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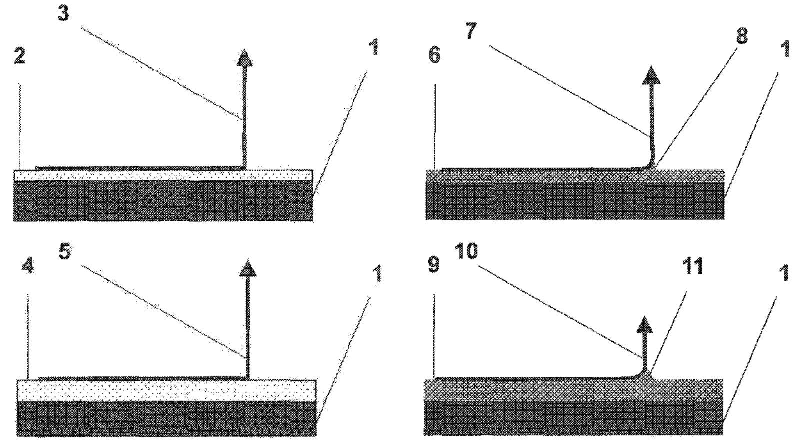

Figure 1

(57) **Abstract**: There is provided a release liner for use in adhesive labelling or packaging film, the release liner comprising a substrate layer and at least one skin layer, the modulus of the skin layer being less than that of the substrate layer and the skin layer having a nano-coating of a release compound thereon.

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RELEASE LINER

The present invention relates to release liners. More specifically, it relates to release liners for use in adhesive labelling or packaging film.

Release liners are used in a variety of applications. In particular, release liners are used with adhesive labels, for example pressure sensitive adhesive labels, and with packaging films. Release liners are generally made up of a substrate and a release coating. Typical release coatings are formed from waxes, silicones or fluoropolymers. The release coating aids the removal of the release liner from the adhesive surface to which it is attached.

It is known that the thickness of the release coating affects the release force i.e. the force required to remove the release liner from the adhesive surface to which it is attached. As the thickness of the release coating increases, there is a decrease in the release force until a minimum is reached. After this point, a further increase in the thickness of the release coating results in the release force either increasing or remaining constant. It is understood that the change in release force as thickness is changed, is due to deformation of the release coating rather than its surface chemistry.

It is known in the art to manufacture release liners by applying a release coating to a substrate using wet-chemical coating processes, for example solvent-based wet-chemical coating or aqueous-based wet-chemical coating. However, solvent-based wet-chemical coating involves the use of volatile organic compounds which are expensive and harmful to the environment. Furthermore, it is often difficult to form a release coating of even thickness using wet-chemical coating methods.

US 4,859,511 describes a release sheet formed on paper, nonwoven fabric, polymeric film or extrusion-coated paper substrates. The release sheet has a low polar surface energy hydrocarbon undercoating of low elastic modulus interposed between the substrate and a silicone release coating. The silicone release coating is applied neat or from a solvent using offset gravure, direct gravure or multiple roll.

WO 94/13474 describes a silicone release film comprising a biaxially oriented PENBB film having a coating thereon in an amount sufficient to act as a silicone release film. The coating comprises glycidoxy silane and an aqueous based thermosetting silicone release composition.

As an alternative to wet-chemical coating processes, release liners have been manufactured using atmospheric plasma processes to deposit a release coating onto a substrate. This avoids the use of harmful volatile organic compounds and can be run as a continuous process.

EP 1 242 515 describes a method for forming a coating on a substrate surface which coating comprises SiO_x groups by plasma treatment of the surface, wherein the substrate comprises a blend of an organic polymeric material and 25% by weight or less of an organosilicon-containing additive which is substantially non-miscible with the organic polymeric material.

EP 1 978 067 describes a release liner for use in a pressure-sensitive adhesive sheet comprising a release layer on a substrate, wherein the release liner is obtainable by a process comprising the steps of: providing a substrate; producing an atmospheric pressure plasma discharge in the presence of a gas; exposing the substrate to said atmospheric pressure plasma discharge; introducing a liquid aerosol comprising a precursor into said atmospheric pressure plasma discharge, thereby forming a release layer on the substrate; and curing the release layer on the substrate.

US 2008/0063811 describes a method of adjusting a surface characteristic of a substrate comprising: providing a substrate; and performing an atmosphere pressure plasma process on the surface of the substrate to form a film layer on the surface of the substrate, so as to adjust the surface energy of the substrate, wherein a process gas of the atmosphere pressure plasma process comprises a surface modifying precursor, a carrier gas and a plasma ignition gas, wherein the surface modifying precursor is selected from fluorosilane, polysiloxane and a combination thereof, and the ratio of fluorosilane to polysiloxane is between 0 and 1.

