 cubic meters/min to provide larger fiber sizes. The resulting PSA web, comprising conglomerated PSA microfibers (fiber sizes were not measurable as they had conglomerated and were frequently "filmed" out when the release liner was laminated to the construction making it extremely difficult to identify individual fibers to measure), has a basis weight of about 78 g/m^2. No voids exposing the 3M 7016 bonding film were evident when examined microscopically. No voids exposing the bottom layer of bonding film were evident.

[0077] PSA Coverage Test. Unless otherwise noted, the percent void levels stated for all examples were measured as follows. Multiple samples per example were microscopically analyzed to estimate percentage of the bonding film covered by PSA as well as estimates of the size distribution of the PSA "fibers." Photomicrographs of the PSA surface of the examples were taken using an Optical Digital Camera, Olympus DP25, equipped with an internal standard for calibrating size. Using Olympus Software (DP2-BSW, 2.1 [Build 6207]). The photomicrographs were analyzed for percent void areas. Multiple photomicrographs were analyzed for each example and the data was compiled to provide a representative estimate for each individual example. Percent (%) void areas (amount of bonding film not covered by PSA) were estimated by taking specific areas and tracing the void spaces within each area. The software then calculated the area of the void spaces versus the outlined total area and provided an estimate of the percent void space.

[0078] PSA Fiber Size Test. Fiber size distribution was similarly using the same software. First, the sides of individual fibers were traced. Then, the software calculated a fiber diameter for each fiber segment trace and ran the statistics to characterize the fiber size distribution – reported as minimum, maximum, and mean fiber size.

[0079] The basis weight of the pressure sensitive adhesive and the initial thickness of the adhesive (i.e., total caliper minus the bonding film and liner calipers) are reported in Table 2. The adhesive fiber size (as measured by the PSA Fiber Size Procedure) and the percent voids in the PSA layer (as measured by the PSA Coverage Procedure) are also reported in Table 2. The percent voids in the PSA corresponds to the percent area of the underlying heat-bondable layer that is exposed.

Table 2: PSA coverage and fiber size results (* Thick = initial adhesive thickness).

Ex.	Basis wt. PSA (g/m^2)	Thick * (µm)	Adhesive fiber size (µm)				% Voids in PSA (bonding film exposed)
			Min	Avg	Max	Std. Dev.	
CE-1	56	84	4	13	52	7.3	No bonding film
CE-2	109	97	Not measureable -- no fibers, no voids evident				
CE-3	5	30	Not measureable -- no fibers, no voids evident				
CE-4	5	33	Not measureable -- no fibers, no voids evident				
CE-5	78	109	Not measureable -- no voids evident				
EX-1	74	94	2	10	28	4.7	> 0 - 9%
EX-2	53	79	3	15	45	7.4	10%
EX-3	53	81	3	11	27	5.4	15%
EX-4	4	33	Not tested				30 - 50%
EX-5	60	203	39	120	293	48.8	47%
EX-6	120	Not tested					
EX-7	9	15	2	11	65	6.5	33%
EX-8	10	15	2	8	59	5.2	35%
EX- 9	34	53	5	16	86	10.6	46%
EX-10	33	51	Not tested				
EX-11	25	43	3	9	31	3.8	47%
EX-12	23	43	Not tested				
EX-13	7	15	1	12	51	7.5	56%
EX-14	20	33	6	15	40	5.0	58%

[0080] For Example 1, it was extremely difficult to visualize void spaces and get a consistent estimate from the software. The reported estimate of > 0 - 9% void space is based upon Example 1 being denser than Example 2 (which was estimated to have 10% void space) and that there were some void spaces evident meaning it is greater than 0%. Example 4 was qualitatively judged to have about 30 – 50% void space based upon photomicrograph images and void space tracings.

[0081] 180 Degree T-Peel Test. The bond strength between the example bonding films and the test fabric was measured at room temperature using a T-peel (or 180° peel) test per ASTM D1876-08 with the following modifications: a) the free crosshead speed used was 12 inches per minute, and b) the average peel resistance was calculated over a peel distance of 4.5 inches. The average peel strength, percent reduction in average peel strength from the control bare heat-bondable adhesive without PSA (3M 7016 heat-bondable adhesive without a PSA layer), and bond failure mode(s) were recorded. The reduction of bond strength for the example compared to the bond strength of the control (3M 7016 bonding film with no PSA, bonded at same conditions to the same fabric) was calculated as follows:

$$\frac{(\text{Control Bonding Film Peel Strength} - \text{Example Peel Strength})}{\text{Control Bonding Film Peel Strength}} \times 100\% = \%\ \text{Reduction}$$

Failure modes are shown in Table 3 (listed in order of preference).

