



(51) International Patent Classification:

B41M 5/50 (2006.01)

B41J 2/345 (2006.01)

B41J 2/325 (2006.01)

B41J 2/525 (2006.01)

(21) International Application Number:

PCT/US2018/027623

(22) International Filing Date:

13 April 2018 (13.04.2018)

(25) Filing Language:

English

(26) Publication Language:

English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,

SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

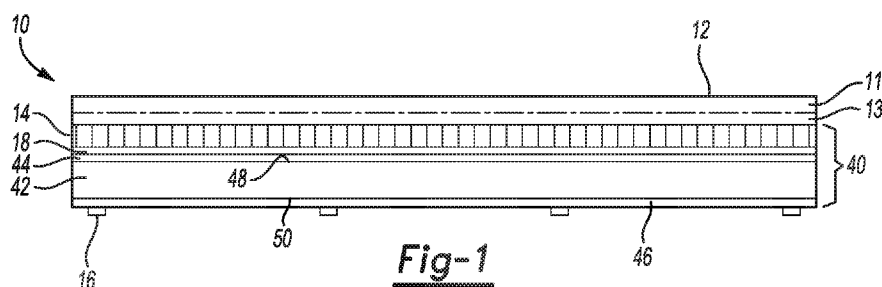
Declarations under Rule 4.17:

— as to the identity of the inventor (Rule 4.17(i))

Published:

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

(54) Title: IMAGING MEDIUM



(57) Abstract: An example of an imaging medium includes an image-receiving substrate, a donor ribbon attached to the image-receiving substrate, and a registration mark. The donor ribbon includes a donor ribbon substrate, a release layer disposed on the donor ribbon substrate, and a color layer disposed on the release layer. The color layer includes a repeated pattern. A repeat of the pattern includes at least adjacent color stripes including a cyan stripe, a magenta stripe, and a yellow stripe, or a grid of four color sections including i) a colored section selected from the group consisting of black, cyan, light cyan, yellow, magenta, and light magenta, ii) a cyan section, iii) a magenta section, and iv) a yellow section. The color layer is in contact with the image-receiving substrate.



IMAGING MEDIUM

BACKGROUND

[0001] Thermal imaging (also known as thermal printing) is a printing process used to form images. During a thermal imaging process, a printer uses heat to produce the images. The heat may be selectively applied, for example, with a thermal printhead. Some thermal imaging methods are direct printing methods that may involve thermal paper. In these thermal imaging methods, the thermal paper changes color where it is heated. Other thermal imaging methods are transfer printing methods that may involve the use of separate donor and receiver materials. In these thermal imaging methods, a heat sensitive donor material may be used to thermally transfer colorants from the donor material to the receiver material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Features of examples of the present disclosure will become apparent by reference to the following detailed description and drawings, in which like reference numerals correspond to similar, though perhaps not identical, components. For the sake of brevity, reference numerals or features having a previously described function may or may not be described in connection with other drawings in which they appear.

[0003] Fig. 1 is a cross-sectional view of an example of an imaging medium disclosed herein;

[0004] Figs. 2A and 2B are top, schematic views of examples of a repeat of a pattern included in a color layer of the donor ribbon of the imaging medium disclosed herein;

[0005] Fig. 3 is a flow diagram illustrating an example of a method of making the imaging medium; and

[0006] Fig. 4 is a diagram illustrating an example of a method of making a colored image.

DETAILED DESCRIPTION

[0007] Thermal imaging may be used to produce multicolored images. In some thermal imaging methods, a separate donor ribbon with successive patches of differently-colored materials or different color-forming materials may be used to produce the multicolored images. These methods involve moving the donor ribbon so that a patch of the desired colored or color-forming material is in contact with a desired location of an image-receiving substrate so that the desired color is transferred from the donor ribbon to the desired location on the image-receiving substrate. This process involves activating each color in separate passes and moving the donor ribbon between each activation (so that the next colored or color-forming material is in contact with the image-receiving substrate), which may result in a slow printing speed. When a separate donor ribbon is used, the size of the printer has to be large enough to accommodate the donor ribbon. Moreover, thermal imaging with a donor ribbon involves two consumables, i.e., the donor ribbon and the separate image-receiving medium, which can increase the cost of printing.

[0008] In other thermal imaging methods, a single imaging medium without a separate donor ribbon may be used to produce multicolored images. An example of the single imaging medium includes multiple layers of different color-forming materials separated by thermal interlayers. These methods involve heating the imaging medium to different temperatures for different time periods to produce different colors from the respective color-forming materials. Heating at a particular

temperature activates a particular color, and thus, activating each color occurs in separate passes, which may result in a slow printing speed. The different temperatures to which and the different time periods for which the imaging medium is heated to produce the different colors may also result in high power consumption. Moreover, the temperature control utilized for color activation may be complex, as a result of trying to avoid cross-talk between the colors. Additionally, producing an imaging medium with multiple layers of different color-forming materials separated by thermal interlayers may be complex and expensive.

[0009] Examples of an imaging medium are disclosed herein, which may be used in a relatively inexpensive thermal imaging process and may be used in a relatively small printer. The imaging medium disclosed herein includes a donor ribbon attached to an image-receiving substrate. Because the donor ribbon is attached to, and not separate from, the image-receiving substrate, one consumable (including the donor ribbon and the image-receiving substrate) is used. Thus, the cost of printing may be reduced (compared to a thermal imaging process that uses two consumables, i.e., separate donor ribbon and imaging medium). Moreover, because the donor ribbon is integrated into the imaging medium in the examples disclosed herein, a separate donor ribbon and cartridge for collecting the used donor ribbon do not need to be accommodated by the printer used to print on the medium. As such, the size of the printer used with the imaging medium disclosed herein may be reduced (as compared to a printer that uses two consumables).

[0010] Further, examples of the imaging medium disclosed herein may result in relatively fast printing and relatively low power consumption. The donor ribbon includes a color layer, which includes a repeated pattern. A repeat of the pattern includes at least adjacent color stripes or a grid of four color sections. A colored image may be produced by transferring, to the image-receiving substrate, one or more thermal transfer dyes from at least a portion of one or more of the color stripes or the color sections in one or more of the repeats. In some examples, each of the thermal transfer dyes may be transferred in a single pass and under the same heat exposure conditions, which may increase the printing speed (as

compared to thermal imaging processes including multiple passes) and/or reduce power consumption (as compared to a thermal imaging process that involves heating an imaging medium to different temperatures for different time periods) and/or simplify the temperature control process.

[0011] Examples of the imaging medium disclosed herein may also be less expensive to produce than a separate donor ribbon and image-receiving substrate and/or than an imaging medium with multiple layers of different color-forming materials separated by thermal interlayers.

[0012] Referring now to Fig. 1, a cross-section of an example of the imaging medium 10 is depicted. In one example, the imaging medium 10 comprises: an image-receiving substrate 12; and a donor ribbon 40 attached to the image-receiving substrate 12, the donor ribbon 40 including: a donor ribbon substrate 42; a release layer 44 disposed on the donor ribbon substrate 42; and a color layer 14 disposed on the release layer 44, the color layer 14 including a repeated pattern, a repeat 20, 20' (see, e.g., Figs. 2A and 2B) of the pattern including: at least three adjacent color stripes 24, 26, 28 (see, e.g., Fig. 2A) including a cyan stripe 24, a magenta stripe 26, and a yellow stripe 28; or a grid 30 (see, e.g., Fig. 2B) of four color sections 32, 34, 36, 38 (see, e.g., Fig. 2B) including i) a colored section 32 selected from the group consisting of black, cyan, light cyan, yellow, magenta, and light magenta, ii) a cyan section 34, iii) a magenta section 36, and iv) a yellow section 38; and a registration mark 16; wherein the color layer 14 is in contact with the image-receiving substrate 12.

[0013] In another example, the imaging medium 10 comprises: an image-receiving substrate 12; and a donor ribbon 40 attached to the image-receiving substrate 12, the donor ribbon 40 including: a donor ribbon substrate 42; a release layer 44 disposed on the donor ribbon substrate 42; and a color layer 14 disposed on the release layer 44, the color layer 14 including a repeated pattern, a repeat 20, 20' of the pattern including: four adjacent color stripes 22, 24, 26, 28 including a black stripe 22, a cyan stripe 24, a magenta stripe 26, and a yellow stripe 28; or a grid 30 of four color sections 32, 34, 36, 38 including a black section (an example

of the colored section 32), a cyan section 34, a magenta section 36, and a yellow section 38; and a registration mark 16; wherein the color layer 14 is in contact with the image-receiving substrate 12.

[0014] In still another example, the imaging medium 10 comprises: an image-receiving substrate 12; and a donor ribbon 40 attached to the image-receiving substrate 12, the donor ribbon 40 including: a donor ribbon substrate 42; a release layer 44 disposed on the donor ribbon substrate 42; and a color layer 14 disposed on the release layer 44, the color layer 14 including a black thermal transfer dye, a cyan thermal transfer dye, a magenta thermal transfer dye, and a yellow thermal transfer dye in a repeated pattern, a repeat 20, 20' of the pattern including: four adjacent color stripes 22, 24, 26, 28 including a black stripe 22, a cyan stripe 24, a magenta stripe 26, and a yellow stripe 28; or a grid 30 of four color sections 32, 34, 36, 38 including a black section, a cyan section 34, a magenta section 36, and a yellow section 38; and a registration mark 16; wherein the color layer 14 is in contact with the image-receiving substrate 12.

[0015] In some examples, the imaging medium 10 consists of the image-receiving substrate 12, the donor ribbon 40, and the registration mark 16, with no other components. In other examples, the imaging medium 10 may include additional components.

[0016] The image-receiving substrate 12 of the imaging medium 10 receives one or more of the thermal transfer dyes from portions of the color layer 14 of the donor ribbon 40 when those portions are selectively exposed to heat. As such, the image-receiving substrate 12 may display a colored image after the imaging medium 10 is selectively exposed to heat.

[0017] Examples of the image-receiving substrate 12 may include natural cellulosic material, synthetic cellulosic material, and a material including one or more polymers. In an example, the image-receiving substrate 12 consists of natural cellulosic material, synthetic cellulosic material, or a polymeric material.

[0018] Natural cellulosic materials include cellulose fibers, alone or in combination with additives, such as internal sizing agents and fillers.

[0019] Synthetic cellulosic materials include, for example, cellulose esters, such as cellulose acetate, cellulose diacetate, cellulose triacetate, cellulose propionate, cellulose butyrate, cellulose acetate butyrate and nitrocellulose. These materials are clear/transparent films that may be suitable for a photobase image-receiving substrate 12.

[0020] Polymers that may be suitable for the image-receiving substrate 12 include polyolefins (e.g., polyethylene, polypropylene), polyesters (e.g., polyethylene terephthalate), polyethers, polyamides, polyimides, ethylene copolymers, polycarbonates, polyurethanes, polyalkylene oxides, polyester amides, polyethylene terephthalate, polystyrene, poly(vinyl acetals), polyalkyloxazolines, polyphenyl oxazolines, polyethylene-imines, polyvinyl pyrrolidones, polyvinyl chloride, polysulfonamides, and combinations thereof. At least some of these materials may be suitable for a photobase type of image-receiving substrate 12 or a transparent film type of image-receiving substrate 12. The polymer materials may also be coated on natural or synthetic cellulose materials, and used as a photobase type of image-receiving substrate 12. Further, opaque photographic materials may be used as the image-receiving substrate 12 including, baryta paper, polyethylene-coated papers, and voided polyester.

[0021] The image-receiving substrate 12 may be a non-coated substrate, and may include any of the previously described materials without additional layer(s).

[0022] As shown in phantom in Fig. 1, the image-receiving substrate 12 may also be a coated substrate. In this example, the image-receiving substrate 12 may include a base layer 11 and an ink-receiving layer 13 coated on the base layer 11. In another example, the image-receiving substrate 12 consists of the ink-receiving layer 13 coated on the base layer 11. When the image-receiving substrate 12 includes the ink-receiving layer 13 coated on the base layer 11, the ink-receiving layer 13 may receive one or more of the thermal transfer dyes from portions of the color layer 14 when those portions are selectively exposed to heat. In one example, the image-receiving substrate 12 is photographic paper that includes the ink-receiving layer 13 coated on the base layer 11.

[0023] The base layer 11 of the image-receiving substrate 12 is shown as the top most layer of the imaging medium 10. After printing is performed, the image-receiving substrate 12 may be removed from the donor ribbon 40, and the image that is formed is visible at the surface of the image-receiving substrate 12 that had been in contact with the donor ribbon 40. As such, the base layer 11 may act as a bottom layer or a base of the printed on image-receiving substrate 12. The terms top, bottom, lower, upper, on, etc. are used herein to describe the various components of the image-receiving substrate 12, the donor ribbon 40, and the imaging medium 10. It is to be understood that these directional terms are not meant to imply a specific orientation, but are used to designate relative orientation between components. The use of directional terms should not be interpreted to limit the examples disclosed herein to any specific orientation(s). As the bottom layer, the base layer 11 may provide structural integrity for the resultant (printed on) image-receiving substrate 12.

[0024] The base layer 11 may include the natural cellulosic material, the synthetic cellulosic material, or the material including one or more polymers.

[0025] In an example, the base layer 11 may have a substantially uniform thickness. For example, the thickness along substantially the entire length and/or width of the base layer 11 may range from about 20 μm to about 450 μm .

[0026] The ink-receiving layer 13 may include an inorganic pigment, a polymeric co-pigment, a binder, a surfactant, a rheology modifier, a defoamer, an optical brightener, a biocide, a pH controlling agent, or a combination thereof. Other suitable ink-receiving layer additives, such as a dye, a mordant, a binder crosslinking agent, etc. may also be included. The composition that is applied to form the ink-receiving layer 13 may include water, alone or in combination with an organic solvent (e.g., thio diethylene glycol, or the like).

[0027] Examples of the inorganic pigment include calcined clay, modified calcium carbonate (MCC), fine and/or ultra-fine ground calcium carbonate (GCC), precipitated calcium carbonate (PCC), silica, and combinations thereof. In an example, the inorganic pigment is selected from the group consisting of calcined

clay, modified calcium carbonate (MCC), ultra-fine ground calcium carbonate (GCC), and combinations thereof. An example of the silica is a stable dispersion of fumed silica with its surface modified by an inorganic treating agent (e.g., aluminum chlorohydrate) and a monoaminoorganosilane treating agent (e.g., 3-aminopropyltriethoxysilane, 3-aminopropyltrimethoxysilane, *N*-butylaminopropyltrimethoxysilane, etc.).