However, the prior art release liners have numerous disadvantages associated therewith, such as they exhibit a higher release force than is desirable.

Thus, there is a need for a release liner which does not suffer from the disadvantages of the prior art. From the description that is to follow, it will become apparent how the present invention addresses the deficiencies associated with prior art release liners, while presenting numerous additional advantages.

According to a first aspect of the present invention there is provided a release liner for use in adhesive labelling or packaging film, the release liner comprising a substrate layer and at least one skin layer, the modulus of the skin layer being less than that of the substrate layer and the skin layer having a nano-coating of a release compound thereon.

‘Release liner’ is a well-known term of art in the pressure sensitive adhesive label industry. A ‘release liner’ typically comprises a substrate and a coating of a release compound which provides a release effect against an adhesive surface to which it is attached, thus aiding the removal of the release liner from the adhesive surface.

In this context, the term ‘nano-coating’ may mean a coating with a thickness up to about 100nm, for example up to about 75nm, about 50nm or about 25nm, or with a thickness of from about 1nm to about 100nm, for example from about 1nm to about 75nm, from about 1nm to about 50nm or from about 1nm to about 25nm. The nano-coating may have a thickness of from about 1 nm to about 20 nm, from about 1 nm to about 15 nm, from about 1 nm to about 10 nm, or from about 1 nm to about 5 nm.

The inventors of the present invention have found that the release force of the release liner is not significantly affected by the thickness of the nano-coating. Rather, it has surprisingly been found that the release force is affected by changing the modulus (i.e. the Young’s modulus) of the skin layer with respect to the substrate layer. In particular, it has been found that a release liner with a reduced release force can be obtained by using a skin layer with a modulus less than that of the substrate layer. This is advantageous since the lower the release force, the more easily the release liner is removed from the adhesive surface to which it is attached.

The release compound may comprise one or more of a wax, for example microcrystalline wax, a silicone for example poly(dimethyl siloxane), and a fluoropolymer for example polytetrafluoroethylene (PTFE). Preferably, the release compound comprises a silicone. More preferably, the release compound comprises poly(dimethyl siloxane), poly(dimethyl dichloro silane), poly(divinyl silane), poly(diphenyl siloxane), poly(phenylmethyl siloxane), 1,3-tetraphenyl 1,3-dimethyl disiloxane, and/or 1,3-diphenyl 1,2-tetramethyl disiloxane. Yet more preferably, the release compound comprises poly(dimethyl siloxane).

The skin layer may comprise an elastomer. Preferably the elastomer is a rubber. The rubber may comprise an ethylene-propylene copolymer (EPM), an ethylene propylene-diene monomer copolymer (EPDM), polybutadiene, polyisoprene, a styrene-butadiene copolymer, a styrene-isoprene copolymer, a urethane, a polyester and/or mixtures or blends thereof. Preferably, the skin layer comprises an ethylene-propylene copolymer, an ethylene propylene diene monomer copolymer and/or amorphous polyester.

The skin layer may have a thickness of from about 0.01μm to about 10μm. Preferably, the skin layer has a thickness of from about 0.1μm, about 0.2μm, about 0.3μm, about 0.4μm, about 0.5μm, about 0.55μm, about 0.6μm, about 0.65μm, about 0.7μm, about 0.75μm, about 0.8μm, about 0.85μm, about 0.9μm or about

0.95µm; to about 1µm, about 1.5µm, about 2µm, about 2.5µm, about 3µm, about 3.5µm, about 4µm, about 4.5µm or about 5µm. For example, the skin layer may have a thickness of from about 0.1µm to about 5µm, from about 0.5µm to about 3µm, from about 0.7µm to about 2µm or from about 0.8µm to about 1.5µm.

The inventors of the present invention have surprisingly found that the release force of the release liner may be affected by the thickness of the skin layer. More specifically, it has been found that the above-identified ranges of skin layer thickness may provide a release liner with an optimum release force. Varying the skin layer thickness within the above-identified ranges may cause a slight increase or decrease in the release force, or the release force may remain the same However, it has been found that if the skin layer thickness exceeds 10µm (and in some cases 5µm, depending on the composition of the skin layer), the release force of the release liner may increase to an unsatisfactory level.

The substrate layer may comprise a polyolefin, for example polyethylene, polypropylene, polybutylene, mixtures, blends or copolymers thereof; a polyester, for example polyethylene terephthalate; a polyamide, for example nylon; a polyurethane; a polyvinyl halide, for example polyvinyl chloride; an acetate and/or a biopolymer, for example cellulose and/or its derivatives, polylactic acid or polyhydroxyalkanoate.