Table 3: T-peel failure modes

Failure Type	Description	Comment
Fabric failure	indicates that the bond is stronger than the fabric itself	Indicates a strong bond
Film cohesive failure	failure within (e.g., splitting of) the bonding film layer	Indicates a strong bond
PSA cohesive failure	failure within (e.g., splitting of) the PSA	associated with unacceptably weak, water vulnerable, and non-durable bonds
PSA adhesive failure	failure between the example and the fabric	associated with unacceptably weak, water vulnerable, and non-durable bonds
#2 Bond failure	failure between the bonding film and the PSA	associated with unacceptably weak, water vulnerable, and non-durable bonds

[0082] Fabric 2 and Fabric 16 (see Tables 1A and 1B for fabric description and bonding conditions) were chosen as being most representative of high performance outerwear (apparel) and footwear bonding applications. “Acceptable” bond strength levels were typical peel strengths considered adequate for these particular applications. All bonding was performed with a platen pressure of 345 kPa (50 psi). All samples were bonded with the conditions optimized for each fabric combination, as summarized in Table 1B.

[0083] Bonded samples of Fabric 2 and Fabric 16 were created by bonding two pieces of 2.5 cm wide fabric (with a 1.25 cm wide overlap seam running down the length of the samples) with each example adhesive article measuring 1.25 cm wide x at least 10 cm long. For all examples, three individual samples were prepared and tested with the average results reported. The results obtained with Fabric 2 are shown in Table 4A and the results obtained with Fabric 16 are shown in Table 4B.

Table 4A: T-peel bond strength results: Fabric 2.

Ex.	Bond strength (Newtons / centimeter)	% reduction (from fabric failure level)	Failure Modes							Suitable for this fabric?
			Fabric failure	Bonding film cohesive	Unacceptable Bond Strength	PSA cohesive	Ooze/Penetration	#2 Bond	PSA adhesive	
CE-1	8	73%			X	X				NO
CE-2	5	84%			X				X	NO
CE-3	18	38%			X				X	NO
CE-4	21	25%			X				X	NO
CE-5	7	73%			X				X	NO
EX-1	Fabric Failure		X							YES
EX-2	Fabric Failure		X							YES
EX-3	Fabric Failure		X							YES
EX-4	Fabric Failure		X							YES
EX-5	Fabric Failure		X							YES
EX-6	Fabric Failure		X							YES
EX-7	Not tested									
EX-8										
EX- 9	Fabric Failure		X							YES
EX-10	Fabric Failure		X							YES
EX-11	Fabric Failure		X							YES
EX-12	Fabric Failure		X							YES
EX-13	Fabric Failure		X							YES

Table 4B: T-peel bond strength results: Fabric #16.

Ex.	Bond strength (Newtons / centimeter)	% reduction (from fabric failure level)	Failure Modes							Suitable for this fabric?
			Fabric failure	Bonding film cohesive	Unacceptable Bond Strength	PSA cohesive	Ooze/Penetration	#2 Bond	PSA adhesive	
CE-1	5	90%			X	X				NO
CE-2	11	75%			X	X				NO
CE-3	20	55%			X			X		NO
CE-4	20	55%			X			X	X	NO
CE-5	8	82%			X	X				NO

EX-1	8	82%			X	X				NO
EX-2	21	55%	X	X	X	X				NO
EX-3	21	55%	X	X	X	X				NO
EX-4	44	0%		X						YES
EX-5	Not Tested									
EX-6										
EX-7	36	8%		X						YES
EX-8	39	14%		X						YES
EX- 9	35	17%		X						YES
EX-10	35	17%		X						YES
EX-11	35	17%		X						YES
EX-12	39	8%		X						YES
EX-13	42	0%		X						YES

[0084] All comparative examples failed to provide acceptable bond strengths and exhibited non-preferred modes of failure. Examples 1-3 had acceptable bond strengths with Fabric 2, unacceptably weak bonds with Fabric 16, and mixed failure modes. These results indicate that these materials may be appropriate for some bonding applications. Examples 4 – 14 exhibited good bond strengths with preferred modes of bond failure, particularly T-peel bond strengths resulting in fabric failure or a reduction in T-peel bond strength, as compared to the bare heat-bondable adhesive without PSA, of 25% or less, 17% or less, 14% or less, 8% or less, and even 0%, as measured on fabric substrates at room temperature according to ASTM D1876-08 with the following modifications: a) the free crosshead speed used was 12 inches per minute, and b) the average peel resistance was calculated over a peel distance of 4.5 inches.

