PRINTED NONWOVEN SUBSTRATES FOR USE IN PERSONAL CARE ARTICLES

Inventors: Varunesh Sharma, Atlanta, GA (US);
Leonard E. Zelazoski, Kennesaw, GA (US)

Correspondence Address:
KIMBERLY-CLARK WORLDWIDE, INC.
401 NORTH LAKE STREET
NEENAH, WI 54956

Appl. No.: 10/955,260
Filed: Sep. 30, 2004

Publication Classification

Int. Cl.
D04H 1/00 (2006.01)
D04H 13/00 (2006.01)
D04H 1/06 (2006.01)

U.S. Cl. 442/327; 442/333; 442/359

ABSTRACT

A personal care product, for example a diaper, that includes a surface upon which is disposed graphics, wherein the graphics comprise an ink composition applied to the substrate at a temperature and further comprises a layer that comprises a hotmelt composition that is applied over the graphics at a temperature that is greater than the temperature that the graphics were applied is provided.
PRINTED NONWOVEN SUBSTRATES FOR USE IN PERSONAL CARE ARTICLES

BACKGROUND OF THE INVENTION

0001. The present invention is directed to printed nonwoven fabrics, films, and laminates of nonwoven fabrics and/or films.

0002. Polymers are used extensively to make a variety of products which include blown and cast films, extruded sheets, injection molded articles, foams, blow molded articles, extruded pipe, monofilaments, fibers and nonwoven fabrics. Polymers that are used to form these products, such as polyolefins, are naturally hydrophobic, and for many uses hydrophobicity is a disadvantage. Polyolefins, such as polyethylene and polypropylene, are used to manufacture polymeric fabrics which are employed in the construction of such disposable absorbent articles as diapers, feminine care products, incontinence products, training pants, and swimming pants, and so forth. Such polymeric fabrics often are nonwoven fabrics prepared by, for example, such processes as melt-blowing, carding, coforming and spunbonding. It would be desirable to provide a method of improving the quality of images printed on hydrophobic substrates such as nonwoven fabrics made from polyolefin fibers.

0003. Absorbent articles, especially personal care absorbent articles, such as diapers, training pants, and swimming pants typically include an outercover that made from a nonwoven polymeric fabric. The outercover of diapers, training pants, and swimming pants are difficult to print on in a fast and economical manner that is amenable to efficient machine production. More particularly, it is difficult to produce printed images on such hydrophobic substrates. Accordingly, there is a need to improve the quality of images printed on outercovers on diapers, training pants, swimming pants and other products that incorporate hydrophobic substrates.

SUMMARY OF THE INVENTION

0004. The present invention provides a personal care product that includes at least one surface upon which is disposed graphics, wherein the graphics include an ink composition wherein the ink composition is applied to the substrate at a temperature Ti wherein the substrate further includes a layer that comprises a hotmelt composition that is applied over at least a portion of the graphics at a temperature Tj that is greater than or equal to Ti. Desirably, the layer includes a hot melt composition having a haze value of less than or equal to 4 as measured by ASTM 1003-00. The hotmelt composition may be or include a composition selected from the group consisting of natural waxes, synthetic hydrocarbons, polyolefins, polyanides, tall oil rosins, polyurethanes, polyesters, and polyacrylcs. In certain embodiments, the nonwoven substrate is a hydrophobic nonwoven substrate. The hydrophobic nonwoven substrate may include fibers that are formed from a hydrophobic polymer composition that is selected from the group consisting of polyolefins, polymers and copolymers of ethylene, polymers and copolymers of propylene. In certain desirable embodiments, the personal care product is a disposable diaper and the substrate is an outer cover for the diaper. The personal care product may be a diaper, a swimming pant, a training pant or an absorbent underpant. In certain embodiments, Ti and Tj are greater than or equal to about 90° C. In certain embodiments, Ti and Tj are in the range of from about 90° C. to about 140° C.

0005. The present invention also provides a method of printing on a substrate, the method of printing includes the steps of: providing a substrate, heating an ink composition to a temperature TJ, depositing the ink composition on a portion of the substrate, heating a second composition to a temperature T that is greater than or equal to TJ, and depositing the second composition over the portion of the substrate that includes the ink composition. In certain embodiments, the step of depositing the second composition over the portion of the substrate that includes the ink composition causes the ink composition to melt. In certain embodiments, the step of depositing the second composition over the portion of the substrate that includes the ink composition enhances dot gain of ink composition. Desirably, depositing the second composition over the portion of the substrate that includes the ink composition increases adherence of the ink composition to the substrate. More desirably, depositing the second composition over the portion of the substrate provides a sacrificial layer that provide abrasion resistance. Still more desirably, depositing the second composition over a portion of a color image improves the color and/or brightness of the image.

0006. The present invention also provides a method of creating high-speed multi-color process images, the method including: providing at least two high operating frequency printheads, said high operating frequency printheads being capable of processing phase-change inks; providing at least two phase-change inks; providing a substrate; activating the printheads such that at least two inks pass therethrough; passing the substrate under the printheads at a rate of at least about 1000 feet per minute; forming an image on the substrate; and depositing a second composition over the image. In certain embodiments, the step of depositing the second composition over the portion of the substrate that includes the ink composition causes the ink composition to melt. In certain embodiments, the step of depositing the second composition over the portion of the substrate that includes the ink composition enhances dot gain of ink composition. Desirably, depositing the second composition over the portion of the substrate that includes the ink composition increases adherence of the ink composition to the substrate. More desirably, depositing the second composition over the portion of the substrate provides a sacrificial layer that provide abrasion resistance.