Preferably, the substrate layer comprises polypropylene or polyethylene terephthalate.

The release liner may be formed by any process known in the art, including, but not limited to, cast sheet, cast film, or blown film.

The skin layer may be coextruded or laminated onto the substrate layer. Alternatively, the skin layer may be applied by coating techniques, including extrusion coating. The substrate may be provided with additional layers on either side provided that the skin layer is available to receive the release compound.

The substrate layer may comprise a biaxially orientated polypropylene (BOPP) film, which may be prepared as a balanced film using substantially equal machine direction and transverse direction stretch ratios, or can be unbalanced, where the film is significantly more orientated in one direction (MD or TD). Sequential stretching can be used, in which heated rollers effect stretching of the film in the machine direction and a stenter oven is thereafter used to effect stretching in the transverse direction. Alternatively, simultaneous stretching, for example, using the so-called bubble process, or simultaneous draw stenter stretching may be used.

The release liner of the present invention can be of a variety of thicknesses depending on the application requirements. The release liner may be from about 5μm, about 10μm, about 15μm, about 20μm, about 25μm, about 30μm to about 40μm, about 50μm, about 75μm, about 100μm, about 125μm, about 150μm, about 200μm or about 250μm.

The substrate layer may have a modulus in the range of from about 0.1 GPa to about 10 GPa. More specifically, the substrate layer may have a modulus in the range of from about 0.5 GPa to about 5 GPa. Even more specifically, the substrate layer may have a modulus in the range of from about 1 GPa to about 3 GPa.

Modulus is defined as the ratio of tensile stress to tensile strain as measured using a Tensometer. Young's modulus (E) describes tensile elasticity, or the tendency of an object to deform along an axis when opposing forces are applied along the axis. It is often simply referred to as the elastic modulus.

The skin layer may have a modulus of at least about 1% less than the modulus of the substrate layer. More preferably, the skin layer has a modulus of at least about 5% less than the modulus of the substrate layer. More preferably still, the skin layer has a modulus of at least about 10%, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80% or at least about 90% less than the modulus of the substrate layer.

The ratio of the modulus of the substrate layer to the modulus of the skin layer may be from 10-30:1; from 10-29:1; from 12-28:1; from 13-27:1; from 14-26:1; from 15-25:1; or from 10-25:1.

It has surprisingly been found that a release liner with a reduced release force can be obtained by using a skin layer with a modulus less than that of the substrate layer.

Without wishing to be bound by any such theory, it is believed that the release force is reduced due to an increase in the effective release angle as a result of skin layer deformation. A skin layer with a lower modulus will deform more when a force is applied thereto, resulting in a greater effective release angle. Consequently, the release force required to remove the release liner from a surface is reduced.

The release force required to remove the release liner from a surface to which it is attached may be from about 0.01 g/cm to about 50 g/cm. Preferably, the release force is from about 0.1 g/cm, about 0.2 g/cm , about 0.3 g/cm, about 0.4 g/cm, about 0.5 g/cm, about 0.6 g/cm, about 0.7 g/cm, about 0.8 g/cm or about 0.9 g/cm; to about 1 g/cm, about 2 g/cm, about 3 g/cm, about 4 g/cm, about 5 g/cm, about 6 g/cm, about 7 g/cm, about 8 g/cm, about 9 g/cm or about 10 g/cm. For example, the release force may be from about 0.1 g/cm to about 3 g/cm, from about 0.1 g/cm to about 2 g/cm or from about 0.1 g/cm to about 1 g/cm.

The release force may be measured in one of two ways, namely, the low speed release force method or the high speed release force method.

Low speed release force is defined as the force required to separate a release liner from the adhesive coated material to which it is attached (or *vice versa*) at an angle of 180° and a jaw separation rate of 300mm/min. The low speed release force can be determined using a tensile tester or similar machine.

Test strips with a width of 50mm and a length of at least 175mm (in the machine direction) are taken from a release liner sample. The release liner test strips are placed in contact with the adhesive surface of the material and kept for 20 hours at 23°C ± 2°C under a pressure of 6.86kPa (70 g/cm^2) to ensure good adhesion therebetween. After storage in this manner, the test strips must be left at standard test conditions (i.e. 23°C ± 2°C and 50% ± 5% relative humidity) for at least 4 hours.