[0085] Example 14 and Comparative Example CE-2 were tested for T-peel (or 180° peel) bond strength against the full series of fabrics to evaluate suitability across a range of potential fabric bonding applications as described above. Again, "acceptable" bond strength levels were typical peel strengths considered adequate for these particular fabric combinations. All bonding was performed with a platen pressure of 345 kPa (50 psi). All samples were bonded with the specified conditions for each fabric combination. The results obtained with the adhesive article of Example 14 are summarized in Table 5A. The results obtained with Comparative Example CE-2 are summarized in Table 5B.

Table 5A: T-peel bond strength: Full fabric series with the adhesive article of Example 14.

Fabric	Bond strength (N/cm)	% reduction from 3M 7016 or fabric strength	Failure Modes							Suitable for this fabric?
			Fabric failure	Bonding film cohesion	Unacceptable Bond	PSA cohesive	oozing / penetration	#2 Bond	PSA adhesive	
1	Fabric failure		X							Yes
2	28	0%		X						Yes
3	Fabric failure		X							Yes
4	55	0%		X						Yes
5	22	0%		X						Yes
6	16	22%		X						Yes
7	51	6%		X						Yes
8	Fabric failure		X							Yes
9	41	1%		X						Yes
10	44	14%		X						Yes
11	20	0%		X						Yes
12	61	15%		X						Yes
13	24	2%		X						Yes
14	Fabric failure		X							Yes
15	Fabric failure		X							Yes
16	40	9%		X						Yes
17	25	7%		X						Yes
18	49	0%		X						Yes
19	36	0%		X						Yes
20	28	0%		X						Yes
21	33	18%		X						Yes
22	Fabric failure		X							Yes
23	54	11%		X						Yes

Table 5B: T-peel bond strength: Full fabric series with the adhesive article of Comparative Example CE-2.

Fabric	Bond strength (N/cm)	% reduction from 3M 7016 or fabric strength	Failure Modes							Suitable for this fabric?
			Fabric failure	Bonding film cohesion	Unacceptable Bond	PSA cohesive	oozing / penetration	#2 Bond	PSA adhesive	
1	7	74%			X					No
2	5			X					X	No
3	8	0%					X			No
4	49				X	X	X			No
5	19					X	X			No
6	17				X	X				No
7	21			X	X	X			X	No
8	28	0%					X			No
9	9			X		X	X		X	No
10	21			X	X				X	No
11	10			X	X	X			X	No
12	29			X		X	X		X	No
13	16			X	X	X			X	No
14	11	*			X	X	X			No
15	Fabric failure			X					X	No
16	11			X	X				X	No
17	23			X					X	No
18	10			X	X				X	No
19	31			X	X	X			X	No
20	11			X	X				X	No
21	9			X	X				X	No
22	12	*			X	X				No
23	34			X		X	X		X	No

* less than fabric

[0086] All of the samples bonded with the inventive adhesive article of Example 14 provided acceptable bond strengths, did not exhibit any PSA penetration through the fabric, and exhibited preferred modes of bond failure indicating suitability for bonding all fabric combinations tested. Particularly, all of the samples bonded with the inventive adhesive article of Example 14 provided T-peel bond strengths resulting in fabric failure or a reduction in T-peel bond strength, as compared to the bare heat-bondable adhesive without PSA, of 25% or less, 22% or less, 18% or less, 15% or less, 14% or less, 11% or less, 9% or less, 7% or less, 6% or less, 2% or less, 1% or less, and even 0%, as measured on fabric substrates at room temperature according to ASTM D1876-08 with the following modifications: a) the free crosshead speed used was 12 inches per minute, and b) the average peel resistance was calculated over a peel distance of 4.5 inches. These fabric combinations tested include both representative of the wide variety of fabrics (or textiles) used in apparel and footwear manufacturing, as well as materials extending beyond those typically used. The results provide an indication of the present disclosure's suitability for a broad range of current and future textile bonding applications. In contrast, none of the samples bonded with the comparative example CE-2 exhibited suitability for any of the fabric combinations tested.