[0028] The inorganic pigment may have a median particle size ranging from about 0.05 μm to about 5 μm . In another example, the inorganic pigment has a median particle size ranging from about 0.5 μm to about 2 μm . In still another example, fumed silica may aggregate and have an aggregate size ranging from about 50 to 1000 nm in size. As used herein, the term "particle size", refers to the diameter of a substantially spherical particle (i.e., a spherical or near-spherical particle having a sphericity of >0.84), or the average diameter of a non-spherical particle (i.e., the average of multiple diameters across the particle).

[0029] In an example, the inorganic pigment may be present in the ink-receiving layer 13 in an amount ranging from about 70 wt% to about 90 wt%, based on the total dry weight of the ink-receiving layer 13.

[0030] Examples of the polymeric co-pigment include plastic pigments (e.g., polystyrene, polymethacrylates, polyacrylates, copolymers thereof, and/or combinations thereof). Suitable solid spherical plastic pigments are commercially available from The Dow Chemical Company, e.g., DPP 756A or HS 3020. The amount of polymeric co-pigment that may be present in the ink-receiving layer 13 may range from about 1 part to 10 parts based on 100 parts of inorganic pigments. The amount of polymeric co-pigment may be present in the ink-receiving layer 13 in an amount ranging from about 0.5 wt% to about 8.5 wt%, based on the total dry weight of the ink-receiving layer 13.

[0031] Examples of the binder include latex polymers, polyvinyl alcohols and polyvinyl pyrrolidones. The latex polymer may be derived from a number of monomers such as, by way of example and not limitation, vinyl monomers, allylic monomers, olefins, and unsaturated hydrocarbons, and mixtures thereof. Classes

of vinyl monomers include, but are not limited to, vinyl aromatic monomers (e.g., styrene), vinyl aliphatic monomers (e.g., butadiene), vinyl alcohols, vinyl halides, vinyl esters of carboxylic acids (e.g., vinyl acetate), vinyl ethers, (meth)acrylic acid, (meth)acrylates, (meth)acrylamides, (meth)acrylonitriles, and mixtures of two or more of the above, for example. The term "(meth) acrylic latex" includes polymers of acrylic monomers, polymers of methacrylic monomers, and copolymers of the aforementioned monomers with other monomers.

[0032] Examples of vinyl aromatic monomers that may form the latex polymeric binder include, but are not limited to, styrene, 3-methylstyrene, 4-methylstyrene, styrene-butadiene, p-chloro-methylstyrene, 2-chlorostyrene, 3-chlorostyrene, 4-chlorostyrene, divinyl benzene, vinyl naphthalene and divinyl naphthalene. Vinyl halides that may be used include, but are not limited to, vinyl chloride and vinylidene fluoride. Vinyl esters of carboxylic acids that may be used include, but are not limited to, vinyl acetate, vinyl butyrate, vinyl methacrylate, vinyl 3,4-dimethoxybenzoate, vinyl malate and vinyl benzoate. Examples of vinyl ethers that may be employed include, but are not limited to, butyl vinyl ether and propyl vinyl ether.

[0033] In some examples, the binder may be a styrene/butadiene latex copolymer. In some other examples, the binder may be a styrene/butadiene/acrylonitrile latex copolymer. Some examples of the latex polymer/copolymer include aqueous, anionic carboxylated styrene/butadiene copolymer dispersions commercially available under the tradenames LITEX® PX 9710, LITEX® 9720, LITEX® 9730 and LITEX® PX 9740, from Synthomer (Essex, UK), styrene/butadiene/acrylonitrile copolymers commercially available under the tradenames GENCRYL® 9525 and GENCRYL® 9750, from RohmNova (Akron, Ohio), a styrene/butadiene copolymer commercially available under the tradename STR 5401, from Dow Chemical Company (Midland, Michigan), poly(vinyl alcohol) commercially available under the tradenames MOWIOL® 4-98 and MOWIOL® 6-98, from Kuraray America, Inc. (Houston, Texas), and/or combination(s) thereof.

[0034] In an example, the binder is present in the ink-receiving layer 13 in an amount ranging from about 5 wt% to about 20 wt%, based on the total weight of the ink-receiving layer 13. In another example, the amount of binder that may be present in the ink-receiving layer 13 may range from about 10 parts to 15 parts based on 100 parts of inorganic pigments.

[0035] Suitable surfactants include nonionic surfactants, such as Surfactant 10G (a glycidol surfactant). As examples, the amount of surfactant in the ink-receiving layer 13 may be in the range of about 0.1 parts to about 5 parts based on 100 parts of inorganic pigments and/or may range from about 0.25 wt% to about 1 wt%, based on the total weight of the ink-receiving layer 13.

[0036] Suitable rheology modifiers include polycarboxylate-based compounds, polycarboxylated-based alkaline swellable emulsions, or their derivatives. The rheology modifier is helpful for building up the viscosity at certain pH, either at low shear or under high shear, or both. In certain examples, a rheology modifier is added to maintain a relatively low viscosity under low shear, and to help build up the viscosity under high shear. It may be desirable to provide a coating formulation that is not so viscous during the mixing, pumping and storage stages, but possesses an appropriate viscosity under high shear. Some examples of rheology modifiers include STEROCOLL® FS (from BASF), CARTOCOAT® RM 12 (from Clariant), ACRY SOL® TT-615 (from Rohm and Haas) and ACUMER® 9300 (from Rohm and Haas). The amount of rheology modifier in the ink-receiving layer 13 may be in the range of about 0.1 parts to about 2 parts, or in the range of about 0.1 part to about 0.5 parts, based on 100 parts of inorganic pigments. In another example, the rheology modifier is present in the ink-receiving layer 13 in an amount ranging from about 0.1 wt% to about 0.4 wt%, based on the total weight of the ink-receiving layer 13.

[0037] Any suitable defoamer may be used. Suitable defoamers include those commercially available from BASF Corp. under the tradename FOAMMASTER®. The amount of defoamer in the ink-receiving layer 13 may be in the range of about 0.1 parts to about 1 part, or in the range of about 0.1 parts to about 0.5 parts,

based on 100 parts of inorganic pigments. In another example, the defoamer is present in the ink-receiving layer 13 in an amount ranging from about 0.2 wt% to about 0.4 wt%, based on the total weight of the ink-receiving layer 13.

[0038] Any suitable optical brighteners may be used, such as those commercially available from BASF Corp. under the tradename TINOPAL®. The amount of optical brighteners in the ink-receiving layer 13 may be in the range of about 0.1 parts to about 2 part, or in the range of about 0.1 part to about 1 part, based on 100 parts of inorganic pigments. In another example, the optical brightener is present in the ink-receiving layer 13 in an amount ranging from about 0.1 wt% to about 0.4 wt%, based on the total weight of the ink-receiving layer 13.

[0039] The ink-receiving layer 13 may also include biocides (i.e., fungicides, anti-microbials, etc.). Example biocides may include the NUOSEPT™ (Troy Corp.), UCARCIDE™ (Dow Chemical Co.), ACTICIDE® B20 (Thor Chemicals), ACTICIDE® M20 (Thor Chemicals), ACTICIDE® MBL (blends of 2-methyl-4-isothiazolin-3-one (MIT), 1,2-benzisothiazolin-3-one (BIT) and Bronopol) (Thor Chemicals), AXIDE™ (Planet Chemical), NIPACIDE™ (Clariant), blends of 5-chloro-2-methyl-4-isothiazolin-3-one (CIT or CMIT) and MIT under the tradename KATHON™ (Dow Chemical Co.), and combinations thereof. Examples of suitable biocides include an aqueous solution of 1,2-benzisothiazolin-3-one (e.g., PROXEL® GXL from Arch Chemicals, Inc.), quaternary ammonium compounds (e.g., BARDAC® 2250 and 2280, BARQUAT® 50-65B, and CARBOQUAT® 250-T, all from Lonza Ltd. Corp.), and an aqueous solution of methylisothiazolone (e.g., KORDEK® MLX from Dow Chemical Co.). In an example, the ink-receiving layer 13 may include a total amount of biocides that ranges from about 0.05 wt% to about 1 wt%, based on the total weight of the ink-receiving layer 13.

[0040] Suitable pH controlling agents include metal hydroxide bases, such as sodium hydroxide (NaOH), potassium hydroxide (KOH), etc. The amount of the pH controlling agent may depend upon the desired pH of the composition used to form the ink receiving-layer 13.

[0041] In an example, ink-receiving layer 13 may have a substantially uniform thickness. For example, the thickness along substantially the entire length and/or width of the ink-receiving layer 13 may range from about 0.5 μm to about 50 μm .

[0042] When the image-receiving substrate 12 includes the ink-receiving layer 13 coated on the base layer 11, the image-receiving substrate 12 may or may not include a barrier layer (e.g., polyethylene) between the base layer 11 and the ink-receiving layer 13. When included, the barrier layer may prevent the thermal transfer dye(s) from penetrating into the base layer 11 when they are transferred from the color layer 14 (or portions thereof) to the ink-receiving layer 13 of the image-receiving substrate 12.

[0043] In some examples, the barrier layer may include a polyolefin resin, such as high density polyethylene (which has a density ranging from about 0.93 g/mL to about 0.97 g/mL, and may be abbreviated as HDPE), low density polyethylene (which has a density ranging from about 0.91 g/mL to about 0.94 g/mL, and may be abbreviated as LDPE), or polypropylene; copolymers of ethylene with other alkenes, such as linear low density polyethylene; polylactic acid (PLA); polyethylene terephthalate (PET); or a combination thereof. In some of these examples the polyolefin resin, the copolymer of ethylene with other alkenes, polylactic acid, polyethylene terephthalate, or the combination thereof may be included in the barrier in an amount up to 100 wt%, based on the total weight of the barrier layer.

[0044] In other examples, the barrier layer may further include an inorganic filler material. Some examples of inorganic filler materials include carbon black, calcium carbonate, talc, barium sulfate, clay, silica, and TiO_2 . In an example, the inorganic filler material is present in the barrier layer in an amount less than 40 wt%, based on the total weight of the barrier layer. In another example, the inorganic filler material is present in the barrier layer in an amount ranging from about 5 wt% to about 15 wt%, based on the total weight of the barrier layer.

[0045] The basis weight of the image-receiving substrate 12 may be dependent on the nature of its application, where lighter weights are employed for magazines

and tri-folds and heavier weights are employed for postcards, for signage, etc. In some examples, the image-receiving substrate 12 has a basis weight ranging from about 60 grams per square meter (g/m^2 or gsm) to about 400 gsm, or from about 100 gsm to about 250 gsm.

[0046] In an example, the image-receiving substrate 12 may have a substantially uniform thickness. For example, the thickness along substantially the entire length and/or width of the image-receiving substrate 12 may range from about 0.025 mm to about 0.5 mm.

[0047] As mentioned above, the imaging medium 10 also includes the donor ribbon 40. The donor ribbon 40 is attached to the image-receiving substrate 12. By “attach,” “attached,” “attachment,” or the like, it is meant that the donor ribbon 40 and the image-receiving substrate 12 are secured or held together. Attachment between the donor ribbon 40 and the image-receiving substrate 12 may occur across the entire surface of the medium 10, or at one or more ends/edges, or at one or more of the corners. When attachment occurs at one or more ends/edges or at one or more of the corners, it is to be understood that the donor ribbon 40 and the image-receiving substrate 12 are still in contact with one another in accordance with the examples disclosed herein (even though attachment does not occur across the entire surface). Moreover, the mechanism for attaching the donor ribbon 40 and the image-receiving substrate 12 may enable the release of the image receiving substrate 12 from the donor ribbon 40 after imaging. In an example, the donor ribbon 40 is attached to the image-receiving substrate 12 by lamination, with an adhesive (e.g., spray adhesive at the edge(s)), via static cling, with an adhesion agent and warm lamination, or via any other suitable mechanism. The attachment point or area may also include a perforated tear tab allowing for easy removal of the donor ribbon 40 from the image-receiving substrate 12 after printing/thermal imaging.

[0048] When an adhesive is used to attach the donor ribbon 40 and the image-receiving substrate 12, the adhesive may be a pressure sensitive adhesive (PSA). For example, the adhesive may include AROSET® 3240 (a pressure-sensitive

acrylate polymer available from Ashland Chemical Co.) and low glass transition temperature (T_g) styrene-butadiene latex polymers, such as GENFLO® 3003 and GENFLO® 3056 (available from Omnova Chemical Co.). The pressure sensitive adhesive may be a low tack pressure sensitive adhesive, such as an acrylic-based adhesives (formulated from cross-linked acrylic polymers, and which may be an emulsion-based adhesive), polyvinyl acetate (PVA), ethylene vinyl acetate.

[0049] The color layer 14 of the donor ribbon 40 is in contact with the image-receiving substrate 12. As such, the donor ribbon 40 may be attached to the image-receiving substrate 12 so that the color layer 14 is in contact with the image-receiving substrate 12. When the image-receiving substrate 12 includes the ink-receiving layer 13 coated on the base layer 11, the donor ribbon 40 may be attached to the image-receiving substrate 12 so that the color layer 14 is in contact with the ink-receiving layer 13.

[0050] As mentioned above, the donor ribbon 40 includes the donor ribbon substrate 42, the release layer 44, and the color layer 14. In some examples, the donor ribbon 40 consists of these components, with no other components. In other examples, the donor ribbon 40 may include additional components, such as a topcoat 18 and/or a back coat 46. In still other examples, the donor ribbon 40 consists of the donor ribbon substrate 42, the release layer 44, the color layer 14, the topcoat 18 and the back coat 46, with no other components.

[0051] In some examples, the donor ribbon substrate 42 may act as a bottom layer or a base of the donor ribbon 40, in that other layer(s) of the donor ribbon 40 may be formed thereon. As the bottom layer, the donor ribbon substrate 42 may provide structural integrity for the resultant donor ribbon 40.

[0052] The donor ribbon substrate 42 may be any substrate: i) on which the release layer 44, the color layer 14, etc. may be applied, and ii) through which the release layer 44, the color layer 14, etc. may be selectively exposed to heat so that the thermal transfer dyes in portions of the color layer 14 may be transferred to the image-receiving substrate 12 without melting the donor ribbon substrate 42.

Examples of the donor ribbon substrate 42 include a polyethylene terephthalate

(PET) film, a polyamide film, a polycarbonate film, a cellulose ester film (e.g., cellulose acetate or any of the other examples set forth herein), etc. Other examples of the donor ribbon substrate 42 include polyesters, polyamides, polycarbonates, glassine paper, condenser paper, fluorine polymers (e.g., polyvinylidene fluoride, and poly(tetrafluoroethylene-cohexafluoropropylene)), polyethers (e.g., polyoxymethylene), polystyrene, polyacetals, and polyolefins (e.g., polystyrene, polyethylene, polypropylene, and methylpentane polymers).