Each test strip is then fixed to the tensile tester plate using double sided tape such that the release liner can be peeled apart from the adhesive coated material at an angle of 180° (or *vice versa*) The tensile tester is then set at a jaw separation rate of 300mm/min and five readings are taken at 10mm intervals from the centre section of the test strip. These five readings are averaged to give a low speed release force value usually expressed in cN/50mm width.

The low speed release force test method is outlined in the standard test FTM 3 (published by FINAT).

High speed release force is defined as i) the force required to separate a release liner from the adhesive coated material to which it is attached or ii) the force required to separate the adhesive coated material from the release liner, at an angle of 180° and a jaw separation rate between 10m/min and 300m/min. Note that i) and ii) will usually give different release forces.

Test strips with a width of 25mm and a length of at least 300mm (in the machine direction) are taken from a release liner sample. The release liner test strips are placed in contact with the adhesive surface of the material and kept for 20 hours at 23°C ± 2°C under a pressure of 6.86kPa (70 g/cm^2) to ensure good adhesion therebetween. After storage in this manner, the test strips must be left at standard test conditions (i.e. 23°C ± 2°C and 50% ± 5% relative humidity) for at least 4 hours.

To test the high speed release force of the adhesive coated material being separated from the release liner, each test strip is placed in the machine and the release liner is fixed in the load cell clamp. A protective strip is often used at this stage to prevent the adhesive sticking to the rollers in the drive mechanism. The machine is set to the desired test speed and the test carried out.

To test the high speed release force of the release liner being separated from the adhesive coated material, the same procedure as described above is used except the adhesive coated material is fixed in the load cell clamp and it is not necessary to use a protective strip.

Results for high speed release force are usually expressed as the peak or average for the test strip in units of cN/25mm width.

The high speed release force test method is outlined in the standard test FTM 4 (published by FINAT).

The substrate layer and/or the skin layer may be biodegradable and/or compostable. This is advantageous as the release liner will have a low carbon footprint.

The substrate layer and/or the skin layer may be recyclable. Advantageously, the entire release liner may be recyclable. Current release liners are often non-recyclable due to the presence of an unacceptably high amount of release compound in/on the liner. However, the release liner of the present invention comprises a nano-coating of the release compound which results in a low dilution factor of the release compound. This may allow the entire release liner to be recycled.

The substrate layer and/or the skin layer may have a radio carbon content i.e. the substrate layer and/or skin layer may be formed, at least in part, from a renewable material. The substrate layer and/or the skin layer may have a radio carbon content of at least about 10pMC, or at least about 20pMC, or at least about 30pMC, or at least about 40pMC, or at least about 50pMC, or at least about 60pMC, or at least about 70pMC, or at least about 80pMC, or at least about 90pMC, or at least about 100pMC.

'pMC' in this connection means 'per cent modern carbon'.

Advantageously, where the substrate layer and/or the skin layer has a radio carbon content, the release liner may have a low carbon footprint.

Release liners according to the present invention may be particularly useful in applications such as pressure sensitive adhesive labels/tapes/packaging films.

According to a second aspect of the present invention, there is provided a process for the manufacture of a release liner for use in adhesive labelling or packaging film, comprising the steps of:

a. providing a release liner comprising a substrate layer and at least one skin layer; and

b. depositing a nano-coating of a release compound on the skin layer,

wherein the modulus of the skin layer is less than that of the substrate layer.

The nano-coating may be deposited on the skin layer using an atmospheric pressure plasma. Preferably, the atmospheric pressure plasma is a dielectric barrier discharge (DBD).

The DBD atmosphere will generally comprise an inert carrier gas such as a noble gas e.g. argon, or nitrogen.

The DBD atmosphere may further comprise at least one functional or reducing agent, for example acetylene, hydrogen or silane. The functional or reducing agent may be present in the DBD atmosphere in an amount of from about 10 ppm to about 20000 ppm. Preferably, the functional or reducing agent is present in the DBD atmosphere in an amount of from about 200 ppm to about 5000 ppm.

Additionally, the DBD atmosphere may comprise at least one oxidising agent such as oxygen, ozone, carbon dioxide, carbon monoxide, nitric and nitrous oxides or sulphur oxide, dioxide or trioxide. The oxidising agent may be present in the DBD atmosphere in an amount of from about 10 ppm to about 20000 ppm. Preferably, the oxidising agent is present in the DBD atmosphere in an amount of from about 200 ppm to about 5000 ppm.

The DBD atmosphere may additionally comprise at least one cross-linker, for example, an unsaturated hydrocarbon such as ethylene or propylene. This is particularly advantageous when the release compound comprises silicone since the cross-linker stabilises the silicone release compound. The cross-linker may be present in the DBD atmosphere in an amount of from about 10 ppm to about 1000 ppm. Preferably, the cross-linker is present in the DBD atmosphere in an amount of from about 50 ppm to 200 ppm.