[0087] Fabric Lap Shear Test. Several of the examples and comparative examples were further evaluated for shear strength with Fabric 16. For all examples, three individual samples were prepared and tested with the average results reported. Bonded samples consisted of two pieces of 2.5 cm wide fabric with a 1.25 cm wide overlap seam. The adhesive used to bond the two pieces of fabric together measured 1.25 cm wide x 2.5 cm long. All samples were bonded according to the method described above for the T-peel testing. The bond strength between the example bonding films and the fabric was then measured at room temperature using a lap shear test per ASTM D1002-10 with the following modifications: a) the substrates used were fabrics, and b) the rate of loading was approximated by a free crosshead speed of 2 inches per minute. The peak load and failure mode were recorded. Failure modes are described in Table 2 above (listed in order preference).

[0088] The reduction of shear strength for the example compared to the shear strength of the control (3M 7016 bonding film with no PSA, bonded at same conditions to the same fabric substrates) was calculated as follows:

$$\frac{(\text{Control Bonding Film Lap Shear Strength} - \text{Example Lap Shear Strength})}{\text{Control Bonding Film Lap Shear Strength}} \times 100\% = \%\ \text{Reduction}$$

The results are summarized in Table 6.

Table 6: Lap shear: Fabric #16

	Fabric Combination #16 AT3828AKS (polyester 3-layer bonded face-to-face)									
			Failure Modes							
	Bond strength (kPa)	% reduction *	Fabric failure	Bonding film cohesive	Unacceptable Bond Strength	PSA cohesive	PSA oozing / penetration	#2 Bond	PSA adhesive	Suitable for this fabric?
CE-1	490	57%			X				X	NO
CE-2	483	58%			X				X	NO
EX-1	1007	12%		X	Mayb e	X				Some
EX-2	Fabric failure		X							YES
EX-3	Fabric failure		X							YES

	Fabric Combination #16 AT3828AKS (polyester 3-layer bonded face-to-face)									
			Failure Modes							
	Bond strength (kPa)	% reduction *	Fabric failure	Bonding film cohesive	Unacceptable Bond Strength	PSA cohesive	PSA oozing / penetration	#2 Bond	PSA adhesive	Suitable for this fabric?
EX-4	Fabric failure		X							YES
EX-9	Fabric failure		X							YES
EX-11	Fabric failure		X							YES
EX-12	Fabric failure		X							YES
EX-13	Fabric failure		X							YES
EX-14	Fabric failure		X							YES

* % reduction in bond strength quoted is the reduction from fabric failure strength measured, not the bare bonding film bond strength level which was not possible to measure since the fabric failed before the bond.

[0089] All comparative examples failed to provide acceptable bond strengths and exhibited non-preferred modes of failure. Example 1 may be appropriate for some bonding applications. Examples 2 – 14 all exhibited good bond strengths with preferred modes of bond failure, particularly fabric lap shear bond strengths resulting in fabric failure or a fabric lap shear bond strength of at least 1.0 MPa, when measured on polyester substrates at room temperature according to ASTM D1002-10 with the following modifications: a) the substrates used were fabrics, and b) the rate of loading was approximated by a free crosshead speed of 2 inches per minute.

[0090] Probe Tack Test. 2.5 cm x 2.5 cm (1” x 1”) samples were cut from example materials and tested for pressure-sensitive tack per ASTM D2979 (average of three samples is reported) using a Polyken™ Probe Tack adhesive testing machine (Model # PT-1000, available from Chemsultants International, Inc., Mentor, OH). The results are summarized in Table 7.

[0091] Initial Hold Test. Example materials were evaluated for suitability in a pre-application step to a curved, vertical surface intended to mimic pre-assembly of footwear or apparel. This involved tacking the heat-bondable layer to a fabric (with heat and pressure), removing the release liner from the pressure sensitive adhesive layer and applying the fabric/bonding film/psa to another fabric surface which was wrapped around a vertical cylinder approximately 10 cm in diameter. These examples were then observed for any lifting from the three dimensional, curved surface and ability to stay in place long enough for the entire assembly to be heat bonded. “Good” means no lifting and article stayed in place for completion of heat bonding step). The results are also summarized in Table 7.

Table 7: Tack and Initial Hold results.