BRIEF DESCRIPTION OF DRAWINGS

0007. Fig. 1 is a schematic diagram of an exemplary process of the present invention.

DEFINITIONS

0008. As used herein, the terms “chemistry” or “chemistries” are intended to include and refer to any and all applications, inks (other than phase-change inks), compositions, formulations, and so forth (including those having solids and/or particulates) which may be processed by the printheads described herein in accordance with the present invention. It is desirable, but not necessary, that the terms “chemistry” or “chemistries” be directed to such applications, inks, compositions, formulations, and so forth which
are compatible with phase-change inks. Suitable chemistries
include, but are not limited to, medicaments, inks, waxes,
paints, lotions, ointments, skin health agents, topical appli-
cations, and so forth or combinations thereof. It will be
appreciated that one of such chemistries may be a medium
which is used to carry or transport the phase-change inks.
Exemplary mediums include, but are not limited, low
molecular weight linear polyethylenes.

[0009] As used herein, the terms “comprises,” “comprising” and
other derivatives from the root term “comprise” are
intended to be open-ended terms that specify the presence
of any stated features, elements, integers, steps, or components,
but do not preclude the presence or addition of one or more
other features, elements, integers, steps, components, or
groups thereof.

[0010] As used herein, the term “fabric” refers to all of the
woven, knitted and nonwoven fibrous webs, as well as paper,
foam, film or the like.

[0011] As used herein, the term “health care product”
means medical gowns, drapes, clothing, as well as devices
which may be used in a medical procedure.

[0012] As used herein, the term “ink” refers to phase-
change inks.

[0013] As used herein, the term “layer” when used in the
singular can have the dual meaning of a single element or a
plurality of elements.

[0014] As used herein the term “melblown fibers” means
fibers formed by extruding a molten thermoplastic material
through a plurality of fine, usually circular, die capillaries as
molten threads or filaments into converging high velocity,
usually hot, gas (e.g. air) streams which attenuate the
filaments of molten thermoplastic material to reduce their
diameter, which may be to microfiber diameter. Thereafter,
the melblown fibers are carried by the high velocity gas
stream and are deposited on a collecting surface to form a
web of randomly dispersed melblown fibers. Such a process
is disclosed, for example, in U.S. Pat. No. 3,849,241 to Butin
et al. Melblown fibers are microfibers which may be con-
tinuous or discontinuous, are generally smaller than 10
microns in average diameter, and are generally tacky when
deposited onto a collecting surface.

[0015] As used herein the terms “nonwoven” and “non-
woven fabric or web” mean a web having a structure of
individual fibers, filaments or threads which are interlaid,
but not in an identifiable manner as in a knitted fabric.
Nonwoven fabrics or webs have been formed from many
processes such as for example, melblowing processes,
spunbonding processes, and bonded carded web processes.
The basis weight of nonwoven fabrics is usually expressed
in ounces of material per square yard (osy) or grams per
square meter (gsm) and the fiber diameters useful are usually
expressed in microns. (Note that to convert from osy to gsm,
multiply osy by 33.91).

[0016] As used herein, the term “personal care product” or
“personal care absorbent product” means diapers, training
pants, swim wear, absorbent underpants, baby wipes, adult
incontinence products, sanitary wipes, wet wipes, feminine
hygiene products, wound dressings, nursing pads, time
release patches, bandages, mortuary products, veterinary
products, hygiene and absorbent products and so forth.

[0017] As used herein, the term “phase-change” applica-
tion, chemistry, ink, liquid, material or the like refers to a
material which is processed in a liquid or substantially liquid
state and then solidifies, returning to its natural state when
cooled, cures, cross-links, or the like.

[0018] As used herein the term “spunbonded fibers” refers
to small diameter fibers which are formed by extruding
molten thermoplastic material as filaments from a plurality
of fine, usually circular capillaries of a spinneret with the
diameter of the extruded filaments then being rapidly
reduced as by, for example, in U.S. Pat. No. 4,340,563 to
Appel et al., and U.S. Pat. No. 3,692,618 to Dorschner et al.,
to Hartman, and U.S. Pat. No. 3,542,615 to Dobo et al.
Spunbond fibers are generally not tacky when they are
deposited onto a collecting surface. Spunbond fibers are
generally continuous and have average diameters (from a
sample of at least 10) larger than 7 microns, more partic-
ularly, between about 10 and 20 microns.

[0019] These terms may be defined with additonal lan-
guage in the remaining portions of the specification.

[0020] As used herein a singular term generally includes
the plural, and a plural term generally includes the singular
unless otherwise indicated.

DESCRIPTION OF TEST METHODS

[0021] A crock test method was used to measure whether
the combinations of treated nonwovens and inks had suffi-
cient abrasion resistance. The crock test method was based
upon American Association of Textile Chemists and Color-
ists (AATCC) Test Method 116-1983, which is incorporated
herein in its entirety with a few modifications.