[0053] In an example, the donor ribbon substrate 42 may have a substantially uniform thickness. For example, the thickness along substantially the entire length and/or width of the donor ribbon substrate 42 may range from about 2 μm to about 30 μm . In other examples, the thickness along substantially the entire length and/or width of the donor ribbon substrate 42 may range from about 2 μm to about 10 μm ; or from about 3 μm to about 8 μm ; or about 4 μm to about 6 μm .

[0054] The release layer 44 is disposed on one side of the donor ribbon substrate 42, as shown in Fig. 1. It is to be understood that, as used herein, the terms “on,” “disposed on,” “formed on,” “deposited on,” “established on,” and the like are broadly defined to encompass a variety of divergent layering arrangements and assembly techniques. These arrangements and techniques include: i) the direct attachment of a layer (e.g., the color layer 14) to another layer (e.g., the release layer 44) with no intervening layers therebetween and ii) the attachment of a layer (e.g., the color layer 14) to another layer (e.g., the release layer 44) with one or more layers (e.g., the clear and colorless topcoat 18) therebetween, provided that the one layer being “on,” “deposited on,” “formed on,” “disposed on,” or “established on” the other layer is somehow supported by the other layer (notwithstanding the presence of one or more additional material layers therebetween). Further, the phrases “directly on,” “disposed directly on,” “formed directly on,” “deposited directly on,” “established directly on” and/or the like are broadly defined herein to encompass a situation(s) wherein a given layer (e.g., the color layer 14) is secured to another layer (e.g., the release layer 44) without any intervening layers therebetween. It is to be understood that the characterizations

recited above are to be effective regardless of the orientation of the donor ribbon materials or the imaging medium materials under consideration.

[0055] In an example of the donor ribbon 40, the release layer 44 is disposed on the donor ribbon substrate 42. As shown in Fig. 1, the release layer 44 may be disposed directly on the donor ribbon substrate 42. In still another example, the release layer 44 is disposed on a front side 48 of the donor ribbon substrate 42. As used herein, the term “front side” may refer to the side upon which the color layer 14 is to be disposed.

[0056] The release layer 44 may enable portions of the color layer 14 (e.g., the thermal transfer dyes) and portions of any layers between the release layer 44 and the color layer 14 (e.g., the clear and colorless topcoat 18) to be readily transferred to the image-receiving substrate 12. The release layer 44 has a sharp melting transition (i.e., small difference between the softening temperature and the melting temperature), which allows for a crisp transfer of portions of the color layer 14. As an example, the release layer 44 may include a material that does not absorb the activated dyes, and thus prevents the activated dyes from migrating toward the donor ribbon substrate 42.

[0057] Examples of the release layer 44 include polyethylene wax and paraffin wax. In some of these examples, the polyethylene wax and/or the paraffin wax may be included in the release layer 44 in an amount up to 100 wt%, based on the total weight of the release layer 44.

[0058] In an example, the release layer 44 may have a substantially uniform thickness. For example, the thickness along substantially the entire length and/or width of the release layer 44 may range from about 0.20 μm to about 1.0 μm .

[0059] As shown in Fig. 1 the color layer 14 is disposed on the release layer 44. In an example of the donor ribbon 40, the color layer 14 is disposed on the release layer 44. In some instances, the color layer 14 is disposed directly on the release layer 44.

[0060] The color layer 14 produces a colored image on the image-receiving substrate 12 when selectively exposed to heat. In some examples, the color layer

14 produces a multicolored image on the image-receiving substrate 12 when selectively exposed to heat.

[0061] The color layer 14 will now be described in reference to Figs. 1, 2A and 2B. As mentioned above, the color layer 14 includes a repeated pattern. In an example, a repeat 20 of the repeated pattern includes at least three adjacent color stripes 24, 26, 28 (as shown in Fig. 2A). In another example, a repeat 20' of the repeated pattern includes a grid 30 of four color sections 32, 34, 36, 38. The repeat 20 or 20' may be replicated any number of times and in any desired configuration across the release layer 44 (or the topcoat 18) to form the repeated pattern.

[0062] It is to be understood that the repeated pattern is two-dimensional and extends throughout the color layer 14 so that the entire repeated pattern may be seen from the top of the color layer 14 (i.e., the "top" is the portion of the layer 14 that is to be in contact with the image-receiving substrate 12). In other words, each repeat 20, 20' of the repeated pattern is in direct contact with the release layer 44 (or the topcoat 18), and the repeats 20, 20' are adjacent to one another, but not layered on top of each other. More specifically, the color stripes 22, 24, 26, 28 of the repeat 20 or the color sections 32, 34, 36, 38 of the repeat 20' are substantially planar throughout the color layer 14 and are not layered on top of each other. Further, the repeats 20, 20' may be contiguous throughout the repeated pattern and the color layer 14. In other words, the configuration of the repeats 20, 20' is such that i) each repeat 20, 20' shares a common border with at least one other repeat 20, 20', and ii) the repeated pattern is devoid of spaces that do not include either a color stripe 22, 24, 26, 28 or a color section 32, 34, 36, 38.

[0063] In Figs. 2A and 2B, two examples of the repeat 20, 20' of the pattern are depicted. As shown in Fig. 2A, one example of the repeat 20 of the pattern includes at least three adjacent color stripes 24, 26, 28 including a cyan stripe 24 (labeled with a "C" in Fig. 2A), a magenta stripe 26 (labeled with a "M" in Fig. 2A), and a yellow stripe 28 (labeled with a "Y" in Fig. 2A). In some examples, the at least three color stripes 24, 26, 28 includes four adjacent color stripes 22, 24, 26,

28, and a fourth of the four adjacent color stripes 22, 24, 26, 28 is a black stripe 22 (labeled with a "K" in Fig. 2A). In other examples (not shown), the at least three color stripes 22, 24, 26, 28 includes more than four adjacent color stripes 22, 24, 26, 28. As shown in Fig. 2A, the stripes 22, 24, 26, 28 may be positioned so that one of the longer sides (having length L) of any stripe 22, 24, 26, 28 abuts one of the longer sides of any other stripe 22, 24, 26, 28. It is to be understood that the color arrangement shown in Fig. 2A is one example, and that the color stripes 22, 24, 26, 28 may be rearranged so that different colors are next to each other.

[0064] As shown in Fig. 2B, another example of the repeat 20' of the pattern includes the grid 30 of four color sections 32, 34, 36, 38 including i) a colored section 32 (labeled with a "K" in Fig. 2B) selected from the group consisting of black, cyan, light cyan, yellow, magenta, and light magenta, ii) a cyan section 34 (labeled with a "C" in Fig. 2B), iii) a magenta section 36 (labeled with a "M" in Fig. 2B), and iv) a yellow section 38 (labeled with a "Y" in Fig. 2B). While the colored section 32 is labeled with a "K" in Fig. 2B (indicating a black section), it is to be understood that a black section is one example of the colored section 32, and in other examples, the colored section 32 may be cyan, light cyan, yellow, magenta, or light magenta. It is to be understood that the color arrangement shown in Fig. 2B is one example, and that the color sections 32, 34, 36, 38 may be rearranged so that different colors are next to each other.

[0065] In some examples, the grid 30 may be the repeat 20' (i.e., the grid 30 is repeated to form the repeated pattern). In other examples, several grids 30 may be arranged in a desirable pattern to form the repeat 20', and the repeat 20' (including several grids 30) is repeated to form the repeated pattern. In any of the examples disclosed herein, the grid 30 has a square or rectangular shape, and the sections 32, 34, 36, 38 may each make up one quarter of the grid 30. The square or rectangular shape of the grid 30 is desirable so that when repeated (e.g., to form the repeated pattern, or arranged to form the repeat 20', which is repeated to form the repeated pattern), the grids 30 can be contiguous without having to accommodate for curves or other non-straight edges. In some examples, the term

“section” refers to a shape that has a length that is at least substantially equal to (e.g., within 5% of) its width. In these examples, each section 32, 34, 36, 38 may have a square shape or a rectangular shape. As such, the shape of the sections 32, 34, 36, 38 may be similar to the shape of the thermal resistors of a thermal printhead, as thermal resistors may be square or rectangular. It is to be understood that when the imaging medium 10 is to be used with thermal resistors 46 having another shape (e.g., oval, round, triangular, parallelograms, or some other arbitrary shape), the shape of the sections 32, 34, 36, 38 may be altered to correspond with the shape of the resistors 46.

[0066] The size (e.g., width, length, area, etc.) of each color stripe 22, 24, 26, 28 or each color section 32, 34, 36, 38 may depend, in part, on desired resolution of the image to be formed with the imaging medium 10. A smaller size may enable the imaging medium 10 to produce (when selectively exposed to heat) an image with reduced grain and higher resolution (as compared to an image produced by the imaging medium 10 when each color stripe 22, 24, 26, 28 or each color section 32, 34, 36, 38 has a larger size).

[0067] When the repeat 20 includes the at least three adjacent color stripes 24, 26, 28, the width W of the repeat 20 may be equal to the sum of the widths W_{24} , W_{26} , W_{28} of the at least three adjacent color stripes 24, 26, 28. While the width W of the repeat 20 is shown in Fig. 2A to be equal to the widths W_{22} , W_{24} , W_{26} , W_{28} of four adjacent color stripes 22, 24, 26, 28, it is to be understood that this is one example, and in other examples the width W of the repeat 20 may be equal to the widths W_{24} , W_{26} , W_{28} of three adjacent color stripes 24, 26, 28 or the widths W_{22} , W_{24} , W_{26} , W_{28} of five or more adjacent color stripes 22, 24, 26, 28. As examples, the at least three adjacent color stripes 24, 26, 28 may each have a width W_{24} , W_{26} , W_{28} of: $1/300^{\text{th}}$ of an inch or smaller; $1/600^{\text{th}}$ of an inch or smaller; or $1/1200^{\text{th}}$ of an inch or smaller. As another example, the at least three adjacent color stripes 24, 26, 28 may each have a width W_{24} , W_{26} , W_{28} equal to the width of a row of thermal resistors of a thermal printhead.

[0068] In an example, the repeat 20 of the pattern includes the at least three color stripes 24, 26, 28; the at least three color stripes 24, 26, 28 includes four adjacent color stripes 22, 24, 26, 28; a fourth of the four adjacent color stripes is a black stripe 22; and each color stripe 22, 24, 26, 28 has a width W_{22} , W_{24} , W_{26} , W_{28} of $1/300^{\text{th}}$ of an inch or smaller. In this example, the repeat 20 may have a width W of $1/75^{\text{th}}$ of an inch or smaller. In another example, the repeat 20 of the pattern includes the four adjacent color stripes 22, 24, 26, 28, and each color stripe 22, 24, 26, 28 has a width W_{22} , W_{24} , W_{26} , W_{28} of $1/600^{\text{th}}$ of an inch or smaller. In this example, the repeat 20 may have a width W of $1/150^{\text{th}}$ of an inch or smaller. In still another example, the repeat 20 of the pattern includes the four adjacent color stripes 22, 24, 26, 28, and each color stripe 22, 24, 26, 28 has a width W_{22} , W_{24} , W_{26} , W_{28} of $1/1200^{\text{th}}$ of an inch or smaller. In this example, the repeat 20 may have a width W of $1/300^{\text{th}}$ of an inch or smaller. In yet another example, the repeat 20 of the pattern includes the four adjacent color stripes 22, 24, 26, 28, and each color stripe 22, 24, 26, 28 has a width W_{22} , W_{24} , W_{26} , W_{28} equal to the width of a row of thermal resistors of a thermal printhead. In this example, the repeat 20 may have a width W equal to four times the width of the row of thermal resistors of the thermal printhead.

[0069] In an example, the repeat 20 of the pattern includes the at least three adjacent color stripes 22, 24, 26, 28, and each color stripe 22, 24, 26, 28 has a length L ranging from about 2 inches to about 7 inches. The length L of each stripe 22, 24, 26, 28 is also the length of the repeat 20. In an example, the length L may be equal to the width of the imaging medium 10. As such, the length L of each color stripe 22, 24, 26, 28 may be 2 inches, 3 inches, 4 inches, or 5 inches.

[0070] When the repeat 20' includes the grid 30, the area of the grid 30 may be equal to the sum of the areas of the four color sections 32, 34, 36, 38. In an example (as shown in Fig. 2B), the grid 30 includes the four color sections 32, 34, 36, 38 in a 2 by 2 array. In some of these examples, the sections 32, 34, 36, 38 are squares or rectangles with equivalent dimensions, and thus the width W_G of the grid 30 may be equal to two times the width W_{32} , W_{34} , W_{36} , W_{38} of the four color

sections 32, 34, 36, 38, and the length L_G of the grid 30 may be equal to two times the length L_{32} , L_{34} , L_{36} , L_{38} of the four color sections 32, 34, 36, 38. As mentioned above, the repeat 20' of the pattern may include multiple grids 30 arranged in a square or rectangular pattern. In some of these examples (as shown in Fig. 2B), the repeat 20' of the pattern includes four grids 30 arranged in a square pattern. In these examples, the area of the repeat 20' may be equal to the sum of the areas of the four grids 30 (or the sum of the areas of the sixteen sections 32, 34, 36, 38 that make up the four grids 30). When the sections 32, 34, 36, 38 of the grids 30 are squares or rectangles with equivalent dimensions, the width W' of the repeat 20' may be equal to two times the width W_G of the grid 30 (or four times the width W_{32} , W_{34} , W_{36} , W_{38} of the four color sections 32, 34, 36, 38), and the length L' of the repeat 20' may be equal to two times the length L_G of the grid 30 (or four times the length L_{32} , L_{34} , L_{36} , L_{38} of the four color sections 32, 34, 36, 38). While one example of the repeat 20' including multiple grids 30 is shown, it is to be understood that multiple grids 30 may be configured in a different square or rectangular arrangement to form the repeat 20'. For example, the repeat 20' may include nine grids 30 (each grid 30 including a 2x2 array of the sections 32, 34, 36, 38) arranged in a 3x3 array to form a square pattern. In these examples, the dimensions of the repeat 20', the grids 30, and the sections 32, 34, 36, 38 may be adjusted so that the dimensions of the sections 32, 34, 36, 38 correspond with the dimensions of the thermal resistors to be used with the imaging medium 10.