		Adhesive Tack (grams)	Initial Hold
CE-1		403	Good
CE-2		604	Good
CE-3		27	Good
CE-4		4	Significant lifting, not enough tack
CE-5		265	Good
EX-1		242	Good
EX-2		117	Good
EX-3		129	Good
EX-4		24	Good
EX-5		235	Good
EX-6		Not tested	Good
EX-7		198	Good
EX-8		177	Good
EX- 9		94	Good
EX-10		Not tested	Good
EX-11		44	Good
EX-12		63	Good
EX-13		112	Good
EX-14		18	Good

[0092] All example materials, with the exception of Comparative Example C4, exhibited high enough room temperature tack to be able to be pre-applied to textiles (three dimensional and vertical surfaces) and remain attached until heat and pressure could be applied to activate the bonding film layer. Comparative Example C4 did not have sufficient tack to be pre-applied to a three dimensional surface and separated from the fabric before heat and pressure could be applied to activate the thermal bonding film layer.

[0093] **Aluminum Lap Shear Test.** Example materials were used to bond aluminum substrates having dimensions of 25.4 mm x 101.6 mm x 1.6 mm together in an overlap seam. Samples were bonded by heat pressing at 150 ºC and 200 kPa, for 15 seconds. After 24 hours elapsed (to allow adequate cooling and full stabilization of the bond) the lap shear strengths of the bonds were then tested according to ASTM D1002-10 at room temperature with the following modification: the crosshead speed was set at 2.5 mm per minute. The results are summarized in Table 8.

Table 8: Lap shear results (aluminum substrate).

	Lap Shear (MPa)	% reduction (from bare film level)
CE-1	0.69	28%
CE-2	0.63	34%
EX-1	0.64	33%
EX-2	0.71	26%
EX-9	0.74	23%
EX-11	0.75	22%
EX-14	0.79	18%

[0094] Lap shear testing of aluminum substrates bonded with the example materials show significant, but acceptable reductions in bond strength compared to the bare heat-bondable adhesive without PSA (3M 7016 bonding film provides a lap shear strength of 0.96 MegaPascals, MPa). Example materials have less reduction in bond strength than the comparative examples in this analysis as compared to the bare heat-bondable adhesive without PSA, particularly aluminum lap shear bond strengths ranging from 0.60 MPa to less than 1 MPa, 0.64 to less than 1 MPa, 0.71 MPa to less than 1 MPa, 0.74 MPa to less than 1 MPa, 0.75 MPa to less than 1 MPa, or even 0.79 to less than 1 MPa, after bonding.

[0095] **Flexibility Test.** The feel or "hand" of a fabric or garment is related to its flexibility. Example materials were used to bond together two layers of a lightweight, knit 72% nylon / 28% spandex blend fabric in an overlap seam. The pliability, flexibility, or "hand" of the seams was then tested per ASTM D6828-02 using a Handle-O-Meter testing machine (available from Thwing-Albert Instrument Company, West Berlin, NJ). The results are summarized in Table 9. The control was 3M 7016 bonding film.

Table 9: Flexibility results.

Ex.	Result (grams)
CE-2	13
EX-1	10
EX-2	9
EX-9	9
EX-11	9
EX-14	9
Control	8

[0096] Flexibility results obtained with the Handle-O-Meter demonstrates that the example materials provide a soft and pliable bond which is often desirable for apparel seams. The example materials provide a significantly softer, more pliable seam than the comparative material tested. The results were comparable to that obtained with the 3M 7016 heat-bondable film alone (no PSA), identified as the control.

[0097] **Stretch Restriction Test.** Example materials were used to bond together two layers of a lightweight, knit 72% nylon / 28% spandex blend fabric in an overlap seam. Samples were bonded by heat pressing at 150 °C and 350 kPa for 15 seconds. The restriction of stretch was evaluated by comparing the percent elongation at break for the fabric alone with the percent elongation at break of the bonded samples. The stress at specific elongations (30%, 40%, 50%, and 60%) representing typical apparel design targets (i.e., percent elongations experienced while a garment is worn) were also compared. Percent elongation testing was performed according to ASTM D412-06a.

Table 10: Stretch restriction results.

	Elongation at Break (max. elong.)	% Reduction in maximum elongation (from film alone)	Stress at percent elongation (Newtons)			
			30%	40%	50%	60%
EX-1	710 %	1%	12	14	16	17
EX-2	599 %	17%	12	13	15	16
EX-9	663 %	8%	12	13	15	16
EX-11	667 %	7%	12	13	15	16
EX-14	689 %	4%	12	14	15	16
Control	719 %	0%	11	12	14	15

[0098] Testing for the stretch properties of a fabric seam utilizing the example materials demonstrates that these materials do not significantly hinder the stretch properties as both the maximum elongation and the stress at specific elongations of importance for apparel design are not significantly different from seams bonded with the control (3M 7016 bonding film alone (no PSA)).