[0022] Crockfastness in the intended use of the product
refers to the transfer resistance of ink from the printed
substrate to another (e.g. apparel) in contact with the prod-
uct. A modification of ASTM test method F 1571-95 using
a Sutherland Ink Rub Tester was used to determine the
crockfastness of the materials of the present invention.
The ASTM test method was modified in that two 1"x2" rubber
pads (available from the DANILEE COMPANY) were
applied at the ends (one pad at each end) of the bottom
surface of the weight so that a stress of 1 pound per square
inch (psi) was achieved across the pads. The second modi-
fication of the standard ASTM test method was that instead
of using a microcloth available from Bueltner, a 80x80 count
bleached muslin cloth, Crockmeter Cloth #3 (available from
Testfabrics, Inc., having offices in Pennsylvania), was used
to rub against the printed material. It is of note that the
ASTM is identified as being intended to present a procedure
for measuring the abrasion resistance and smudge tendency
of typewritten and impact written images; however, in the
modified test method it was used to test images produced by
an ink-jet printer. The procedure was also modified such that
the tester ran for 40 cycles, rather than 10. The modified
test method also includes a visual comparison of the color which
was transferred onto the muslin cloth to the AATCC 9-Step
Chromatic Transference Scale (1996 Edition) (available
from American Association of Textile Chemists and Color-
ists, having offices in Research Triangle Park, N.C.) so as to
determine a crockfastness rating between 1 and 5. A rating
of 5 indicates no transfer of color on the muslin cloth.
DETAILED DESCRIPTION OF THE INVENTION

[0023] The present invention relates to printed nonwoven substrates, printed film substrates and to printed laminates. An improved method of producing printed nonwoven and film substrates is also provided. An exemplary description of the method is provided herein. The exemplary method is schematically illustrated in FIG. 1 and includes providing at plurality of high-operating frequency printheads 10 that can be used to processing phase-change inks, e.g. hot melt ink compositions. The printheads 10 jet droplets of one or more phase-change inks 14 onto a substrate 16 so that an image (not shown) is formed on the substrate 16. Desirably, the method is capable of operating at high speeds, for example at a rate of at least about 1000 feet per minute. For example, it is suggested that the printheads have operating frequencies of at least about twenty kHz. Any suitable printhead may be used provided it is capable of performing at the frequencies identified by any one or more of the phase-change inks discussed herein. One suggested printhead includes, but is not limited to, a 1000 Hz Direct Dispensing VHS-IT, With Integral Nozzle, Long Throw Micro-Drop Valve available from The Lee Company of Westbrook, Conn. Another suggested printhead suitable for use with the present invention is Spectra’s printhead model Galaxy PH 256/80, a piezo-driven printhead available from Spectra, Inc., having offices in Lebanon, N.H. It is also desirable that the phase-change inks are hot-melt phase-change inks, and in some instances more desirable for the phase-change inks to be wax based. While reference is made throughout the disclosure to passing, conveying or transporting the substrate or material under the printhead, that same terminology is also intended to include passing the printhead over the substrate or the combined movement of the printhead and the material such that the desired production speeds may be achieved.

[0024] As discussed in more detail herein, the use of phase-change inks, specifically hot-melt inks, and more specifically wax-based inks enables the high speed printing desired herein as the phase-change inks do not require drying. The drying time of inks and compositions used in printers can limit production speeds. The use of phase-change inks eliminates the need for additional drying steps and/or space between the printheads which was previously necessary. Thus, desired registration and image quality can be obtained at high speeds.

[0025] Images produced by utilizing the processes and methods discussed herein may be affected by the fluid handling properties of the printheads of some of the suitable devices. That is, the ability of some of the printheads to provide for the degassing of the inks further enables the high frequency jetting as there may be less disruption in the supply of inks to the printheads. It is believed that the combination of the phase-change inks and the ability to degas those inks during processing may provide enhanced results.

[0026] The method may further include providing a controller or a control means 18 that is in communication with the printheads 10. The control means 18 is desirably capable of operating in multiple modes and may control the printheads 10 such that the printheads 10 act together or independently from one another. It will be appreciated that any number of control means are suitable for use with the present invention depending on the number of printheads each control means is in communication with. The control means may include manual, computer controlled or computer regulated control elements. Exemplary control means include, but are not limited to, manual switches, line driven switches, photo-optic sensors, software driven switching circuits and so forth.

[0027] Also illustrated in FIG. 1 as part of the material transport system is a drum 20 and a plurality of idlers 22. The drum 20 and idlers 22 are designed to be compatible with the material 16 which is passing thereover such that the material 16 passes over or around the drum 20 in a substantially wrinkle-free fashion. The idlers 22 may be adjusted such that a desired level of tension may be applied to the material to eliminate or reduce the wrinkles which might otherwise be present in the material 16 were it to pass over or about the drum 20 without having some tension force applied thereto. That is, the idlers 22 may be used to create or maintain a desired tension on the material 16 as it passes over or about the drum 20. It will be appreciated and understood that while a drum 20 is shown in FIG. 1, the present application is not intended to be limited thereto and that the term is intended to mean or include, but not be limited to, any and all surfaces over which the material which is to be printed upon may pass such that the material is suitable for printing thereon as it passes over or about the surface. Additionally, while reference is made to a plurality of idlers 22, it is also intended for the scope of the present invention to include any other suitable means which may be used to maintain or adjust the tension on the material as the material passes under the printheads. Further, it will be appreciated that while the distance or spacing between the printheads and the material onto which they are to print may vary, however, it is desirable for the material to be about 2 mm to about 3 mm from the printhead when the ejection or printing of ink occurs. It will be further appreciated that when a drum and idler set or the like is used as part of the system used to transport the material, that the printheads may be positioned in a desired fashion such that the gap or spacing between the printhead and the material passing over the drum is a desired distance. It should also be appreciated that the use of a drum or the like will enable the printing of more consistent images as the distance between the printhead and material can be maintained at a relative constant.