[0071] In an example, the repeat 20' of the pattern includes the grid 30, and each color section 32, 34, 36, 38 has an area of $1/300^{\text{th}}$ of an inch by $1/300^{\text{th}}$ of an inch or smaller. In this example, the grid 30 may have an area of $1/150^{\text{th}}$ of an inch by $1/150^{\text{th}}$ of an inch or smaller. When four of these grids 30 are arranged in the square pattern to form the repeat 20', the repeat 20' may have an area of $1/75^{\text{th}}$ of an inch by $1/75^{\text{th}}$ of an inch or smaller. In another example, the repeat 20' of the pattern includes the grid 30, and each color section 32, 34, 36, 38 has an area of $1/600^{\text{th}}$ of an inch by $1/600^{\text{th}}$ of an inch or smaller. In this example, the grid 30 may have an area of $1/300^{\text{th}}$ of an inch by $1/300^{\text{th}}$ of an inch or smaller. When four of

these grids 30 are arranged in the square pattern to form the repeat 20', the repeat 20' may have an area of $1/150^{\text{th}}$ of an inch by $1/150^{\text{th}}$ of an inch or smaller. In still another example, the repeat 20' of the pattern includes the grid 30, and each color section 32, 34, 36, 38 has an area of $1/800^{\text{th}}$ of an inch by $1/800^{\text{th}}$ of an inch or smaller. In this example, the grid 30 may have an area of $1/400^{\text{th}}$ of an inch by $1/400^{\text{th}}$ of an inch or smaller. In still another example, the repeat 20' of the pattern includes the grid 30, and each color section 32, 34, 36, 38 has an area of $1/1200^{\text{th}}$ of an inch by $1/1200^{\text{th}}$ of an inch or smaller. In this example, the grid 30 may have an area of $1/600^{\text{th}}$ of an inch by $1/600^{\text{th}}$ of an inch or smaller. When four of these grids 30 are arranged in the square pattern to form the repeat 20', the repeat 20' may have an area of $1/300^{\text{th}}$ of an inch by $1/300^{\text{th}}$ of an inch or smaller. In yet another example, the repeat 20' of the pattern includes the grid 30, and each color section 32, 34, 36, 38 has a width W_{32} , W_{34} , W_{36} , W_{38} equal to the width of each of the thermal resistors in a row of thermal resistors of a thermal printhead, and a length L_{32} , L_{34} , L_{36} , L_{38} equal to the length of each of the thermal resistors. In this example, the grid 30 may have a width W_G equal to two times the width of each of the thermal resistors and a length L_G equal to two times the length of each of the thermal resistors, and the repeat 20' may have a width W' equal to four times the width of each of the thermal resistors and a length equal to four times the length L' of each of the thermal resistors.

[0072] In some examples, each color stripe 22, 24, 26, 28 has a width W_{22} , W_{24} , W_{26} , W_{28} , or each color section 32, 34, 36, 38 has a width W_{32} , W_{34} , W_{36} , W_{38} that is greater than the width of a row of thermal resistors of a thermal printhead. In these examples, the line advance of the thermal resistors may be combined (during thermal imaging) to transfer at least the thermal transfer dye from the entire width W_{22} , W_{24} , W_{26} , W_{28} of a color stripe 22, 24, 26, 28 or from the entire width W_{32} , W_{34} , W_{36} , W_{38} of a color section 32, 34, 36, 38.

[0073] In some examples, the color layer 14 includes a cyan thermal transfer dye, a magenta thermal transfer dye, and a yellow thermal transfer dye. In one of these examples, the at least three adjacent color stripes 22, 24, 26, 28 includes the

cyan stripe 24, the magenta stripe 26, the yellow stripe 28, and the black stripe 22, or the grid 30 of four color sections 32, 34, 36, 38 includes a black colored section (an example of the colored section 32), the cyan section 34, the magenta section 36, and the yellow section 38; and the color layer 14 includes a black thermal transfer dye, a cyan thermal transfer dye, a magenta thermal transfer dye, and a yellow thermal transfer dye.

[0074] The thermal transfer dyes form the repeated pattern in the color layer 14. As such, the cyan stripe(s) 24 or section(s) 34 may include the cyan thermal transfer dye, the magenta stripe(s) 26 or section(s) 36 may include the magenta thermal transfer dye, and the yellow stripe(s) 28 or section(s) 38 may include the yellow thermal transfer dye. When the repeat 20, 20' of the pattern includes the black stripe(s) 22 or section(s), the black stripe(s) 22 or section(s) may include the black thermal transfer dye. When the repeat 20' of the pattern includes the grid 30 and the colored section 32 is cyan or light cyan, the colored section 32 may include the cyan thermal transfer dye. When the repeat 20' of the pattern includes the grid 30 and the colored section 32 is yellow, the colored section 32 may include the yellow thermal transfer dye. When the repeat 20' of the pattern includes the grid 30 and the colored section 32 is magenta or light magenta, the colored section 32 may include the magenta thermal transfer dye.

[0075] It is to be understood that a combination of thermal transfer dyes may be used together in any one stripe 22, 24, 26, 28 or section 32, 34, 36, 38. The thermal transfer dyes of a combination may individually exhibit different colors/hues, but when used together in the combination exhibit the desired color/hue. For example, a combination of blue, red, and/or violet thermal transfer dyes may be included in the magenta stripe(s) 26 or section(s) 36, and those stripe(s) 26 or section(s) 36 exhibit magenta. Prior to being selectively transferred, the thermal transfer dyes are all present in the color layer 14 in the repeated pattern. Due to the small dimensions of the stripes 22, 24, 26, 28 or sections 32, 34, 36, 38, the color layer 14 may appear to the naked eye (i.e., without magnification) to be black or gray prior to being selectively transferred.

[0076] The thermal transfer dyes may be any dye transferable by heat. In an example, the total amount of the thermal transfer dye(s) present in the color layer 14 may range from about 10 wt% to about 40 wt%, based on the total weight of the color layer 14. In some examples, some of the color stripes 22, 24, 26, 28 or sections 32, 34, 36, 38 that make up the color layer 14 may include a higher or lower amount of thermal transfer dye than others of the color stripes 22, 24, 26, 28 or sections 32, 34, 36, 38. For example, when the repeat 20' of the pattern includes the grid 30 and the colored section(s) 32 is/are light cyan, the colored section(s) 32 may include a lower amount of thermal transfer dye than the cyan section(s) 34. As another example, when the repeat 20' of the pattern includes the grid 30 and the colored section(s) 32 is/are light magenta, the colored section(s) 32 may include a lower amount of thermal transfer dye than the magenta section(s) 36.

[0077] In some examples, the color layer 14 includes the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye; and each of the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye is a sublimable dye. In one of these examples, the at least three adjacent color stripes 22, 24, 26, 28 includes the cyan stripe 24, the magenta stripe 26, the yellow stripe 28, and a black stripe 22, or the grid 30 of four color sections 32, 34, 36, 38 includes a black colored section, the cyan section 34, the magenta section 36, and the yellow section 38; the color layer 14 includes the black thermal transfer dye, the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye; and each of the black thermal transfer dye, the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye is a sublimable dye.

[0078] A sublimable dye is a dye that may vaporize (i.e., transform directly from a solid state to a gaseous state without going through a liquid state) when exposed to heat. The sublimable dye may have an enthalpy of vaporization that is high enough to prevent premature vaporization (e.g., to prevent the dyes from transferring during shipping and/or handling) and low enough for fast, low energy

thermal imaging. In some examples, the sublimable dye may have an enthalpy of vaporization that is less than or equal to 90 kJ per mole; or less than or equal to 75 kJ per mole; or less than or equal to 60 kJ per mole. It is to be understood, however, that the enthalpy of vaporization is not so low that the dyes can evaporate quickly at ambient temperatures (e.g., 18°C -25°C).

[0079] Examples of sublimable dyes include anthraquinone dyes, azo dyes, direct dyes, acid dyes, basic dyes, quinhydrone dyes, etc. Examples of anthraquinone dyes include Sumikalon Violet RS® (from Sumitomo Chemical Co., Ltd.), Dianix Fast Violet 3R-FS® (from Mitsubishi Chemical Corp.), Kayalon Polyol Brilliant Blue N-BGM® (from Nippon Kayaku Co., Ltd.), and KST Black 146® (from Nippon Kayaku Co., Ltd.). Examples of azo dyes include Kayalon Polyol Brilliant Blue BM® (from Nippon Kayaku Co., Ltd.), Kayalon Polyol Dark Blue 2BM® (from Nippon Kayaku Co., Ltd.), KST Black KR® (from Nippon Kayaku Co., Ltd.), Sumickaron Diazo Black 5G® (from Sumitomo Chemical Co., Ltd.), and Miktazol Black 5GH® (from Mitsui Toatsu Chemicals, Inc.). Examples of direct dyes include Direct Dark Green B® (from Mitsubishi Chemical Corp.), Direct Brown Mg (from Nippon Kayaku Co., Ltd.), and Direct Fast Black D® (from Nippon Kayaku Co., Ltd.). An example of an acid dye includes Kayanol Milling Cyanine 5R® (from Nippon Kayaku Co., Ltd.). Examples of basic dyes include Sumicacryl Blue 6G® (from Sumitomo Chemical Co., Ltd.), and Aizen Malachite Green® (from Hodogaya Chemical Co., Ltd.).

[0080] Other examples of sublimation dyes include RIAPLAS® Yellow 3GL-TP (color index number (CI No) Y54), RIAPLAS® Yellow 8G-TP (CI No Y82), RIAPLAS® Yellow 5G-TP (CI No Y64), RIAPLAS® Orange 2RL-TP (CI No O25), RIAPLAS® Brown RL-TP (CI No Br27), RIAPLAS® Red 2BL-TP (CI No R60), RIAPLAS® Red GL-TP (CI No R4), RIAPLAS® Pink 5B-TP (CI No R364), RIAPLAS® Violet 2RL-TP (CI No V28), RIAPLAS® Blue 5RLN-TP (CI No B72), RIAPLAS® Violet GL-TP (CI No B72), RIAPLAS® Blue 3GL-TMP (CI No B359), RIAPLAS® Blue DB-TP (B360), RIAPLAS® Blue G-TP (CI No B14), RIAPLAS® Blue 2R-TP (CI No B19), RIAPLAS® Blue 2GN-TP (CI No B60), RIAPLAS® Green

5B-TP (CI No Sol Gr 3), and mixtures thereof. Still other examples of sublimation dyes include intratherm yellow P-1343NT, intratherm yellow P-1346NT, intratherm yellow P-346, intratherm brilliant yellow P-348, intratherm yellow P-343NT, intratherm brilliant orange P-365, intratherm orange P-367, intratherm brown P-1301, intratherm dark brown P-1303, intratherm pink P-1335NT, intratherm brilliant red P-1314NT, intratherm red P-1339, Vat Red 41, intratherm blue P-1305NT, intratherm blue P-1404, intratherm brilliant blue P-1309, Vat Blue 3, Vat Blue 1, and mixtures thereof.

[0081] Disperse sublimation dyes may also be used. Examples of disperse sublimation dyes include carboxyl- and/or sulfo-free nitro, nitroarylamine, amino, amino ketone, ketone imine, methine, polymethine, diphenylamine, quinoline, benzimidazole, xanthene, oxazine or coumarin dyes, some anthraquinone dyes and azo dyes, such as monoazo or disazo dyes. Yellow disperse dyes may include disperse yellow 54, disperse yellow 64, disperse yellow 71, disperse yellow 86, disperse yellow 114, disperse yellow 153, disperse yellow 233, disperse yellow 245, disperse yellow 1, disperse yellow 3, disperse yellow 7, disperse yellow 9, disperse yellow 16, disperse yellow 23, disperse yellow 41, disperse yellow 51, disperse yellow 60, disperse yellow 77, disperse yellow 79, disperse yellow 82, disperse yellow 141, disperse yellow 116, and mixtures thereof. Magenta disperse dyes may include disperse red 60, disperse red 82, disperse red 86, disperse red 86:1, disperse red 167:1, disperse red 279, disperse red 1, disperse red 4, disperse red 6, disperse red 9, disperse red 11, disperse red 13, disperse red 15, disperse red 17, disperse red 55, disperse red 59, disperse red 73, disperse red 83, disperse red 135, disperse red 146, and mixtures thereof. Cyan disperse dyes may include disperse blue 27, disperse blue 60, disperse blue 73, disperse blue 77, disperse blue 87, disperse blue 257, disperse blue 291:1, disperse blue 359, disperse blue 360, disperse blue 367, disperse blue 3, disperse blue 14, disperse blue 19, disperse blue 24, disperse blue 26, disperse blue 55, disperse blue 56, disperse blue 64, disperse blue 72, disperse blue 99, disperse blue 108, disperse

blue 134, disperse blue 154, disperse blue 165, disperse blue 180, disperse blue 287, disperse blue 301, disperse blue 334, and mixtures thereof.

[0082] A black disperse dye may include disperse black 3. Black disperse dye dispersions often include a blend of disperse dyes, such as, for example, blends of blue, brown and yellow disperse dyes, or blends of blue, orange and violet disperse dyes, or blends of blue, orange and yellow disperse dyes, or blue, magenta, and yellow dyes. An example of a suitable blue, brown and yellow disperse dye blend includes disperse blue 360 (DB360), disperse brown 27, and disperse yellow 54 (DY54). Some examples of suitable blue, orange and violet disperse dye blends include disperse blue 291:1 (DB291:1), disperse orange 29 (DO29) and disperse violet 63, or DB291:1, DO29 and disperse violet 99. An example of a suitable blue, orange and yellow dye blend includes DB360, disperse orange 25, and DY54. An example of a suitable blue, magenta, and yellow dye blend includes disperse blue 77 (DB77), disperse red 92, and disperse yellow 114 (DY 114).

[0083] Other examples of disperse sublimation dyes include disperse orange 3, disperse orange 25, disperse orange 7, disperse orange 1, disperse violet 1, disperse violet 4, disperse violet 13, disperse violet 36, disperse violet 56, disperse violet 31, and mixtures thereof or mixtures with any of the other dyes disclosed herein.

[0084] Still other suitable sublimation dyes that may be used in the examples disclosed herein include oil-soluble dyes, such as solvent yellow 14, solvent yellow 16, solvent yellow 29, solvent yellow 56, solvent yellow 77, solvent yellow 116, solvent red 18, solvent red 19, solvent red 23, solvent red 24, solvent red 25, solvent red 27, solvent red 81, solvent red 135, solvent red 143, solvent red 146, solvent red 182, solvent blue 11, solvent blue 35, solvent blue 36, solvent blue 49, solvent blue 50, solvent blue 63, solvent blue 70, solvent blue 83, solvent blue 97, solvent blue 105, solvent blue 111, solvent black 3, solvent violet 13, solvent green 3, and mixtures thereof or mixtures with any of the other dyes disclosed herein.