[0099] Various modifications and alterations to this disclosure will become apparent to those skilled in the art without departing from the scope and spirit of this disclosure. It should be understood that this disclosure is not intended to be unduly limited by the illustrative embodiments and examples set forth herein and that such examples and embodiments are presented by way of example only with the scope of the disclosure intended to be limited only by the claims set forth herein as follows.

What is claimed is:

1. An adhesive article comprising a heat-bondable adhesive layer having a first surface, and a first discontinuous pressure sensitive adhesive layer disposed upon a first portion of the first surface of the heat-bondable adhesive layer; wherein the first discontinuous pressure sensitive adhesive layer comprises a web of pressure sensitive adhesive microfibers having an average diameter of from about 10 μm to about 200 μm.

2. The adhesive article of claim 1, wherein the adhesive article has, after bonding, a fabric lap shear bond strength resulting in fabric failure or a fabric lap shear bond strength of at least 1.0 MPa, when measured on polyester substrates at room temperature according to the Fabric Lap Shear Test.

3. The adhesive article of claim 1, wherein the adhesive article has, after bonding, a T-peel bond strength resulting in fabric failure or a reduction in T-peel bond strength, as compared to the bare heat-bondable adhesive without PSA, of 25% or less, as measured on fabric substrates at room temperature according to the 180 Degree T-Peel Test.

4. The adhesive article according to any of the preceding claims, wherein the first portion of the first surface comprises from about 12% to less than 100% of the first surface.

5. The adhesive article according to any of the preceding claims, wherein the heat-bondable adhesive layer comprises a second surface; wherein the first surface and the second surface are on opposite faces of the heat-bondable adhesive layer; and wherein the adhesive article further comprises a second discontinuous pressure sensitive adhesive layer disposed upon a first portion of the second surface of the heat bondable adhesive layer.

6. The adhesive article according to any of the preceding claims, further comprising at least one finished layer disposed upon at least a portion of a layer selected from the group consisting of the first discontinuous pressure sensitive adhesive layer, the heat-bondable adhesive layer, the second discontinuous pressure sensitive adhesive layer, and combinations thereof.

7. An adhesive article comprising a heat-bondable adhesive layer having a first surface, a first discontinuous pressure sensitive adhesive layer disposed upon a first portion of the first surface

of the heat-bondable adhesive layer, and at least one finished layer disposed upon at least a portion of a layer selected from the group consisting of the first discontinuous pressure sensitive adhesive layer, the heat-bondable adhesive layer, and combinations thereof.

8. The adhesive article of claims 5 or 6, wherein the at least one finished layer is selected from the group consisting of a fabric, a foam, a film, a nonwoven, and combinations thereof.

9. The adhesive article of any of the preceding claims, wherein the first discontinuous pressure sensitive adhesive layer comprises two or more discontinuous pressure sensitive adhesive layers.

10. The adhesive article of any of the preceding claims, wherein the heat-bondable adhesive layer comprises two or more heat-bondable adhesive layers.

11. A footwear article comprising the adhesive article of any of the preceding claims.

12. A footwear article comprising a seam bonded by the adhesive article of any of claims 1-10.

13. A fabric article comprising the adhesive article of any of claims 1-10.

14. A fabric article comprising a seam bonded by the adhesive article of any of claims 1-10.

15. An article comprising

(i) the adhesive article of claim 1; and

(ii) a substrate selected from the group comprising a fabric, a foam, a non-woven, a film, and combinations thereof;

wherein the adhesive article contacts the substrate or is bonded to the substrate.