[0028] In one embodiment of the method of the present invention, inks and/or chemistries that have varying degrees of penetration into the material may be applied to the material or substrate such that the varying degrees of ink and/or chemistry penetration may result in a material having a variety of topographies. As will be appreciated, the degree of penetration may vary in part because of the temperature at which the inks and/or the medium, if any, they are in are processed, the material to which the inks are applied and/or the composition of the inks and/or the medium, if any, in which they are in. Thus, for example, where the material is receptive to penetration, if the inks are passed through one or more of the printheads at a temperature of at least about 115° C., as desired, the penetration can generally be expected to greater than at cooler temperatures.

[0029] One or more inks may be selectively applied to all or a portion of the substrate in order to form an image. The inks may be applied to the substrate in an image or pattern which is repeating or random and may also be applied to the
substrate so as to produce a fluid barrier. As will be discussed in more detail below, at least two inks will be applied to a substrate in such a manner that the inks form an image on at least a portion of the material or substrate. It has been discovered that depositing a second layer of a transparent or translucent composition, preferably a clear ink, over the printed image will provide a protective layer over the image below. This second layer can provide protection to the image from potential abrasion during use of a product. For example, a protective or “sacrificial” layer is provided over an image on a disposable diaper, training pants or swimming pants to protect the image from abrasion during manufacturing and packaging of the diaper as well as during intended use of the diaper. In certain embodiments, the printed substrate is a component of a personal care product, particularly a disposable, personal care article such as a diaper, a swimming pant, a training pant or an absorbent underpant.

[0030] Generally, a clear layer is provided over an image on an absorbent product to protect the image on the absorbent product from abrasion during manufacturing, processing and use of the product. It has also been discovered that the application of a hot composition over an image printed using one or more hot melt inks increases the dot gain of the image, also increasing the print coverage of the image on the substrate. Traditionally, printing processes try to reduce dot gain. The present invention teaches increasing dot gain. It has been discovered that increasing dot gain of images printed on nonwoven substrates increases not only the print coverage but also increases the perception of vibrancy and adherence of the image to a nonwoven substrate. Thus, images can be printed at lower resolution and spread to reduce the cost of achieving a vibrant image on a nonwoven substrate.

[0031] Exemplary inks are described in U.S. Pat. No. 4,390,369 to Hitachi; U.S. Pat. No. 5,053,079 to Coates Electrographics Limited; U.S. Pat. No. 5,102,448 to Imperial Chemical Industries PLC; U.S. Pat. No. 5,350,789 to Hitachi, Ltd.; and U.S. Pat. No. 5,354,368 to Markem Corporation. Desirably, the composition of the second protective layer does not contain pigments or colorants and is transparent. However, the composition used to form the second layer may be translucent as long as a layer of the composition does not obscure an image printed under the layer of the composition. Desirably, the composition is a clear ink. Desirably, the composition has a haze of less than 4 as measured by ASTM 1003-00. It is also desirable that the layer of the dried composition has a hardness that is greater than the hardness of the dried colored ink composition(s) used to produce the image below the layer. Suggested clear hotmelt composition may include or be based on a composition selected from the group consisting of natural waxes, synthetic hydrocarbons, polyolefins, polyamides, tall oil rosin, polyurethanes, polyesters, and polyacrylates. Suggested commercial examples of transparent ink compositions for the protective layer include, but are not limited to 7061-028-1 Hot Melt Flushing Ink obtained from Spectra, Inc. of Lebanon, N.H. and EXPGCS514A ink from the MARKEM Corporation of Keene, N.H.

[0032] The protective composition can be deposited on the printed substrate over the printed image using any of a variety of methods including, but not limited to, inkjet printing, wax jet printing, rotogravure printing, spraying, flexographic printing, offset printing and so forth. In one desirable embodiment, both the image and the protective coating or layer are applied to the substrate using an inkjet printing process. However, the protective coating or layer can be applied using any known process for applying a layer of a meltable composition to a plastic substrate including the methods listed above.

[0033] Although it is generally desired for the inks to remain in place on the receiving material or substrate after placement (i.e., non-releasable), there may be instances when it is desirable for at least a portion of the ink to be releasable. Alternately, there may be instances when the inks remain in place but one or more of the chemistries which were processed with the phase-change inks may be releasable. Thus, while it may be desirable in one or more embodiments for the inks to remain in place and/or exhibit a higher level of crockfastness, where the inks are processed in a medium or the like, one or more of the chemistries may release from the substrate or other chemistries when exposed to certain conditions or upon the happening of certain events (e.g., exposure to certain temperatures (e.g., at least about body temperature (about 23° C.), insult, and so forth)). It is further contemplated that the release of one or more chemistries from the substrate may cause or result in triggered degradation of all or portion of the product or substrate. That is, a resulting product may be designed such that degradation begins or is initiated upon the release of one or more inks and/or chemistries of the product.

[0034] As suggested above, the method of the present invention includes the step of providing a substrate upon which the discharged inks and/or chemistries may form discrete droplets or segments thereon. While it is desirable in at least one embodiment of the present invention that the material be a porous material, and more desirably a polyolefin, the methods and processes of the present invention, contemplate the use of any suitable porous or non-porous material. The suitability of a particular material may depend, at least in part, on the inks and/or chemistries being used in conjunction therewith. Exemplary substrate materials include, but are not limited to, wovens, nonwovens, papers, foams, films, tissues, metals, plastics, glass, laminates, and generally any surface of any substrate or product which is capable of having the inks or inks and chemistries described herein applied thereto either in the manner described or so as to produce materials such as those discussed herein. It is further contemplated that the material may comprise or be incorporated in a flexible packaging product, an article of clothing, a health care product, a personal care product, one or more components thereof, and so forth.