The process may additionally comprise the step of feeding a release compound precursor into the DBD. The release compound precursor may be a liquid which is vaporised prior to entering the DBD. The release compound precursor may comprise a silicone. Preferably, the release compound precursor comprises hexamethyldisiloxane and/or tetramethyldisiloxane. It is believed that these release compound precursors polymerise in the DBD and are deposited on the surface of the skin layer as polydimethylsiloxane.

The release compound precursor may be present in an amount of from about 10 ppm to about 20000 ppm. Preferably, the release compound precursor is present in an amount of from about 200 ppm to about 5000 ppm.

The release liner may be provided as a web.

The process may additionally comprise the step of feeding a section of the release liner web into the DBD such that at least one surface of the release liner comes into contact with the DBD. The at least one surface of the release liner is the skin layer.

The process may further comprise the step of removing the section of the release liner web from the DBD, which may be achieved by winding the web onto a roller. As the section of the release liner web is removed from the DBD, a further section of the web may simultaneously be fed into the DBD. Thus, the process may be run continuously.

The same section of the release liner web may be passed through the DBD multiple times, for example twice or three times. This may allow the thickness of the nano-coating to be increased.

According to a third aspect of the present invention, there is provided a pressure sensitive adhesive label comprising a release liner according to the first aspect of the present invention, and a label comprising an adhesive layer, wherein the label is attached to the release liner via the adhesive layer.

According to a fourth aspect of the present invention, there is provided an article labelled with the pressure sensitive adhesive label according to the third aspect of the present invention.

It should be noted that all features of the first aspect of the invention also relate to the second, third and fourth aspects of the invention and *vice versa*.

The present invention is more specifically described with reference to Figure 1. Figure 1 is a schematic representation of how the effective release force is altered when the modulus and/or thickness of the skin layer changes.

Figure 1 schematically shows four different release liners. All of the release liners comprise a substrate layer **1**, a skin layer and a nano-coating of release compound (not shown) thereon. In the top left release liner, skin layer **2** has a high modulus which is equal to or greater than the substrate layer **1**. The effective release force at 90° is shown by arrow **3**.

In the bottom left release liner, skin layer **4** is composed of the same material as skin layer **2** but the thickness of the skin layer has been increased. However, the effective release force at 90° shown by arrow **5** is the same as that of the top left release liner.

In the top right release liner, the skin layer **6** has a low modulus which is less than that of the substrate layer. Deformation **8** of the skin layer **6** occurs when a force is applied to the skin layer. Due to deformation of the skin layer **6**, the effective release angle is greater than 90°C. As a result, the effective release force at 90°C is less than that of the previously discussed release liners, as shown by arrow **7**.

In the bottom right release liner, the skin layer **9** is composed of the same material as skin layer **6** but the thickness of the skin layer has been increased. The effective release force at 90°, shown by arrow **10**, is smaller than release force **7**. This is due to greater deformation **11** of the low modulus skin layer **9** which in turn creates an even larger effective release angle.

Comparative Examples 1 and 2

A release liner having a substrate layer of polypropylene homopolymer and coextruded skin layers of polyethylene/polypropylene/polybutylene random terpolymer each having a thickness of approximately 1µm, was manufactured by means of a bubble process. The three-layer release liner had an overall thickness of 30 µm. The release liner was fed into a DBD with an atmosphere of nitrogen and argon. A small amount of vaporised hexamethyl disiloxane was injected into the plasma discharge which resulted in a nano-coating of poly(dimethyl siloxane) release compound being deposited on one of the outer skin layers of the release liner.

For each example, different DBD parameters were used, as follows:

Example 1: DBD treated at 65w.min/m^2 and a speed of 50m/min, in an atmosphere of 400 ppm HDMSO in nitrogen.

Example 2: DBD treated at 65w.min/m^2 and a speed of 50m/min, in an atmosphere of 200 ppm HDMSO in nitrogen.

Each coated release liner was tested to determine its release force using the low speed release method. An adhesive tape, as can be purchased from Tesa^{RTM}, was attached to the nano-coated surface of the release liner. The tape was then pulled vertically upwards at a 90° angle (rather than 180°) and the force required to remove the tape after 30 mm, 40 mm and 50 mm (of the tape had been detached) was recorded along with the force average required. The force was measured using an instron tensometer fitted with a load cell of 10 N. An angle of 90° was used as this is more applicable to PSA bottle labelling than an angle of 180°.