16. The article of claim 15, wherein the article is a footwear article or an apparel article.

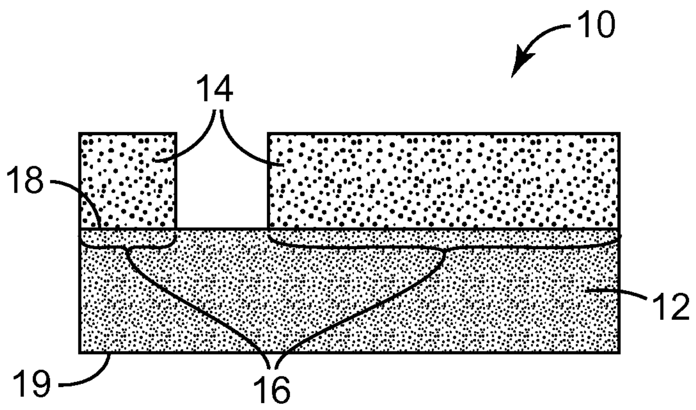

FIG. 1A

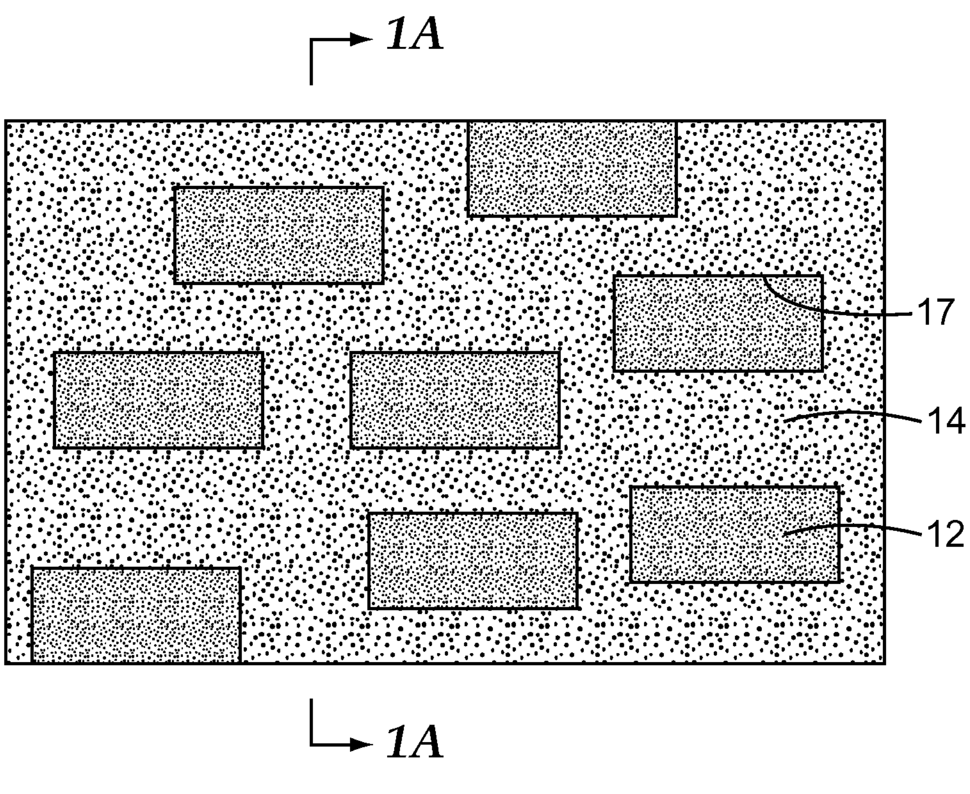

FIG. 1B