[0085] While several examples of thermal transfer dyes have been provided, it is to be understood that any suitable thermal transfer dye known in the art may be used.

[0086] Heat transfers the thermal transfer dyes (and the other components of the color layer 14). As such, the portions of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 that are selectively exposed to heat transfer to the image-receiving substrate 12. In some examples, the heat actually causes the dye to diffuse into the image-receiving substrate 12. In other examples, the heat actually sublimates the dye so that it converts to a gas and penetrates into the image-receiving substrate 12.

[0087] In some examples, the color layer 14 includes the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye; and each of the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye is transferable under the same heat exposure conditions as each other dye in the color layer 14. In one of these examples, the at least three adjacent color stripes 22, 24, 26, 28 includes the cyan stripe 24, the magenta stripe 26, the yellow stripe 28, and the black stripe 22, or the grid 30 of four color sections 32, 34, 36, 38 includes a black colored section, the cyan section 34, the magenta section 36, and the yellow section 38; the color layer 14 includes the black thermal transfer dye, the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye; and each of the black thermal transfer dye, the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye is transferable under the same heat exposure conditions.

[0088] In some of these examples, the heat exposure conditions include heating to a temperature ranging from about 70°C to about 300°C for a time period ranging from about 10 μ s to about 200 μ s. In some other of these examples, the heat exposure conditions include heating to a temperature ranging from about 70°C to about 200°C for a time period ranging from about 10 μ s to about 200 μ s. In still some other of these examples, the heat exposure conditions include heating to a

temperature ranging from about 70°C to about 100°C for a time period ranging from about 10 μ s to about 200 μ s. In yet some other of these examples, the heat exposure conditions include heating for a time period of about 100 μ s. The low end of the temperature range for dye transfer (i.e., the low end of the heating conditions) may be high enough to prevent premature color transfer (e.g., to prevent the dyes from transferring during shipping and/or handling). The heat exposure conditions may also include heating to a temperature low enough (e.g., $\leq$ 100°C) for fast, low energy thermal imaging.

[0089] In some examples, the color layer 14 may include, in addition to the thermal transfer dyes, a binder. In some of these examples, the color layer 14 consists of the thermal transfer dyes, the binder, or a combination thereof. In others of these examples, the color layer 14 may include additional components, such as the registration mark 16. Other examples of additional components include surfactant(s), coating aid(s), wax(es), anti-oxidant(s), UV light stabilizer(s), thermal solvent(s), humectant(s), and combinations thereof. In still others of these examples, the color layer 14 consists of the thermal transfer dyes, the binder, the registration mark 16 or a combination thereof.

[0090] A binder may be included in the color layer 14 to bind the thermal transfer dyes so that the repeated pattern of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 is maintained, and so that a thermal transfer dye from one stripe 22, 24, 26, 28 or section 32, 34, 36, 38 does not migrate to another stripe 22, 24, 26, 28 or section 32, 34, 36, 38. The binder may also maintain the component(s) of the color layer 14 within the layer 14 and/or bind it/them to the image-receiving substrate 12 after its/their transfer. In an example, the binder may be an acrylic, styrene acrylic, polyethylene, or polyurethane binder. Other examples of the binder include polycarbonate, poly(styrene-co-acrylonitrile), polysulfone, polyphenylene oxide, cellulose acetate hydrogen phthalate, cellulose acetate, cellulose acetate butyrate, etc. In an example, the total amount of binder(s) present in the color layer 14 may range from about 5 wt% to about 40 wt%, based on the total weight of the color layer 14. In another example, the total

amount of binder(s) present in the color layer 14 may range from about 5 wt% to about 25 wt%, based on the total weight of the color layer 14.

[0091] In an example, the color layer 14 may have a substantially uniform thickness. For example, the thickness along substantially the entire length and/or width of the color layer 14 may range from about 1 μm to about 20 μm . In another example, the thickness along substantially the entire length and/or width of the color layer 14 may range from about 0.5 μm to about 4 μm .

[0092] In an example, the color layer 14 may have a basis weight (after being dried) ranging from about 1 gsm to about 10 gsm.

[0093] In some examples, the donor ribbon 40 further includes a clear and colorless topcoat 18 disposed on the release layer 44; and the color layer 14 is disposed on the clear and colorless topcoat 18. In one of these examples, the clear and colorless topcoat 18 is disposed directly on the release layer 44; and the color layer 14 is disposed directly on the clear and colorless topcoat 18. As used herein, "clear," means that 80% or more of visible light (i.e., light with a wavelength ranging from 390 nm to 700 nm) can be transmitted through the topcoat 18. As used herein, "colorless," means that the topcoat 18 is achromatic and does not include a colorant.

[0094] As shown in Fig. 1, the clear and colorless topcoat 18 may be a continuous, porous layer positioned between the release layer 44 and the color layer 14. Portions of the clear and colorless topcoat 18 may be transferred (e.g., as a result of heat exposure) to the image-receiving substrate 12 when portions (e.g., the thermal transfer dyes) of the color layer 14 are activated and transferred to the image-receiving substrate 12. It is to be understood that the dye(s) in the portions of the clear and colorless topcoat 18 that are selectively exposed to heat will transfer to the image-receiving substrate 12, and that the dye(s) in the portions of the clear and colorless topcoat 18 that are not selectively exposed to heat will not transfer to the image-receiving substrate 12. As such, once transferred to the image-receiving substrate 12, the clear and colorless topcoat 18 will no longer be a continuous layer.

[0095] The portions of the clear and colorless topcoat 18 that are transferred to the image-receiving substrate 12 will be disposed on the portions of the color layer 14 that have transferred to the image-receiving substrate 12. Thus, when the image-receiving substrate 12 is separated from the donor ribbon 40, the transferred portions of the clear and colorless topcoat 18 may act as a protective coating over the image formed from the activated and transferred portions of the color layer 14. The clear and colorless topcoat 18, acting as a protective coating, may improve the robustness or durability of the colored image formed on the image-receiving substrate 12 (as compared to the robustness or durability of a colored image formed without the clear and colorless topcoat 18). Since the topcoat 18 is clear and colorless, the colored image formed using the color layer 14 may be seen through the clear and colorless topcoat 18.

[0096] The clear and colorless topcoat 18 may be any material that is: i) clear and colorless, ii) capable of acting as a protective coating, and iii) capable of having portions thereof be transferred upon the selective exposure to heat. In an example, the clear and colorless topcoat 18 may include a polymeric binder. In another example, the clear and colorless topcoat 18 may consist of a polymeric binder. In still other examples, the clear and colorless topcoat 18 may include polyvinyl alcohol (e.g., AIRVOL™ 540, available from Air Products and Chemicals, Inc., Allentown, PA), a surfactant (e.g., ZONYL® FSA and/or ZONYL® FSN, available from DuPont Corporation, Wilmington, DE), zinc stearate (e.g., HYMICRON™ ZK-349, available from Cytech Products, Inc., Elizabethtown, KY), silica (e.g., KLEBOSOL® 30V-25, available from Clariant Corporation, Muttenz, Switzerland), and glyoxal (OCHCHO, available from Aldrich Chemical Co., Milwaukee, WI). In yet another example, the clear and colorless topcoat 18 may include from about 30 wt% to about 35 wt% of the polyvinyl alcohol, from about 3 wt% to about 5 wt% of the surfactant, from about 30 wt% to about 35 wt% of the zinc stearate, from about 20 wt% to about 25 wt% of the silica, and from about 7 wt% to about 10 wt% of glyoxal.

[0097] In an example, the clear and colorless topcoat 18 may have a substantially uniform thickness. For example, the thickness along substantially the entire length and/or width of the clear and colorless topcoat 18 may range from about 0.50 μm to about 5.0 μm . In another example, the thickness along substantially the entire length and/or width of the clear and colorless topcoat 18 is about 1 μm .

[0098] In some examples, the donor ribbon 40 further includes a back coat 46 disposed on a back side 50 of the donor ribbon substrate 42. For example, the back coat 46 may be disposed directly on the back side 50 of the donor ribbon substrate 42. As used herein in reference to the donor ribbon substrate 42, the term "back side" may refer to the side opposed to the front side 48. The back side 50 may be the side that is placed into contact with the thermal printhead during printing/imaging, and the side upon which the color layer 14 is not to be disposed.

[0099] As shown in Fig. 1, the back coat 46 may be a continuous layer on the back side 50 of the donor ribbon substrate 42. As such, the back coat 46 may provide support to the donor ribbon substrate 42 and/or improve the ability of the imaging medium 10 to feed through a printer. Additionally or alternatively, the back coat 46 may prevent the donor ribbon 40 from sticking to a thermal printhead and/or prevent the donor ribbon 40 from contaminating a thermal printhead.

[0100] The back coat 46 may be any material that is capable of providing support to the donor ribbon substrate 42, improving the ability of the imaging medium 10 to feed through a printer, preventing the donor ribbon 40 from sticking to a thermal printhead, and/or preventing the donor ribbon 40 from contaminating a thermal printhead. In an example, the back coat 46 may include heat resistant materials. In another example, the back coat 46 may include a polymeric binder. In still another example, the back coat 46 may consist of the polymeric binder. In yet another example, the back coat 46 may include denatured polyvinyl alcohols, starch, oxidized starch, urea-phosphorylated starch, styrene-maleic anhydride copolymers, alkyl esters of styrene-maleic anhydride copolymers, styrene-acrylic acid copolymers, or a combination thereof. In yet another example, the denatured

polyvinyl alcohols, starch, oxidized starch, urea-phosphorylated starch, styrene-maleic anhydride copolymers, alkyl esters of styrene-maleic anhydride copolymers, styrene-acrylic acid copolymers, or the combination thereof may be included in the back coat 46 in an amount up to 100 wt%, based on the total weight of the back coat 46.

[0101] In an example, the back coat 46 may have a substantially uniform thickness. For example, the thickness along substantially the entire length and/or width of the back coat 46 may be less than or equal to 1 μm . In another example, the thickness along substantially the entire length and/or width of the back coat 46 may be about 0.1 μm .

[0102] As mentioned above, the imaging medium 10 also includes a registration mark 16. The registration mark 16 enables a particular area of the repeated pattern to be accurately aligned with a particular thermal resistor or a plurality of thermal resistors (e.g., a column and/or row of thermal resistors). Accurate alignment enables the desired color stripes 22, 24, 26, 28, color sections 32, 34, 36, 38, or portions thereof to be transferred from the donor ribbon 40 to the image-receiving substrate 12 to form a printed image. Accurate alignment also enables the color stripes 22, 24, 26, 28, color sections 32, 34, 36, 38, or portions thereof that are to remain non-transferred to remain non-transferred.

[0103] The registration mark(s) 16 may be detected by a printer. Upon detecting the registration mark(s) 16, the printer can de-skew the path of the imaging medium 10, and can determine the locations of each color stripe 22, 24, 26, 28 or each color section 32, 34, 36, 38 with respect to the location(s) of the registration mark(s) 16. As such, the registration mark 16 may be any mark that is capable of being detected by a printer. Examples of the registration mark(s) 16 include electronic marks (e.g., conductive traces), marks that emit or react to near-infrared (NIR) radiation, and marks that emit or react to ultraviolet (UV) radiation.

[0104] The registration mark(s) 16 may be located anywhere on the imaging medium 10 that enables the registration mark(s) 16 to be detected. As such, the registration mark 16 may be disposed on (directly or indirectly) any component of

the donor ribbon 40 or the image-receiving substrate 12. As examples, the registration mark(s) 16 may be disposed on (directly or indirectly) the donor ribbon substrate 42, disposed on (directly or indirectly) the back coat 46 (as shown in Fig. 1), disposed on (directly or indirectly) the release layer 44, disposed on (directly or indirectly) the clear and colorless topcoat 18, disposed on (directly or indirectly) the color layer 14, or disposed on the image-receiving substrate 12 (e.g., on the base layer 11 or the ink-receiving layer 13). In some examples, the registration mark(s) 16 may be included in the color layer 14. In these examples, the registration mark(s) 16 may be present in one or more of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 in one or more of the repeats 20, 20'. In these examples, the registration mark(s) 16 may be considered to be disposed on or disposed directly on the release layer 44 or disposed on or disposed directly on the clear and colorless topcoat 18.

[0105] The imaging medium 10 may include one registration mark 16 or multiple registration marks 16. The example of the imaging medium 10 shown in Fig. 1 includes multiple registration marks 16.

[0106] The imaging medium 10 may be any size (e.g., width, length, area, etc.) that is desired. As an example, the imaging medium 10 may have a width of 2 inches. As another example, the imaging medium 10 may have a width of 4 inches. In still another example, the imaging medium 10 may have a width greater than 4 inches. In yet another example, the imaging medium 10 may have a width of 2 inches and a length of 3 inches. In other examples, the imaging medium 10 may have a width of 3 inches and a length of 5 inches, may have a width of 4 inches and a length of 6 inches, or may have a width of 5 inches and a length of 7 inches.

[0107] Referring now to Fig. 3, a method 100 of making the imaging medium 10 is depicted. In one example, the method 100 of making the imaging medium 10 comprises: forming a donor ribbon 40 by: applying at least a cyan ink, a magenta ink, and a yellow ink on a release layer 44 of a donor ribbon substrate 42 to form a color layer 14 including a repeated pattern, a repeat 20, 20' of the pattern including:

at least three adjacent color stripes 24, 26, 28 including a cyan stripe 24, a magenta stripe 26, and a yellow stripe 28; or a grid 30 of four color sections 32, 34, 36, 38 including i) a colored section 32 selected from the group consisting of black, cyan, light cyan, yellow, magenta, and light magenta, ii) a cyan section 34, iii) a magenta section 36, and iv) a yellow section 38 (reference numeral 102); attaching the donor ribbon 40 to an image-receiving substrate 12 so that the color layer 14 is in contact with the image-receiving substrate 12 (reference numeral 104); and applying a registration mark 16 on a component of the donor ribbon 40 or the image-receiving substrate 12 (reference numeral 106).