[0035] Combinations of four basic colors (e.g., cyan, magenta, yellow and black) can be used to create a very broad multi-color spectrum thereby utilizing few printheads and colorbanks. This approach not only reduces the equipment cost and the number of inks needed to be kept in inventory, but also reduces the amount of converting equipment needed, the amount of floor space occupied, as well as time costs associated with color change overs as compared with prior contact printing devices. While the four color combination specified above has been found to be simplistic yet flexible enough to accommodate the graphic requirements discussed herein, a variety of other color combinations are possible and are contemplated in the use of the present invention. Exemplary combinations include those having just one color as well as those with more that 12
colors to allow for the production of a broader range of colors with more intense color concentrations. It is appreciated that more than 12 colors of ink may be used in a combination, however, the size of the drum(s) used in manufacture, the number of printheads, and/or color banks necessary to accommodate the different inks may necessitate a practical limit on the number of colors ultimately used.

[0036] It will also be appreciated by those of skill in the art that inks which are suitable for use in the present invention may be available in a variety of colors, and it is desirable that inks of at least two different colors are used. Furthermore, where inks and/or chemistries of different colors are used in the above methods and processes, the resulting pattern or image formed on the material may be such that a single or multi-color image is produced. That is, for example, where yellow and blue inks are used, the resulting image could be green or it could be yellow and blue or it could be green, yellow and blue. Of course a variety of shades of each color is also possible to produce.

[0037] While not specifically directed thereto, the method of the present invention may be achieved at least in part by an apparatus arranged so as to provide for process printing. That is at least two printheads should be positioned such that the resulting emissions or discharges therefrom overlap at least in part so as to create a process image. Any number of printhead orientations are possible and all suitable configurations are contemplated for use in the present invention. The basics of process printing, for example as described in the Pocket Guide to Color Reproduction Communication & Control, by Miles Southworth (1972), are known to those of skill in the art. The present invention, however, describes the use of phase-change inks to produce an image at high speeds on absorbent articles or a component of an absorbent article and a protective layer of a heated composition over the image to improve and protect the printed image.

[0038] In a further embodiment of the present invention, the method may include the provision of a temperature sensor, wherein the temperature sensor measures, and optionally allows for the control of, the temperature of the inks and/or chemistries which pass through the printheads used. It will be appreciated that more than one sensor may be used where multiple inks and/or chemistries are used with the inkjet printing device.

[0039] It will be appreciated that the methods and processes discussed herein will result in the discharge of discrete segments of inks and/or chemistries, and while discrete segments of many sizes are contemplated, the discrete droplets or segments will desirably have a volume of between about 5 picoliters (or nanograms) and about 100 picoliters, more desirably between about 20 picoliters and about 90 picoliters, and even more desirably between about 50 picoliters and about 80 picoliters. The droplets or segments will also desirably have a length and width less than about 5 mm, more desirably less than about 3 mm, and still more desirably less than about 2 mm and greater than about 0.02 mm. The discrete segments are desirably discharged at a frequency of at least 20 kHz, and more desirably between about 20 kHz and about 80 kHz. Furthermore, inks and chemistries having a wide range of the viscosities may be processed in accordance with the methods and processes suggested and described in more detail herein. It is desirable for the viscosity of the inks and/or chemistries discharged from the printheads to be between about 5 and about 50 centipoise and more desirably between about 8 and about 30 centipoise at the time of discharge (at an elevated jetting temperature). Additionally, as the printheads generally operate at drive voltages within a broad range, it will be appreciated and understood that manipulation of the voltages at which the printheads are operated can provide for operation of the printheads at higher frequencies while still maintaining the desired drop size or volume and thus accommodate higher material line or processing speeds.

[0040] Although droplets or discrete segments of particular cross-sectional shapes, dimension or volume are contemplated and desired in certain embodiments, in those embodiments not requiring specific droplet size or shape, any variety of cross-sectional shapes of the droplets are contemplated for use on or in the material of the present invention. The cross-sectional shape of the droplets which solidify, return to their normal state under ambient conditions, cure, crosslink, and so forth on or below the surface of the substrate may be changed or controlled, at least to some degree, depending on the selection of the chemistries to be applied to the selected substrate as well as the apparatus or method selected for application. Specifically, for example, the cross-sectional shape of the droplets which solidify on or below the surface of the substrate may be changed, by manipulating, for example, the temperature, velocity, and throw distance. Thus, for example, if the temperature of the ink or chemistry is increased, it will typically penetrate further into the substrate before solidifying, thereby resulting in a dome-shaped deposit having less height than one formed at a lower temperature. As an alternative to increased or higher penetration, the manipulation of temperature can also result in better fusing between the ink and the substrate (especially thermoplastics) so that there is better adhesion of the ink. Of course, depending on the intended function of the domes (e.g. liquid barrier, fluid management, skin separation, aesthetics, and so forth), and whether the application is intended to be permanent or releasable, the desired makeup, including, but not limited to, weight, shape and composition of the discrete segments applied should be carefully selected.