In theory, the force average i.e. the average force required to remove the entire length of the tape should be equal to the force required at any particular point along the tape. However, in practice this is not the case due to several factors. In particular, the unevenness of the tape adhesive, the varying pressure applied to adhere the tape to the release liner, and the amount of time lapsed between applying the tape to the release liner and testing the release force. All of these factors cause variation in the degree of adhesion of the tape to the release liner and thus, the measured release force.

The results from the tests are shown in Table 1 and Table 2.

Table 1

Example 1				
	Force (30 mm) (g/cm)	Force (40 mm) (g/cm)	Force (50 mm) (g/cm)	Force Average (g/cm)
Test 1	7.3	7.2	7.5	7.0
Test 2	7.7	7.3	7.0	5.8
Test 3	5.9	6.5	6.2	6.1
Average	6.9	7.0	6.9	6.3

Table 2

Example 2				
	Force (30 mm) (g/cm)	Force (40 mm) (g/cm)	Force (50 mm) (g/cm)	Force Average (g/cm)
Test 1	8.8	9.0	9.5	9.8
Test 2	6.7	7.2	7.1	9.1
Test 3	6.5	4.3	5.8	8.8
Average	7.3	6.9	7.5	9.2

Examples 3 and 4

A release liner having a substrate layer of polypropylene homopolymer and coextruded skin layers of ethylene propylene copolymer (EPM) each having a thickness of approximately 1µm, is manufactured by means of a bubble process. The release liner is subsequently fed into a DBD with an atmosphere of nitrogen and argon. A small amount of vaporised hexamethyl disiloxane is injected into the plasma discharge which results in a nano-coating of poly(dimethyl siloxane) release compound being deposited on one of the outer skin layers of the release liner.

For each example, different DBD parameters are used, as follows:

Example 3: DBD treated at 65w.min/m^2 and a speed of 50m/min, in an atmosphere of 400 ppm HDMSO in nitrogen.

Example 4: DBD treated at 65w.min/m^2 and a speed of 50m/min, in an atmosphere of 200 ppm HDMSO in nitrogen.

Each coated release liner is tested to determine its release force. This is achieved in the same manner as for Examples 1 and 2.

The results are shown in Table 3 and Table 4.

Table 3

Example 3				
	Force (30 mm) (g/cm)	Force (40 mm) (g/cm)	Force (50 mm) (g/cm)	Force Average (g/cm)
Test 1	0.73	0.72	0.75	0.70
Test 2	0.77	0.73	0.70	0.58

Test 3	0.59	0.65	0.62	0.61
Average	0.70	0.7	0.69	0.63

Table 4

	Example 4			
	Force (30 mm) (g/cm)	Force (40 mm) (g/cm)	Force (50 mm) (g/cm)	Force Average (g/cm)
Test 1	0.88	0.90	0.95	0.98
Test 2	0.67	0.72	0.71	0.91
Test 3	0.65	0.43	0.58	0.88
Average	0.73	0.69	0.75	0.92

From the results, it can be seen that the presence of a skin layer with a modulus less than that of the substrate layer results in a significant reduction in the force required to remove the tape from the release liner.

CLAIMS

1. A release liner for use in adhesive labelling or packaging film, the release liner comprising a substrate layer and at least one skin layer, the modulus of the skin layer being less than that of the substrate layer and the skin layer having a nano-coating of a release compound thereon.

2. A release liner according to Claim 1, wherein the release compound comprises one or more of a wax, a silicone and a fluoropolymer.

3. A release liner according to Claim 2, wherein the release compound comprises a silicone.

4. A release liner according to Claim 3, wherein the release compound comprises poly(dimethyl siloxane), poly(dimethyl dichloro silane), poly(divinyl silane), poly(diphenyl siloxane), poly(phenylmethyl siloxane), 1,3-tetraphenyl 1,3-dimethyl disiloxane, and/or 1,3-diphenyl 1,2-tetramethyl disiloxane.

5. A release liner according to any one of claims 1 to 4, wherein the nano-coating is deposited on the skin layer using an atmospheric pressure plasma.

6. A release liner according to Claim 5, wherein the atmospheric pressure plasma is a dielectric barrier discharge.

7. A release liner according to any one of claims 1 to 6, wherein the skin layer comprises an elastomer.

8. A release liner according to Claim 7, wherein the elastomer is a rubber.

9. A release liner according to Claim 8, wherein the rubber comprises an ethylene-propylene copolymer (EPM), an ethylene propylene-diene monomer copolymer (EPDM), polybutadiene, polyisoprene, a styrene-butadiene copolymer, a styrene-isoprene copolymer, a urethane, a polyester and/or mixtures or blends thereof.