[0108] In another example, the method 100 of making the imaging medium 10 comprises: forming a donor ribbon 40 by: applying a black ink, a cyan ink, a magenta ink, and a yellow ink on a release layer 44 of a donor ribbon substrate 42 to form a color layer 14 including a repeated pattern, a repeat 20, 20' of the pattern including: four adjacent color stripes 22, 24, 26, 28 including a black stripe 22, a cyan stripe 24, a magenta stripe 26, and a yellow stripe 28; or a grid 30 of four color sections 32, 34, 36, 38 including a black section, a cyan section 34, a magenta section 36, and a yellow section 38; attaching the donor ribbon 40 to an image-receiving substrate 12 so that the color layer 14 is in contact with the image-receiving substrate 12; and applying a registration mark 16 on a component of the donor ribbon 40 or the image-receiving substrate 12.

[0109] In still another example, the method 100 of making the imaging medium 10 comprises: forming a donor ribbon 40 by: applying a black ink including a black thermal transfer dye, a cyan ink including a cyan thermal transfer dye, a magenta ink including a magenta thermal transfer dye, and a yellow ink including a yellow thermal transfer dye on a release layer 44 of a donor ribbon substrate 42 to form a color layer 14 including a repeated pattern, a repeat 20, 20' of the pattern including: four adjacent color stripes 22, 24, 26, 28 including a black stripe 22, a cyan stripe 24, a magenta stripe 26, and a yellow stripe 28; or a grid 30 of four color sections 32, 34, 36, 38 including a black section, a cyan section 34, a magenta section 36, and a yellow section 38; attaching the donor ribbon 40 to an image-receiving

substrate 12 so that the color layer 14 is in contact with the image-receiving substrate 12; and applying a registration mark 16 on a component of the donor ribbon 40 or the image-receiving substrate 12.

[0110] The method 100 of making the imaging medium 10 may be less complex and/or less expensive than the construction of a medium with a layer for each color to be formed (i.e., a black-forming layer, a cyan-forming layer, a magenta-forming layer, and a yellow-forming layer) with thermal barrier layers between each color-forming layer. The method 100 of making the imaging medium 10 may also be less complex and/or less expensive than the construction of a separate donor ribbon and image-receiving substrate.

[0111] As shown at reference numeral 102, the method 100 includes forming the donor ribbon 40. The donor ribbon substrate 42 may be as described above.

[0112] Forming the donor ribbon 40 includes applying at least a cyan ink, a magenta ink, and a yellow ink on the release layer 44 to form a color layer 14. In some examples, the method 100 further comprises applying a black ink in addition to the cyan ink, the magenta ink, and the yellow ink. In other examples, the method 100 further comprises applying a black ink, a light cyan ink or a light magenta ink in addition to the cyan ink, the magenta ink, and the yellow ink.

[0113] In one example, the at least three adjacent color stripes 22, 24, 26, 28 further include a black stripe 22 and the method 100 further comprises applying a black ink in addition to the cyan ink, the magenta ink, and the yellow ink; or the colored section 32 of the grid 30 is selected from the group consisting of black, light cyan, and light magenta, and the method 100 further comprises applying a black ink, a light cyan ink or a light magenta ink in addition to the cyan ink, the magenta ink, and the yellow ink.

[0114] In an example, the cyan ink, the magenta ink, and the yellow ink (and the black ink, light cyan ink, or light magenta ink when used) are applied directly on the release layer 44 to form the color layer 14 directly on the release layer 44.

[0115] In some examples of the method 100, the applying of at least the cyan ink, the magenta ink, and the yellow ink is accomplished with offset printing, inkjet

printing, or flexographic printing. In one of these examples, the method 100 includes applying the black ink, the light cyan ink, or the light magenta ink, in addition to the cyan ink, the magenta ink, and the yellow ink; and the applying of the black ink, the light cyan ink, or the light magenta ink is accomplished with offset printing, inkjet printing, or flexographic printing.

[0116] The cyan ink, the magenta ink, and the yellow ink (and the black ink, light cyan ink, or light magenta ink when used) are applied on the release layer 44 to form the repeated pattern. As such, the cyan ink is applied where the cyan stripe(s) 24, or the cyan section(s) 34 and the colored section(s) 32 (when cyan) are to be formed; the magenta ink is applied where the magenta stripe(s) 26, or the magenta section(s) 36 and the colored section(s) 32 (when magenta) are to be formed; and the yellow ink is applied where the yellow stripe(s) 28, or the yellow section(s) 38 and the colored section(s) 32 (when yellow) are to be formed. Additionally, the black ink may be applied where the black stripe(s) 22 or the colored section(s) 32 (when black) are to be formed; the light cyan ink may be applied where the colored section(s) 32 (when light cyan) are to be formed; and the light magenta ink may be applied where the colored section(s) 32 (when light magenta) are to be formed.

[0117] In an example, the cyan ink includes a cyan thermal transfer dye, the magenta ink includes a magenta thermal transfer dye, and the yellow ink includes a yellow thermal transfer dye. In another example, the black ink includes a black thermal transfer dye, the light cyan ink includes a cyan thermal transfer dye, and the light magenta ink includes a magenta thermal transfer dye. Each of the black thermal transfer dye, the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye may be a sublimable dye. The sublimable dyes may be any of the sublimable dyes described above. The total amount of the sublimable dye(s) present in each of the inks may range from about 1 wt% to about 10 wt%, based on the total weight of the ink. In another example, the total amount of the sublimable dye(s) present in each of the inks may range from about 4 wt% to about 6 wt%, based on the total weight of the ink. In some examples, the light

cyan ink may include a lower amount (e.g., by weight) of sublimable dye than the cyan ink, and/or the light magenta ink may include a lower amount (e.g., by weight) of sublimable dye than the magenta ink.

[0118] Each of the inks may additionally include the binder. The binder may be as described above. In an example, the total amount of binder(s) present in each of the inks may range from about 0.5 wt% to about 10 wt%, based on the total weight of the ink. Higher binder amounts may be used, depending upon the type of ink.

[0119] Additionally, each of the inks may include a liquid vehicle. The liquid vehicle may enable the inks to be applied on the release layer 44 (or another layer, e.g., the clear and colorless topcoat 18). As mentioned above, in some examples, the inks may be applied via offset printing, inkjet printing, or flexographic printing. In these examples, the liquid vehicle may be formulated to enable the inks to be applied by the desired printing process. As such, the formulation of the liquid vehicle of each of the inks may depend, in part, upon the technique used to form the color layer 14.

[0120] In some examples, the liquid vehicle of each of the inks may include water and one or more co-solvents. The co-solvent(s) may be present in an amount ranging from about 1 to about 25 wt% (based on the total weight of the ink). In some other examples, the vehicle may be a non-aqueous vehicle. In these examples, the vehicle solvent may be isopropyl alcohol or methyl ethyl ketone.

[0121] The liquid vehicle may also contain one or more surfactants present in an amount ranging from about 0.1 to about 8 wt% (based on the total weight of the ink).

[0122] The liquid vehicle may further include other components common to some inks, such as humectants, viscosity control agents, antimicrobial agents (e.g., biocides and fungicides), anti-kogation agents (for thermal inkjet printing), etc.

[0123] An example of an offset ink formulation includes the thermal transfer dye, a binder (e.g., phenolic resins, maleic acid resins, ester resins, petroleum resins, etc.), and a high boiling point (160°C or higher) solvent. The thermal transfer dye

may be present in an amount ranging from about 1 wt% to about 10 wt% based on a total weight of the offset ink composition. The binder may be present in an amount ranging from about 40 wt% to about 95 wt%. Examples of the solvent include a paraffinic solvent, an isoparaffinic solvent, naphthenic solvent, alpha-olefin solvents, light oil, spindle oil, machine oil, cylinder oil, turpentine oil, mineral spirits, liquid paraffin, and the like. The solvent may be present in an amount ranging from about 5 wt% to about 50 wt%. Other suitable additives for offset inks include wax compounds, drying agents, dispersants, rheology modifiers, lubricants, fillers, and/or anti-oxidants.

[0124] A flexographic ink may include a solvent, the thermal transfer dye, and a binder. Examples of suitable solvents include hydrocarbons such as toluene or xylene, alcohols, for example ethanol, 1-propanol, 2-propanol, ethylene glycol, propylene glycol, or diethylene glycol, substituted alcohols, such as ethoxypropanol, esters, for example ethyl acetate, isopropyl acetate, n-propyl or n-butyl acetate. The solvent(s) may be present in an amount ranging from about 50 wt% to about 80 wt%, of the total weight of the flexographic ink. The thermal transfer dye may be present in an amount ranging from about 1 wt% to about 10 wt% based on a total weight of the flexographic ink composition. Examples of suitable binders include polyvinylbutyral, nitrocellulose, polyamides, polyacrylates, and polyacrylate copolymers. Another suitable binder is a hyperbranched polymer having functional groups. The binder(s) may account for from about 5 wt% to about 30 wt% based on a total weight of the flexographic ink composition.

[0125] An inkjet ink may also be used. This inkjet ink may include water, a water-soluble organic solvent and/or a humectant, and the thermal transfer dye. Examples of the water-soluble organic solvent include alkylene glycol. Specific examples include ethylene glycol, propylene glycol, 1,3-propanediol, 1,2-butanediol, 1,3-butanediol, 1,4-butanediol, 2,3 butanediol, 3-methyl-1,3-butanediol, 1,2-pentanediol, 1,5-pentanediol, 2-methyl-2,4-pentanediol, 3-methyl-1,5-pentanediol, 1,2-hexanediol, 1,6 monoalkylene glycol typified hexanediol diethylene glycol, triethylene glycol, polyalkylene glycol represented by dipropylene

glycol. Other examples of the water-soluble organic solvent include acetone, ethanol, and methanol. The water-soluble organic solvent may be present in an amount ranging from about 1 wt% to about 20 wt% or in an amount ranging from about 1 wt% to about 10 wt%. Examples of the humectant include a high-boiling organic solvent, such as glycols (e.g., glycerin or polyethylene glycol), sugar alcohols, and saccharides. The humectant may be present in an amount ranging from about 15 wt% to about 40 wt%. The thermal transfer dye may be present in dispersed form in an amount ranging from about 1 wt% to about 10 wt% based on a total weight of the inkjet ink composition. Some example inkjet inks also include a dispersant.

[0126] Some examples the inkjet inks may also include a decap control agent to improve the decap performance of the inkjet ink. The term "decap performance," as referred to herein, means the ability of the inkjet ink to readily eject from the printhead, upon prolonged exposure to air. Examples of the decap control agent include modified perfluoropolyethers, such as FLUOROLINK® A10, a dialkyl amide perfluoropolyether derivative with the chemical structure

$\text{CH}_3(\text{CH}_2)_{17}\text{HNOCCF}_2\text{O}(\text{CF}_2\text{CF}_2\text{O})_p(\text{CF}_2\text{O})_q\text{CF}_2\text{CONH}(\text{CH}_2)_{17}\text{CH}_3$ available from Solvay-Solexis. The decap control agent may be present in an amount ranging from 0 wt% to about 1 wt%.

[0127] As the inks dry on the release layer 44, they form the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38. As such, the cyan ink forms the cyan stripe(s) 24, or the cyan section(s) 34 and the colored section(s) 32 (when cyan) when it dries; the magenta ink forms the magenta stripe(s) 26, or the magenta section(s) 36 and the colored section(s) 32 (when magenta) when it dries; and the yellow ink forms the yellow stripe(s) 28, or the yellow section(s) 38 and the colored section(s) 32 (when yellow) when it dries. Additionally, the black ink may form the black stripe(s) 22, or the colored section(s) 32 (when black) when it dries; the light cyan ink may form the colored section(s) 32 (when light cyan) when it dries; and the light magenta ink may form the colored section(s) 32 (when light magenta) when it dries. The repeat 20, 20' of the pattern including the at least

three adjacent color stripes 22, 24, 26, 28 or the grid 30 of the four color sections 32, 34, 36, 38 may be formed to be as described above.

[0128] In some examples of the method 100, forming the donor ribbon 40 further includes: applying the release layer 44 on a front side 48 of the donor ribbon substrate 42; applying a back coat 46 on a back side 50 of the donor ribbon substrate 42; and applying a clear and colorless topcoat 18 on the release layer 44 prior to forming the color layer 14. In some other examples of the method 100, the donor ribbon substrate 42 may be obtained (e.g., purchased) with the release layer 44 and the back coat 46 already applied thereon. In these examples, forming the donor ribbon 40 may further include applying a clear and colorless topcoat 18 on the release layer 44.

[0129] In an example, the release layer 44 may be applied directly on the front side 48 of the donor ribbon substrate 42. The release layer 44 may be as described above.

[0130] In an example, the back coat 46 is applied directly on the back side 50 of the donor ribbon substrate 42. The back coat 46 may be as described above.

[0131] In another example, the clear and colorless topcoat 18 is applied directly on the release layer 44. In this example, the clear and colorless topcoat 18 may be formed before the color layer 14, and thus the at least the cyan ink, the magenta ink, and the yellow ink may be applied directly on the clear and colorless topcoat 18 to form the color layer 14 directly on the clear and colorless topcoat 18. In another example of the method 100, the application of the clear and colorless topcoat 18 is accomplished with offset printing, inkjet printing, or flexographic printing. The clear and colorless topcoat 18 may be as described above.

[0132] As shown at reference numeral 104, the method 100 may continue by attaching the donor ribbon 40 to an image-receiving substrate 12 so that the color layer 14 is in contact with the image-receiving substrate 12. The image-receiving substrate 12 may be as described above.

[0133] In an example of the method 100, the attaching of the donor ribbon 40 to the image-receiving substrate 12 is accomplished by lamination. In another

example of the method 100, the image-receiving substrate 12 includes the ink-receiving layer 13 coated on the base layer 11, and the donor ribbon 40 is attached to the image-receiving substrate 12 so that the color layer 14 is in contact with the ink-receiving layer 13.

[0134] As shown at reference numeral 106, the method 100 includes applying the registration mark 16 on a component of the donor ribbon 40 or the image-receiving substrate 12. The registration mark 16 may be as described above.

[0135] In an example, the registration mark 16 is applied on the donor ribbon substrate 42, on the back coat 46, on the release layer 44, on the clear and colorless topcoat 18, on the color layer 14, or on the image-receiving substrate 12 (e.g., on the base layer 11 or the ink-receiving layer 13). In another example, the registration mark 16 is applied directly on the donor ribbon substrate 42, directly on the back coat 46, directly on the release layer 44, directly on the clear and colorless topcoat 18, directly on the color layer 14, or directly on the image-receiving substrate 12 (e.g., on the base layer 11 or the ink-receiving layer 13).

[0136] In an example of the method 100, the registration mark 16 is applied in the color layer 14. In this example, the applying of the registration mark 16 may be accomplished during the applying of the black ink, the cyan ink, the light cyan ink, the magenta ink, the light magenta ink, and/or the yellow ink. In this example, a registration mark precursor (e.g., an electronic material, a material that emits or reacts to NIR radiation, or a material that emits or reacts to UV radiation) may be included in one or more of the inks used to form the repeated pattern.