[0041] It will be recognized that the inks and/or chemistries which are used have a temperature at which they begin to degrade. The temperature at which degradation occurs will vary depending on the inks and/or chemistries used and care should generally be used not to exceed the degradation temperature during processing; however, it is contemplated that there may be one or more instances in which partial degradation produces a desired characteristic.

[0042] Although not necessarily the case, depending on the inks and materials which are selected for use with each other, a higher level of penetration may lead to a higher level of crockfastness. While crockfastness is not necessarily dependent on the level of penetration (as there may also be, for example, chemical bonding or interaction which contributes to the crockfastness), where an ink achieves a higher degree of penetration within a material it is more likely some or all of the ink will remain in place. It is desirable for the inks in images produced in accordance with the processes described and discussed herein to achieve a crockfast rating of at least about 4 and more desirably at least about 5.

[0043] In yet another embodiment, the present invention is also directed to a process for achieving high-speed crockfast
process printing on a material with phase-change ink. The process including providing a array of printheads capable of processing phase-change inks; providing a substrate; providing a material transport system capable of transporting the substrate to the printheads; providing a plurality of phase-change inks; transporting the substrate to the plurality of printheads; ejecting ink from at least two of the printheads onto the substrate so as to form, at least in part, a process image; and providing a layer or a coating over the image on the substrate. An array of printheads can be provided by arranging printheads in rows and/or columns so as to provide a matrix of printheads. The step of ejecting ink may include registered placement of the ink. Depending on the frequency at which the printheads are operated, the step of ejecting ink may form an image having up to about 200 drops/printhead/linear inch. In other embodiments the ink may form an image having up to about 100 drops/printhead/linear inch. The ink may be selectively applied to all or a portion of the substrate, may be applied to the substrate in a pattern or random fashion and/or may be applied to the substrate so as to create topography. As with the other embodiments, certain topographies may provide or produce skin health benefits. The application of inks and/or chemistries so as to provide topography on a substrate can provide a final product or component thereof which exhibits improved fluid management and/or skin separation during use.

0044] The plurality of inks should include inks of at least two different colors. The image formed on the material may be a multi-color image and the process may further include a control element, wherein the control element is in communication with at least one array of printheads, and wherein the control element regulates at least one array of printheads such that the inks are ejected onto the material in registered placement.

0045] It will be appreciated that a piezo jet printer, amongst others, may be suitable for use in connection with the methods and processes described herein. As such, the step of ejecting or discharging the ink and/or chemistries from the at least one printhead may include firing or triggering one or more of the at least one printheads. The process may also include the provision of a control element or control means, wherein the control element is in communication with one or more of the at least one printheads. The control element allows one or more of the printheads to be regulated in such a manner so as to permit the ink and/or chemistries which are ejected or discharged therefrom onto the substrate to be deposited so as to create or generate a pattern.

0046] The control element may also provide for real-time adjustment of the discharge from at least one of the printheads. Real-time adjustment allows or provides for the immediate or essentially instantaneous control or change in the operation of the printing apparatus of the present invention. The speed at which an apparatus used in connection with the present invention may be adjusted is generally limited by the time equal to about one-half of the minimum period of firing or pulse period associated with the printheads of the apparatus. That is, the minimum pulse or firing period is the shortest time it takes for the printhead in question to change from a firing or discharging position and return to that same position, or, stated another way, the minimum pulse or firing period is the shortest time required for a printhead to cycle between firings or ejections. As the operation speed of printheads suitable for use in the present invention continues to increase, so too will the firing or discharge frequency resulting in a decreased pulse period. All such developments are contemplated by the present invention.

0047] Real-time control may also be combined with one or more sensors located along the machines being used to produce a product or component thereof such that changes in the pattern, amount, position, and so forth of the inks and/or chemistries may be made. Real-time changes in the operation of a printhead or an array of printheads may be beneficial if multiple sizes or shapes of materials are being processed by the printing apparatus such that different patterns, applications, orientations thereof and so forth are desired depending on the product or component being processed. The precise control of this system provides extreme graphics flexibility that can be used to make substantially instantaneous graphics changes during production, creating the opportunity to introduce new features such as variety packs, or seasonal graphics with the push of a button, not possible with typical printing techniques. The ability to have real-time control or “shift on the fly” production changes may result in significant production improvements when compared to previous process printing techniques which used fixed printing patterns, such as those found on rotogravure printing rolls, and which require production downtime associated with the replacement of the rolls each time a pattern or product was changed.

0048] Additionally, the use of computer generated print designs or computer operated print heads allows for nearly limitless design configurations and applications. A computer program may be configured to use mathematic requirements particular to the substrate, inks and/or chemistries, such as capillary size, length, pressure, degradation temperatures, etc, to design a resulting material. Once created, a design may be accurately produced on the substrate by inkjet printing in accordance with the present invention.

0049] Because the image patterns may be digitally generated, they are infinitely variable and instantly changeable. The use of phase-change inks as discussed herein further enhances the number of possible patterns which may be suitable and can enable process printing at speeds and with certain materials or substrates. The use of phase-change inks can enable different substrate penetration or adhesion to a material than with non-phase-change inks. Accordingly, higher crockfastness ratings may in some instances be achieved.

0050] Further embodiments of the methods and processes of the present invention allow for the application of the desired inks and/or chemistries in one pass of the substrate past the printheads. The processes and methods of the present invention are able to achieve the printing described herein without the need for drying or chemical pre- or post-treatment of the material, inks or chemistries. The ability to print in a single pass without the need for pre-or post-treatment or drying provides for in-line production. That is, the material or substrate may be unwound, printed, and cut. Of course multi-stage production is also possible. However, multi-stage production is generally less desirable.