10. A release liner according to any one of claims 1 to 9, wherein the skin layer thickness is in the range of:

    a. from about 0.01µm to about 10µm;
    b. from about 0.1µm to about 5µm;
    c. from about 0.5µm to about 3µm;
    d. from about 0.7µm to about 2µm; or
    e. from about 0.8µm to about 1.5µm.

11. A release liner according to any one of claims 1 to 10, wherein the substrate layer comprises a polyolefin, for example polyethylene, polypropylene, polybutylene, mixtures, blends or copolymers thereof; a polyester, for example polyethylene terephthalate; a polyamide, for example nylon; a polyurethane; a polyvinyl halide, for example polyvinyl chloride; an acetate

and/or a biopolymer, for example cellulose and/or its derivatives, polylactic acid or polyhydroxyalkanoate.

12. A release liner according to Claim 11, wherein the substrate layer comprises polypropylene.

13. A release liner according to Claim 11, wherein the substrate layer comprises polyethylene terephthalate.

14. A release liner according to any one of claims 1 to 13, wherein the substrate layer has a modulus in the range of from about 0.1 GPa to about 10 GPa.

15. A release liner according to Claim 14, wherein the substrate layer has a modulus in the range of from about 0.5 GPa to about 5 GPa.

16. A release liner according to Claim 15, wherein the substrate layer has a modulus in the range of from about 1 GPa to about 3 GPa.

17. A release liner according to any one of claims 1 to 16, wherein the skin layer has a modulus of at least about 1% less than the modulus of the substrate layer.

18. A release liner according to Claim 17, wherein the skin layer has a modulus of at least about 5% less than the modulus of the substrate layer.

19. A release liner according to Claim 18, wherein the skin layer has a modulus of at least about 10%, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80% or at least about 90% less than the modulus of the substrate layer.

20. A release liner according to any one of claims 1 to 19, wherein the ratio of the modulus of the substrate layer to the modulus of the skin layer is from:
    a. 10-30:1;
    b. 10-29:1;
    c. 12-28:1;
    d. 13-27:1;
    e. 14-26:1;
    f. 15-25:1; or
    g. 10-25:1.

21. A release liner according to any one of claims 1 to 20, wherein the substrate layer and/or the skin layer are compostable.

22. A release liner according to any one of claims 1 to 21, wherein the substrate layer and/or skin layer are recyclable.

23. A release liner according to any one of claims 1 to 22, wherein the release liner is recyclable.

24. A release liner according to any one of claims 1 to 23, wherein the substrate and/or the skin layer has a radio carbon content.

25. A release liner according to Claim 24, wherein the substrate layer and/or the skin layer has a radio carbon content of at least about 10pMC, or at least about 20pMC, or at least about 30pMC, or at least about 40pMC, or at least about 50pMC, or at least about 60pMC, or at least about 70pMC, or at least about 80pMC, or at least about 90pMC, or at least about 100pMC.

26. A process for the manufacture of a release liner for use in adhesive labelling or packaging film, comprising the steps of:

   a. providing a release liner comprising a substrate layer and at least one skin layer; and
   b. depositing a nano-coating of a release compound on the skin layer,

wherein the modulus of the skin layer is less than that of the substrate layer.

27. A process according to Claim 26, wherein the nano-coating is deposited on the skin layer using an atmospheric pressure plasma.

28. A process according to Claim 27, wherein the atmospheric pressure plasma is a dielectric barrier discharge.

29. A pressure sensitive adhesive label, comprising a release liner according to any one of claims 1 to 25 and a label comprising an adhesive layer, wherein the label is attached to the release liner via the adhesive layer.