[0137] In an example, the applying of the registration mark 16 may include applying a single registration mark 16 or multiple registration marks 16.

[0138] Also disclosed herein is a printing system. In one example, the printing system comprises: a thermal printhead including a row of thermal resistors; and an imaging medium 10 including: an image-receiving substrate 12; and a donor ribbon 40 attached to the image receiving substrate 12, the donor ribbon 40 including: a donor ribbon substrate 42; a release layer 44 disposed on the donor ribbon substrate 42; and a color layer 14 disposed on the release layer 44, the color layer

14 including a repeated pattern, a repeat 20, 20' of the pattern including: at least three adjacent color stripes 24, 26, 28 including a cyan stripe 24, a magenta stripe 26, and a yellow stripe 28, wherein a width of each color stripe 24, 26, 28 is equal to a width of the row of thermal resistors; or a grid 30 of four color sections 32, 34, 36, 38 including i) a colored section 32 selected from the group consisting of black, cyan, light cyan, yellow, magenta, and light magenta, ii) a cyan section 34, iii) a magenta section 36, and iv) a yellow section 38, wherein a width of each color section 32, 34, 36, 38 is equal to a width of each of the thermal resistors and a length of each color section 32, 34, 36, 38 is equal to a length of each of the thermal resistors; and a registration mark 16; wherein the color layer 14 is in contact with the image-receiving substrate 12.

[0139] The thermal printhead may be a component of a printer. The thermal printhead includes a row of thermal resistors. The thermal printhead may include one row of thermal resistors or multiple rows of thermal resistors.

[0140] The thermal resistors are capable of selectively exposing the imaging medium 10 to heat. In an example, the thermal resistors are capable of selectively exposing the imaging medium 10 to a temperature ranging from about 70°C to about 300°C for a time period ranging from about 10 μ s to about 200 μ s. In another example, the thermal resistors are capable of selectively exposing the imaging medium 10 to a temperature ranging from about 70°C to about 200°C for a time period ranging from about 10 μ s to about 200 μ s. In still another example, the thermal resistors are capable of selectively exposing the imaging medium 10 to a temperature ranging from about 70°C to about 100°C for a time period ranging from about 10 μ s to about 200 μ s.

[0141] As examples, the thermal resistors may have a width and/or length of 1/300th of an inch or smaller, 1/600th of an inch or smaller, or 1/1200th of an inch or smaller. In some examples, the size of each thermal resistor is equivalent to the width W_{22} , W_{24} , W_{26} , W_{28} of each stripe 22, 24, 26, 28 or to the size of each section 32, 34, 36, 38, and thus a single thermal resistor may be used to activate a single section 32, 34, 36, 38 or a portion of the stripe 22, 24, 26, 28.

[0142] The thermal printhead may be part of the printer, which may also be able to detect the registration mark 16, optically or electronically. The printer may then use the registration mark 16 to determine the location of particular color stripes 22, 24, 26, 28 or sections 32, 34, 36, 38 where heat should be selectively applied to the imaging medium 10 to form a colored image.

[0143] The imaging medium 10 may be as described above.

[0144] Referring now to Fig. 4, a method 200 of making a colored image is depicted. In one example, the method 200 of making the colored image comprises: selectively exposing an imaging medium 10 to heat; wherein the imaging medium 10 includes: an image receiving substrate 12; and a donor ribbon 40 attached to the image receiving substrate 12, the donor ribbon 40 including: a donor ribbon substrate 42; a release layer 44 disposed on the donor ribbon substrate 42; and a color layer 14 disposed on the release layer 44, the color layer 14 including at least a cyan thermal transfer dye, a magenta thermal transfer dye, and a yellow thermal transfer dye in a repeated pattern, a repeat 20, 20' of the pattern including: at least three adjacent color stripes 24, 26, 28 including a cyan stripe 24, a magenta stripe 26, and a yellow stripe 28; or a grid 30 of four color sections 32, 34, 36, 38 including i) a colored section 32 selected from the group consisting of black, cyan, light cyan, yellow, magenta, and light magenta, ii) a cyan section 34, iii) a magenta section 36, and iv) a yellow section 38; and a registration mark 16; wherein the color layer 14 is in contact with the image-receiving substrate 12; and wherein the selectively exposing of the imaging medium 10 to heat transfers, to the image-receiving substrate 12, a respective dye from at least a portion of one or more of the color stripes 24, 26, 28 or the color sections 32, 34, 36, 38 in one or more of the repeats 20, 20'.

[0145] The method 200 includes selectively exposing the imaging medium 10 to heat. In some examples, the selectively exposing of the imaging medium 10 to heat is accomplished with a thermal printhead including a row of thermal resistors. In one of these examples, the selectively exposing of the imaging medium 10 to heat is accomplished in a single pass of the thermal printhead over the imaging

medium 10. In this example, the printing speed of the method 200 may be faster than the printing speed of a comparative method that uses a medium with a layer for each color to be formed, as the comparative method may involve multiple passes (e.g., to create multicolored images). In this example, the printing speed of the method 200 may also be faster than the printing speed of another comparative method that uses a donor ribbon with successive patches of differently-colored or different color-forming material, as the other comparative method may involve multiple passes (e.g., to create multicolored images). In an example, the printing speed of the method 200 may be faster than the comparative method and/or the other comparative method by 20% or more.

[0146] In an example, heat may be selectively applied to the imaging medium 10 from the back of the donor ribbon 40. As such, the printhead and/or the thermal resistors may be in contact with the back side 50 of the donor ribbon substrate 42 or the back coat 46 during the selectively exposing of the imaging medium 10 to heat.

[0147] In some examples, the method 200 further comprises aligning a thermal resistor of a thermal printhead at a location adjacent to a back side of the donor ribbon 40, where the location is aligned with the at least the portion of one or more of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38, and wherein the selectively exposing of the imaging medium 10 to heat is accomplished with the thermal resistor. As used herein in reference to the donor ribbon 40, the term “back side” may refer to the side opposed to the side to which the image-receiving substrate 12 is be attached.

[0148] The selectively exposing of the imaging medium 10 to heat transfers (via diffusion or sublimation), to the image-receiving substrate 12, the black thermal transfer dye, the cyan thermal transfer dye, the magenta thermal transfer dye, the yellow thermal transfer dye, or combinations thereof from at least a portion of one or more of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 in one or more of the repeats 20, 20'. It is to be understood that all or less than all of the dye(s) in the color stripe 22, 24, 26, 28 or the color section 32, 34, 36, 38 may

be transferred to the image-receiving substrate 12 during a single heating event, and this may depend upon the size of the color stripe 22, 24, 26, 28 or the color section 32, 34, 36, 38, the size of the thermal resistor, and/or the number of thermal resistors that are activated during the heating event. For example, when the width of each thermal resistor is equivalent to the width W_{22} , W_{24} , W_{26} , W_{28} of each stripe 22, 24, 26, 28 but the length of each thermal resistor is less than the length L of each stripe 22, 24, 26, 28, several thermal resistors in a row may be activated in order to generate color along the stripe 22, 24, 26, 28. For another example, when the size of each thermal resistor is equivalent to the size of each section 32, 34, 36, 38, a single thermal resistor may be activated in order to generate color at a single section 32, 34, 36, 38, or any number of thermal resistors may be activated in order to generate color at the same number of aligned sections 32, 34, 36, 38.

[0149] The transfer to the image-receiving substrate 12 of the dye(s) in the at least a portion of one or more of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 in one or more of the repeats 20, 20' forms the colored image. In an example of the method 200, the dyes in the at least a portion of at least two of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 in one or more of the repeats 20, 20' are transferred to the image-receiving substrate 12. In another example of the method 200, the dyes in the at least a portion of at least three of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 in one or more of the repeats 20, 20' are transferred to the image-receiving substrate 12. In still another example of the method 200, the dyes in the at least a portion of four of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 in one or more of the repeats 20, 20' are transferred to the image-receiving substrate 12. In all of these examples, the transfer to the image-receiving substrate 12 forms a multicolored image.

[0150] When the dye(s) are transferred to the image-receiving substrate 12, they may be disposed on the image-receiving substrate 12. In some of these examples, the dye(s) may be at least partially absorbed into the image-receiving

substrate 12 or a portion of the image-receiving substrate 12 (e.g., the ink-receiving layer 13). In others of these examples, the dye(s) may form a film or layer (which may be non-continuous) on the image-receiving substrate 12.

[0151] In some examples, the selectively exposing of the imaging medium 10 to heat is accomplished such that each color stripe 22, 24, 26, 28, color section 32, 34, 36, 38, or portion thereof (or the thermal transfer dye therein) that is transferred to the image-receiving substrate 12 is exposed to the same heat exposure conditions. In one example of the method 200 of making the colored image, the heat exposure conditions include heating each color stripe 22, 24, 26, 28, color section 32, 34, 36, 38, or portion thereof (or the thermal transfer dye therein) to a temperature ranging from about 70°C to about 300°C for a time period ranging from about 10 μ s to about 200 μ s. In another example, the heat exposure conditions include heating each color stripe 22, 24, 26, 28, color section 32, 34, 36, 38, or portion thereof (or the thermal transfer dye therein) to a temperature ranging from about 70°C to about 200°C for a time period ranging from about 10 μ s to about 200 μ s. In still another example, the heat exposure conditions include heating each color stripe 22, 24, 26, 28, color section 32, 34, 36, 38, or portion thereof (or the thermal transfer dye therein) to a temperature ranging from about 70°C to about 100°C for a time period ranging from about 10 μ s to about 200 μ s. In yet another example, the heat exposure conditions include heating each color stripe 22, 24, 26, 28, color section 32, 34, 36, 38, or portion thereof (or the thermal transfer dye therein) for a time period of about 100 μ s. The method 200 may consume less power than the comparative method that uses a medium with a layer for each color to be formed (i.e., a black-forming layer, a cyan-forming layer, a magenta-forming layer, and a yellow-forming layer), as the comparative method may involve heating at a different temperature for a different time period to form each color.

[0152] In some examples, after making the colored image, the method 200 may include removing the donor ribbon 40 from the image-receiving substrate 12. When the donor ribbon 40 is attached to the image-receiving substrate 12 by

lamination, the donor ribbon 40 may be removed from the image-receiving substrate 12 by peeling the donor ribbon 40 from the image-receiving substrate 12. In an example, the imaging medium 10 may include a perforated tear tab at or near one end or both ends of the medium 10. This perforated tear tab may allow for easy removal of the donor ribbon 40 from the image-receiving substrate 12 after printing/thermal imaging.

[0153] Separating the donor ribbon 40 from the image-receiving substrate 12 reveals the colored image on the surface of the image-receiving substrate 12 that had been in contact with the donor ribbon 40.

[0154] The colored image produced by the method 200 may have better image quality than an image produced by the comparative method that uses a medium with a layer for each color to be formed (i.e., a black-forming layer, a cyan-forming layer, a magenta-forming layer, and a yellow-forming layer) and/or an image produced by the other comparative method that uses a donor ribbon with successive patches of differently-colored or different color-forming material. The image quality may be better due to higher resolution, which may be a result of the size (e.g., width, length, area, etc.) of the color stripes 22, 24, 26, 28 or the color sections 32, 34, 36, 38 and/or the size (e.g., width, length, area, etc.) of the thermal resistors. The image quality may also be better due to reduced cross talk between colors as compared to the amount of cross talk between colors that may occur in the comparative method that uses a medium with a layer for each color to be formed.

[0155] Moreover, as thermal imaging using the imaging medium 10 disclosed herein does not use a donor ribbon that is separate from the image-receiving substrate 12, thermal imaging using the imaging medium 10 may use about 1/4th of the amount of a donor ribbon to produce a colored image than a comparative imaging medium that uses a separate donor ribbon. Additionally, a separate cartridge (for collecting the used separate donor ribbon) is not used. Thus, the imaging medium 10 may produce less waste than media that use a separate donor ribbon.

[0156] To further illustrate the present disclosure, a prophetic example is given herein. It is to be understood that this example is provided for illustrative purposes and is not to be construed as limiting the scope of the present disclosure.

PROPHETIC EXAMPLE

[0157] Examples of the imaging medium can be prepared in accordance with the examples disclosed herein.

[0158] *Image-Receiving Substrates*

[0159] An image-receiving substrate can be selected for the imaging medium. In this prophetic example, two image-receiving substrates (PE1 and PE2) include an ink-receiving layer, one image-receiving substrate (PE3) is a photopaper, and another image-receiving substrate (PE4) is a transparency sheet.

[0160] The ink-receiving layer compositions for PE1 and PE2 are shown in Table 1.

TABLE 1

Component	Specific Component	PE1 Dry parts	PE 2 Dry parts
Inorganic pigment	Precipitated Calcium Carbonate OPACARB® A40 (Specialty Minerals)	50	55
	Modified calcium carbonate OMYAJET® 5010 (Omya Inc.)	20	15
	Calcined clay ANSILEX® 93 (BASF Corp.)	30	30
Plastic Pigment	DPP 756A (Dow Chemical Co.)	5	5
Binder	Styrene acrylic latex ACRONAL® S728 (BASF Corp.)	11	11
	Polyvinyl alcohol MOWIOL® 40-88 (Kuraray Europe)	0.5	0.5
Dispersant and/or Rheology Modifier	Acrylic homopolymer ACUMER® 9300 (Dow Chemical Co.)	0.2	0.2
	acrylic acid/alkyl acrylate copolymer STEROCOLL® FS (BASF Corp.)	0.2	0.2
pH modifier	KOH	0.5	0.5
Surfactant	Surfactant 10G (Dixie Chemical Co.)	0.3	0.3
Defoamer	FOAMMASTER® VF (BASF Corp.)	0.3	0.3
Optical Brightener	TINOPAL® ABP (BASF Corp.)	0.5	0.5

[0161] The ink-receiving layer compositions can be mixed with water to obtain dispersions with 54% solids. Each coating composition can be applied onto an uncoated, lightly calendered paper base made from cellulosic fibers. The coatings can be applied using a blade coater to obtain a coating layer with a coat weight of about 20 gsm. The coated substrates PE1 and PE2 can be dried and then calendered at 2500 psi (pounds per square inch), 54°C, 1 pass.

[0162] The photopaper substrate PE3 can include an ink receiving layer coated on a photobase, which can include a highly sized cellulosic paper extruded with a

polyethylene coating on both sides. The ink-receiving layer composition for PE3 is shown in Table 2.