0051] Although the process of the present invention is such that it contemplates an array of printheads oper-
ating (e.g. having lengthier dwell times or having multiple rows of printheads, and so forth) such that the printing may be accomplished in one pass of the printheads over the substrate or one pass of the substrate by the printheads, in some instances it may be desirable for the inks and/or chemistries, and hence the image, pattern, topography, the fluid management characteristics and so forth, to be produced or achieved by multiple passes of the substrate past the printhead. As noted above, the processes and methods of the present invention generally do not require pre- or post-treatment, however, pre- or post-treatment is not excluded from the disclosure herein. Thus, the multiple pass approach may be desirable for a number of reasons including, but not limited to, those instances where it is desired to pre- or post-treat the material, ink or chemistries. Additionally, it may be desirable to produce a material via multiple passes of the substrate past the printhead where releasable treatments or chemistries are used such as those disclosed, for example, in commonly assigned U.S. patent application Ser. No. 09/938,347 to Yahioui et al.

[0052] While much of this disclosure speaks generally of printheads, and while any suitable printhead is contemplated hereby, a printhead which is suitable for use with the present invention is Spectra’s printhead model Galaxy P1 256/80, a piezo-driven printhead available from Spectra, Inc., having offices in Lebanon, N.H. It has been determined that with Galaxy P1 256/80 printhead that it is desirable for the printhead to operate at voltages of between about 100 and about 200 volts, and more desirable between about 110 and about 185 volts, to achieve the drop mass size and consistency which are discussed herein. The above mentioned voltage ranges are not intended to be inclusive for all printheads, but rather are intended only as a desired range for the specific Spectra model mentioned above. As such any and all operating voltages which result in the drop mass consistency under the other operating conditions described herein are suitable and are contemplated by the present invention.

[0053] Additionally, although piezo-driven printheads have a variety of performance capabilities, such devices are typically capable of emitting droplets having a diameter in the range of about 50-90 micrometers with placement resolution to at least about ½00 of an inch. It is contemplated that the processes and methods of the present invention could be used with any improvement in piezo-driven printheads or the like which provide for an increase in firing or printhead operating frequency, expansion of the range of droplet diameter and/or the placement resolution.

[0054] Examples of other suitable printheads include, but are not limited to, non-contact, drop-on-demand printheads such as those operating on piezo electric crystals and which are capable of operating in a range of about 20 to about 80 kHz range while delivering a drop size of up to about 80 ng. This capability enables the print head to discharge from about 20,000 to about 40,000 to even about 80,000 drops per second per nozzle. Operation of the printheads in this frequency range while implementing typical web or line speeds of at least about 1000 to about 2000 feet per minute (fpm) will result in the delivery of up to about 100 to 200 drops/ hole/linear inch at least about 1000 fpm, and up to about 100 drops/ hole/linear inch at least about 2000 fpm.

[0055] As a result of this discovery, resulting four-color process printed graphics can be delivered in-line at cost effective production speeds with minimal ink usage to materials such as those used in disposable absorbent products, personal care products and so forth. These graphics will generally consist of up to about 100 to about 200 drops per linear inch of any one color, and up to about 400 to about 800 drops per linear inch where a four-color combination is used. [Note: Reference to drops per inch are intended to be drops per linear inch or drops per inch in the machine-direction, unless expressly indicated to the contrary. Further, unless expressly indicated to the contrary, reference to drops per inch are also per printhead or hole and thus per color.]

[0056] In sum, the present invention is directed to a method of delivering multi-color, registered graphics to materials, desirably personal care products, health care products, disposable absorbent product and so forth, by applying non-contact, drop-on-demand, phase-change inks and then depositing a layer or coating of a protective composition over the phase-change inks. Desirably, the layer or coating of a protective composition protects any image formed by the inks and, in some instances, improves the quality of the image by increasing dot gain. While one would see or expect to see advantages of going to higher dots/drops per inch (dpi) in typical graphics media, with many substrates, such as those used in the production of disposable products (e.g. personal care products and so forth), the higher dpi does not give the same perceived advantages. This is especially true with porous materials. Thus, as an increase in dpi does not necessarily provide appreciable differences in image quality. Thus, depending on the material or substrate selected for use, and especially so with substrates used in personal care products, it has been determined that by reducing the drop density of inks, delivering acceptable graphics for disposable products may be realized at an affordable delivery cost (e.g., capital/equipment, ink and manufacturing costs). That is the utilization of the higher frequency printheads while providing a reduction in the drops per inch used to produce the images on the substrate provides the opportunity to continue to operate at production speeds that are cost effective in industry yet still produce an image of appropriate quality while using less ink. That is, with some materials or end products it is acceptable to use a lower density (e.g. lower quality) graphic. As the lower density graphics are satisfactory, the increase in production speeds which can be achieved is significant in terms of production volumes and manufacturing costs.

EXAMPLES

[0057] Each of the following examples were prepared by first printing four stripes of four different ink colors on a spunbonded nonwoven fabric, such as the spunbonded nonwoven fabric used in the outercover laminates of HUGGIES Supreme diapers. Four separate stripes of color, one stripe of each of four colors, were printed on spunbonded nonwoven fabrics using four inks contained in a hotmelt printing test kit obtained from Spectra Incorporated of Lebanon, N.H. The inks obtained from Spectra Incorporated designated part numbers 7053-803, 7054-803, 7057-803, 7058-803 and 7061-028 were used to print four separate and distinct stripes on the spunbonded nonwoven fabric.