30. An article labelled with the pressure sensitive label according to Claim 29.

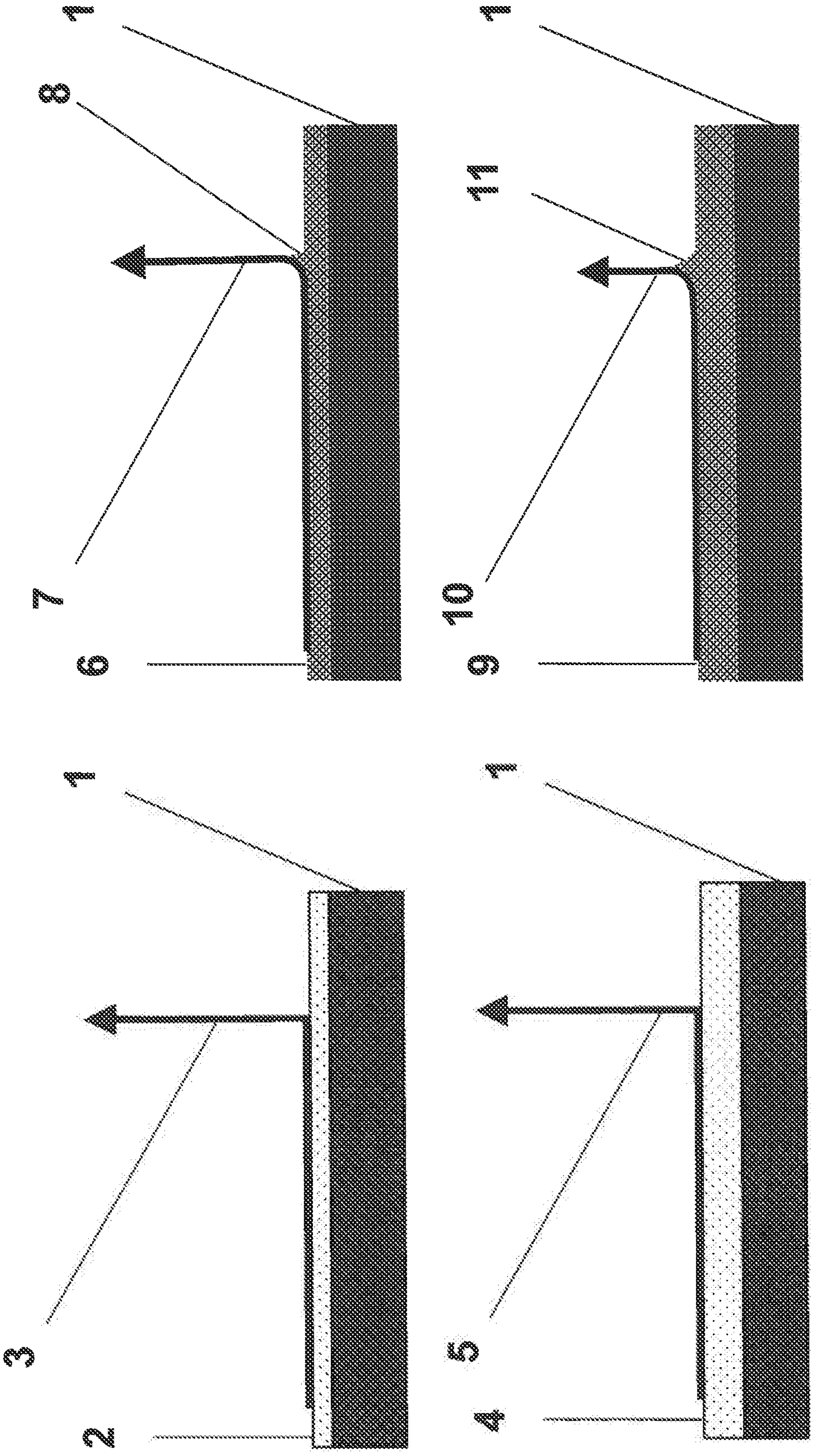

Figure 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/052362

A. CLASSIFICATION OF SUBJECT MATTER

INV. B32B7/02 B32B7/12 B32B25/08 B32B25/16 B32B27/08
B32B27/28 B32B27/32 B32B27/34 B32B27/36 C09J7/02

ADD.

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)

B32B C09J G09F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 372 669 A (FREEDMAN MELVIN S [US]) 13 December 1994 (1994-12-13) column 4, lines 54-68 - column 7, lines 55-65; claims 1-6, 10-11; figures 1-2 column 5, line 63 - column 6, line 20 column 1, lines 46-47 -----	1-3,11, 12,16, 29,30
X	US 2007/231571 A1 (LANE RICHARD [NL] ET AL) 4 October 2007 (2007-10-04) paragraphs [0047], [0050] - [0056]; claims 1, 5-7, 11, 18, 20-38, 43, 62,; figure 2; example 22 ----- -/--	1-4,7-9, 13

☒ 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

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"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 10 November 2014	Date of mailing of the international search report 18/11/2014
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Derz, Thomas

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/004749 A1 (HAO ENCAI [US] ET AL) 3 January 2013 (2013-01-03) paragraphs [0022], [0031] - [0035], [0040], [0060], [0095] - [0104], [0135], [0170]; claims 40,42,44-45,47-48; figure 6 -----	1,2,7-9

INTERNATIONAL SEARCH REPORT

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