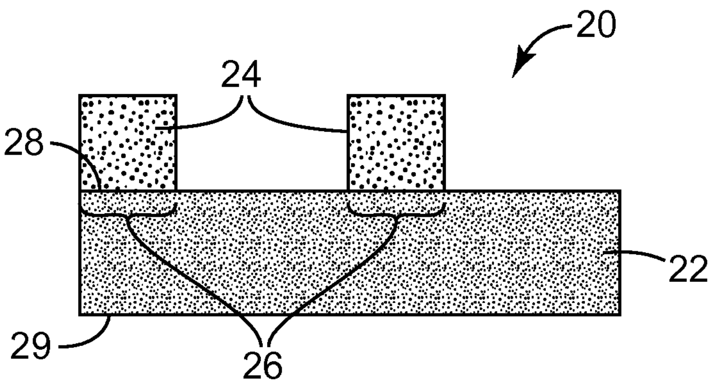

FIG. 2A

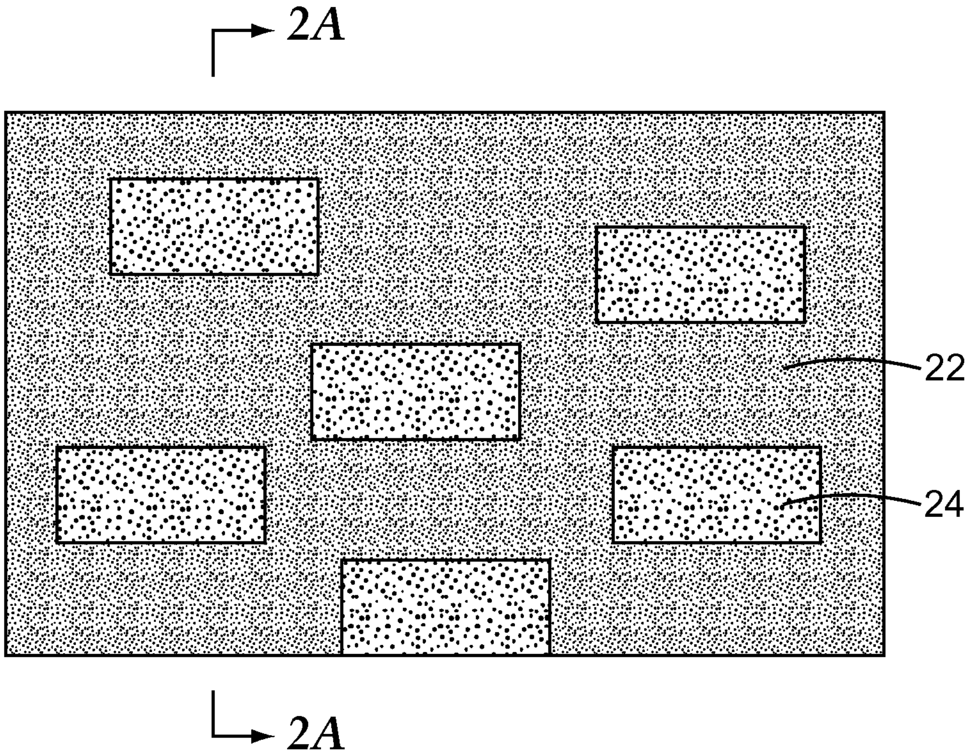

FIG. 2B

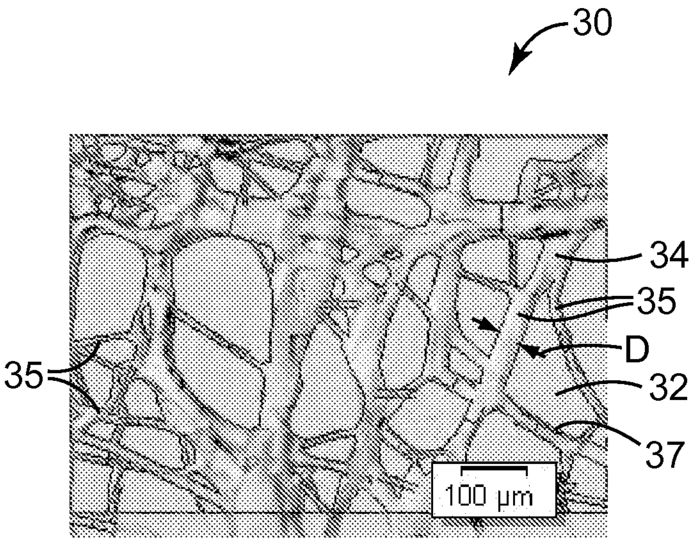

FIG. 3

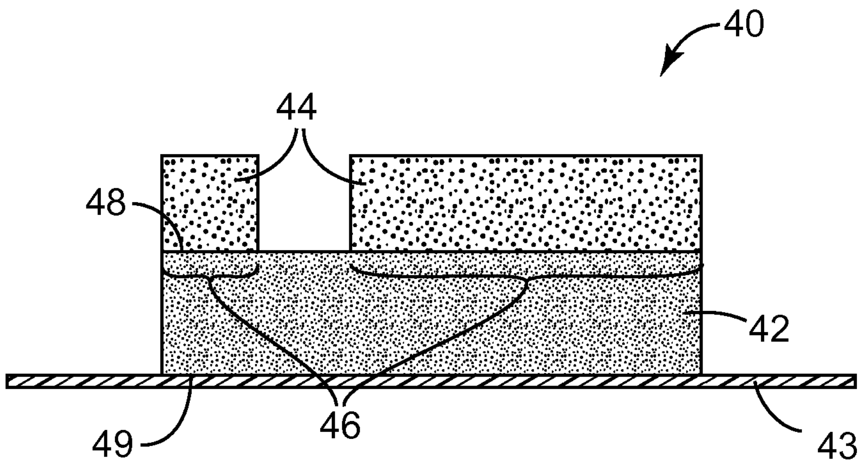

FIG. 4