[0058] Two 8-inch wide stripes were printed via an inkjet printing apparatus obtained from Spectra, Inc. of Lebanon, N.H. The inkjet printhead of inkjet printing apparatus was heated to 125° C. The inks were jetted as an “all pattern”
meaning all the 80 nozzles in the printhead were fired continuously to obtain 100 dot per inch (dpi) print resolution in the machine direction (MD). The printhead was aligned perpendicular to the MD to give 2.8 inches of print width on the substrate. In a subsequent step, a clear hotmelt ink obtained from Spectra, Inc, and designated as 7061-028-1 Hot Melt Flushing Ink was heated to 125°C in the inkjet printhead. The clear hotmelt ink was then jetted on the printed substrates at 150 dpi in the MD to be able to overlay the printed dots from the first step. This second step provided an additional layer on top of the first printed colored layer.

[0059] Printed substrates, including those printed substrates coated with the additional clear layer and printed substrates not coated with a second layer, were tested for crockfastness using the crockfastness test method described above. The coated samples showed an enhanced crockfastness value of 4.5 versus a crockfastness value of 3.5 for the uncoated print samples. It is believed that the additional second layer of a “sacrificial” clear coat rubbed away in the testing procedure and provided improved printed substrates and may also improve the appearance of the printed image by making the color image appear brighter. The coated samples also showed print enhancement via an average dot gain by 7 percent as measured with a QEA Personal IAS Image Analysis System. The QEA Personal IAS Image Analysis System was obtained from Quality Engineering Associates, Inc. of Burlington, Mass.

[0060] While the invention has been described in detail with respect to specific embodiments thereof, those skilled in the art, upon obtaining an understanding of the invention, may readily conceive of alterations to, variations of, and equivalents to the described embodiments. It is intended that the present invention include such modifications and variations as come within the scope of the appended claims and their equivalents.

We claim:

1. A personal care product comprising a substrate having a surface upon which is disposed graphics, wherein the graphics comprise an ink composition wherein the ink composition is applied to the substrate at a temperature $T_1$ wherein the substrate further comprises a layer that comprises a hotmelt composition that is applied over the graphics at a temperature $T$ that is greater than or equal to $T_1$.

2. The personal care product of claim 1 wherein the layer comprises a hot melt composition having a haze value of less than or equal to 4 as measured by ASTM 1903-00.

3. The personal care product of claim 1 wherein the hotmelt composition comprises a composition selected from the group consisting of natural waxes, synthetic hydrocarbons, polyolefins, polyamides, tall oil resins, polyurethanes, polyesters, and polyacrylates.

4. The personal care product of claim 1 wherein the substrate is a hydrophobic nonwoven substrate.

5. The personal care product of claim 4 wherein the nonwoven substrate comprises fibers that comprise a hydrophobic polymer selected from the group consisting of polyolefins, polymers and copolymers of ethylene, polymers and copolymers of propylene.

6. The personal care product of claim 5 wherein the substrate is an outer cover for a diaper.

7. The personal care product of claim 1 wherein the substrate is an outer cover for a diaper, a swimming pant, a training pant or an absorbent underpant.

8. The personal care product of claim 1 wherein the substrate is an outer cover for a diaper.

9. The personal care product of claim 1 wherein $T$ and $T_1$ are greater than or equal to about 90°C.

10. The personal care product of claim 1 wherein $T$ and $T_1$ are in the range of from about 90°C to about 140°C.

11. A method of printing on a substrate, the method of printing comprising:
   a. providing a substrate,
   b. heating an ink composition to a temperature $T_1$,
   c. depositing the ink composition on a portion of the substrate,
   d. heating a second composition to a temperature $T$ that is greater than or equal to $T_1$, and
   e. depositing the second composition over the portion of the substrate that includes the ink composition.

12. The method of claim 11 wherein depositing the second composition over the portion of the substrate that includes the ink composition causes the ink composition to melt.

13. The method of claim 11 wherein depositing the second composition over the portion of the substrate that includes the ink composition enhances dot gain of ink composition.

14. The method of claim 11 wherein depositing the second composition over the portion of the substrate that includes the ink composition increases adherence of the ink composition to the substrate.

15. The method of claim 11 wherein depositing the second composition over the portion of the substrate provides a sacrificial layer that provides abrasion resistance.

16. A method of creating high-speed multi-color process images, said method comprising:
   a. providing at least two high operating frequency printheads, said high operating frequency printheads being capable of processing phase-change inks;
   b. providing at least two phase-change inks;
   c. providing a substrate;
   d. activating the printheads such that at least two inks pass there through;
   e. passing the substrate under the printheads at a rate of at least about 1000 feet per minute;
   f. forming an image on the substrate; and
   g. depositing a second composition over the image.

17. The method of claim 16 wherein depositing the second composition over the portion of the substrate that includes the ink composition causes the ink composition to melt.

18. The method of claim 16 wherein depositing the second composition over the portion of the substrate that includes the ink composition enhances dot gain of ink composition.

19. The method of claim 16 wherein depositing the second composition over the portion of the substrate that includes the ink composition increases adherence of the ink composition to the substrate.

20. The method of claim 16 wherein depositing the second composition over the portion of the substrate provides a sacrificial layer that provides abrasion resistance.