TABLE 2

Component	Specific Component	Wt % of Total Composition*
Inorganic pigment	Silica Dispersion	78.1
Binder	Polyvinyl Alcohol (Mowiol 40-88)	16.8
Co-solvent	Thio diethylene glycol	1.9
Binder Crosslinker	Boric acid	3.0
Surfactant	Surfactant 10G	35mg/100g of coating mixture
	Water	Balance

*unless presented otherwise

[0163] This ink-receiving layer composition can be applied to the standard resin-coated photobase (a highly sized cellulosic paper extruded with a polyethylene coating on both sides) using a Meyer rod coater to 27 gsm coat weight.

[0164] The transparency sheet image-receiving substrate (PE4) can be prepared as follows: 180 grams of methanol can be heated to near boiling and 20 grams of poly(methylvinylether/maleic anhydride) can be slowly added with continuous stirring. After 3 to 4 hours the milky, opaque solution can turn clear. The clear solution can be coated onto a 100 micrometer thick polyester sheet (which can be primed with polyvinylidene chloride) to a wet thickness of about 75 micrometers on a knife coater. The coated sheet can then be dried in an 80°C oven for about 2 to 3 minutes to remove the solvent.

[0165] *Donor Ribbon*

[0166] The donor ribbon for the imaging medium can include the donor ribbon substrate, the release layer, and the color layer. The donor ribbon substrate can be a polyethylene terephthalate (PET) film, and the release layer can be a polyethylene wax deposited on the PET film.

[0167] The color layer can include the repeated pattern of four-adjacent color stripes. A black ink, a magenta ink, a cyan ink, and a yellow ink can be inkjet printed on the release layer in the four-adjacent color stripe pattern disclosed herein to form the color layer.

[0168] For each of the inks a thermal transfer dye is combined with a solvent mixture and a decap control agent to form the respective inks.

[0169] Magenta ink: Red solvent dye (C. I. Solvent Red 23) is combined with a solvent mixture and a decap control agent to form the magenta ink. The solvent mixture may include acetone and/or ethanol. The decap control agent may be a modified perfluoropolyether (such as FLUOROLINK® A10, a dialkyl amide perfluoropolyether derivative with the chemical structure $\text{CH}_3(\text{CH}_2)_{17}\text{HNOCCF}_2\text{O}(\text{CF}_2\text{CF}_2\text{O})_p(\text{CF}_2\text{O})_q\text{CF}_2\text{CONH}(\text{CH}_2)_{17}\text{CH}_3$ available from Solvay-Solexis). Table 3 illustrates examples of the magenta ink formulation.

TABLE 3

Component	Specific Component	Wt%
Thermal transfer dye	Solvent dye*	3-7.5
Decap control agent	FLUOROLINK® A10 Solvay-Solexis	0.1-1
Solvent mixture	Acetone	1-80
	Ethanol	Balance

*Selected based on color that is to be formed

[0170] Black ink: A black ink can be prepared the same way as the magenta ink, except that black solvent dye (C. I. Solvent Black 3) is used as the black thermal transfer dye. The black solvent dye can be combined with a solvent mixture and a decap control agent to produce a formulation similar to that shown in Table 3 (with the black solvent dye replacing the magenta solvent dye).

[0171] Yellow ink: A yellow ink can be prepared the same way as the magenta ink, except that yellow solvent dye (C. I. Solvent Yellow 56) is used as the yellow thermal transfer dye. The yellow solvent dye can be combined with a solvent mixture and a decap control agent to produce a formulation similar to that shown in Table 3 (with the yellow solvent dye replacing the magenta solvent dye).

[0172] Cyan ink: A cyan ink can be prepared the same way as the magenta ink, except that blue solvent dye (C. I. Solvent Blue 35) is used as the blue thermal transfer dye. The blue solvent dye can be combined with a solvent mixture and a decap control agent to produce a formulation similar to that shown in Table 3 (with the blue solvent dye replacing the magenta solvent dye).

[0173] As mentioned herein, each of the black ink, the magenta ink, the cyan ink, and the yellow ink can be inkjet printed on the release layer of the donor ribbon in the four-adjacent color stripe pattern disclosed herein to form the color layer. In this prophetic example, each color stripe has a width of $1/300^{\text{th}}$ of an inch.

[0174] *Imaging Medium*

[0175] The color layer of the donor ribbon and the image-receiving side of the selected image-receiving substrate can be placed into contact. A pressure sensitive adhesive may be applied to the edge between the donor ribbon and the image-receiving substrate to form the imaging medium.

[0176] It is to be understood that the ranges provided herein include the stated range and any value or sub-range within the stated range, as if the value(s) or sub-range(s) within the stated range were explicitly recited. For example, from about 70°C to about 300°C should be interpreted to include not only the explicitly recited limits of from about 70°C to about 300°C, but also to include individual values, such as about 75°C, about 92.1°C, about 119.25°C, about 160.85°C, about 190.5°C, about 250°C, about 287°C, etc., and sub-ranges, such as from about 70°C to about 225°C, from about 83.5°C to about 123.35°C, from about 110.15°C to about 190.5°C, from about 75°C to about 280.5°C, etc. Furthermore, when “about” is

utilized to describe a value, this is meant to encompass minor variations (up to +/- 10%) from the stated value.

[0177] Reference throughout the specification to “one example”, “another example”, “an example”, and so forth, means that a particular element (e.g., feature, structure, and/or characteristic) described in connection with the example is included in at least one example described herein, and may or may not be present in other examples. In addition, it is to be understood that the described elements for any example may be combined in any suitable manner in the various examples unless the context clearly dictates otherwise.

[0178] In describing and claiming the examples disclosed herein, the singular forms “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise.

[0179] While several examples have been described in detail, it is to be understood that the disclosed examples may be modified. Therefore, the foregoing description is to be considered non-limiting.

What is claimed is:

1. An imaging medium, comprising:
an image-receiving substrate; and
a donor ribbon attached to the image-receiving substrate, the donor ribbon

5 including:

a donor ribbon substrate;

a release layer disposed on the donor ribbon substrate; and

a color layer disposed on the release layer, the color layer including a
repeated pattern, a repeat of the pattern including:

10 at least three adjacent color stripes including a cyan stripe, a
magenta stripe, and a yellow stripe; or

a grid of four color sections including i) a colored section
selected from the group consisting of black, cyan, light cyan, yellow,
magenta, and light magenta, ii) a cyan section, iii) a magenta section,
15 and iv) a yellow section; and

a registration mark;

wherein the color layer is in contact with the image-receiving substrate.

2. The imaging medium as defined in claim 1 wherein:

20 the repeat of the pattern includes the at least three color stripes;
the at least three color stripes includes four adjacent color stripes;
a fourth of the four adjacent color stripes is a black stripe; and
each color stripe has a width of $1/300^{\text{th}}$ of an inch or smaller.

25 3. The imaging medium as defined in claim 1 wherein the repeat of the
pattern includes the grid, and each color section has an area of $1/300^{\text{th}}$ of an inch
by $1/300^{\text{th}}$ of an inch or smaller.

4. The imaging medium as defined in claim 1 wherein:

the at least three adjacent color stripes includes the cyan stripe, the magenta stripe, the yellow stripe, and a black stripe, or the grid of four color sections includes a black colored section, the cyan section, the magenta section,
5 and the yellow section;

the color layer includes a black thermal transfer dye, a cyan thermal transfer dye, a magenta thermal transfer dye, and a yellow thermal transfer dye; and

each of the black thermal transfer dye, the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye is transferable
10 under the same heat exposure conditions.

5. The imaging medium as defined in claim 4 wherein the heat exposure conditions include heating to a temperature ranging from about 70°C to about 300°C for a time period ranging from about 10 μ s to about 200 μ s.

15

6. The imaging medium as defined in claim 1 wherein the grid includes the four color sections in a 2 by 2 array.

7. The imaging medium as defined in claim 6 wherein the repeat of the pattern includes four grids arranged in a square pattern.
20

8. The imaging medium as defined in claim 1 wherein:

the at least three adjacent color stripes includes the cyan stripe, the magenta stripe, the yellow stripe, and a black stripe, or the grid of four color sections includes a black colored section, the cyan section, the magenta section,
25 and the yellow section;

the color layer includes a black thermal transfer dye, a cyan thermal transfer dye, a magenta thermal transfer dye, and a yellow thermal transfer dye; and

each of the black thermal transfer dye, the cyan thermal transfer dye, the magenta thermal transfer dye, and the yellow thermal transfer dye is a sublimable dye.

- 5 9. The imaging medium as defined in claim 1 wherein:
the donor ribbon further includes a clear and colorless topcoat disposed on the release layer; and
the color layer is disposed on the clear and colorless topcoat.

- 10 10. The imaging medium as defined in claim 1 wherein the donor ribbon further includes a back coat disposed on a back side of the donor ribbon substrate.

11. A method of making an imaging medium, comprising:
forming a donor ribbon by:

- 15 applying at least a cyan ink, a magenta ink, and a yellow ink on a release layer of a donor ribbon substrate to form a color layer including a repeated pattern, a repeat of the pattern including:

at least three adjacent color stripes including a cyan stripe, a magenta stripe, and a yellow stripe; or

- 20 a grid of four color sections including i) a colored section selected from the group consisting of black, cyan, light cyan, yellow, magenta, and light magenta, ii) a cyan section, iii) a magenta section, and iv) a yellow section;

- attaching the donor ribbon to an image-receiving substrate so that the color
25 layer is in contact with the image-receiving substrate; and

applying a registration mark on a component of the donor ribbon or the image-receiving substrate.

12. The method as defined in claim 11 wherein the applying of the at least the cyan ink, the magenta ink, and the yellow ink is accomplished with offset printing, inkjet printing, or flexographic printing.

5 13. The method as defined in claim 11 wherein:

the at least three adjacent color stripes further include a black stripe and the method further comprises applying a black ink in addition to the cyan ink, the magenta ink, and the yellow ink; or

10 the colored section of the grid is selected from the group consisting of black, light cyan, and light magenta, and the method further comprises applying a black ink, a light cyan ink or a light magenta ink in addition to the cyan ink, the magenta ink, and the yellow ink.

14. A method of making a colored image, comprising:
15 selectively exposing an imaging medium to heat;
wherein the imaging medium includes:

an image-receiving substrate; and

a donor ribbon attached to the image-receiving substrate, the donor ribbon including:

20 a donor ribbon substrate;

a release layer disposed on the donor ribbon substrate; and

a color layer disposed on the release layer, the color layer including at least a cyan thermal transfer dye, a magenta thermal transfer dye, and a yellow thermal transfer dye in a repeated pattern,
25 a repeat of the pattern including:

at least three adjacent color stripes including a cyan stripe, a magenta stripe, and a yellow stripe; or

a grid of four color sections including i) a colored section selected from the group consisting of black, cyan, light

cyan, yellow, magenta, and light magenta, ii) a cyan section, iii) a magenta section, and iv) a yellow section; and a registration mark;

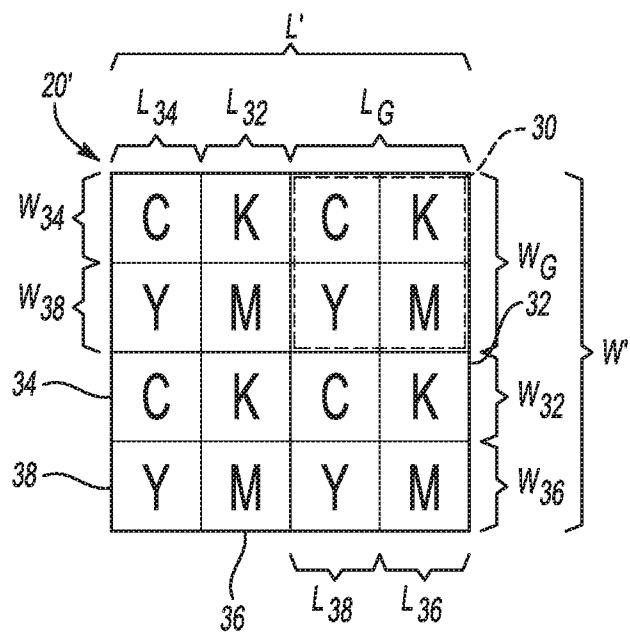
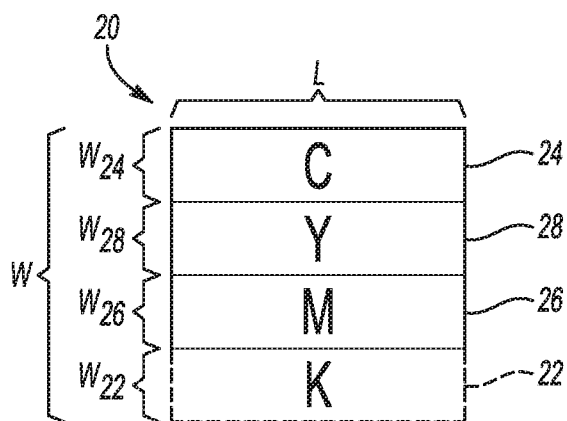
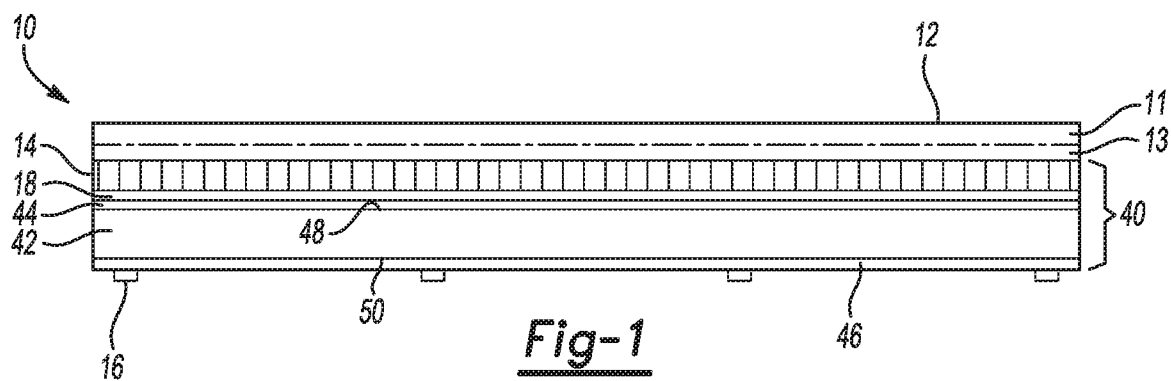
wherein the color layer is in contact with the image-receiving

5 substrate; and

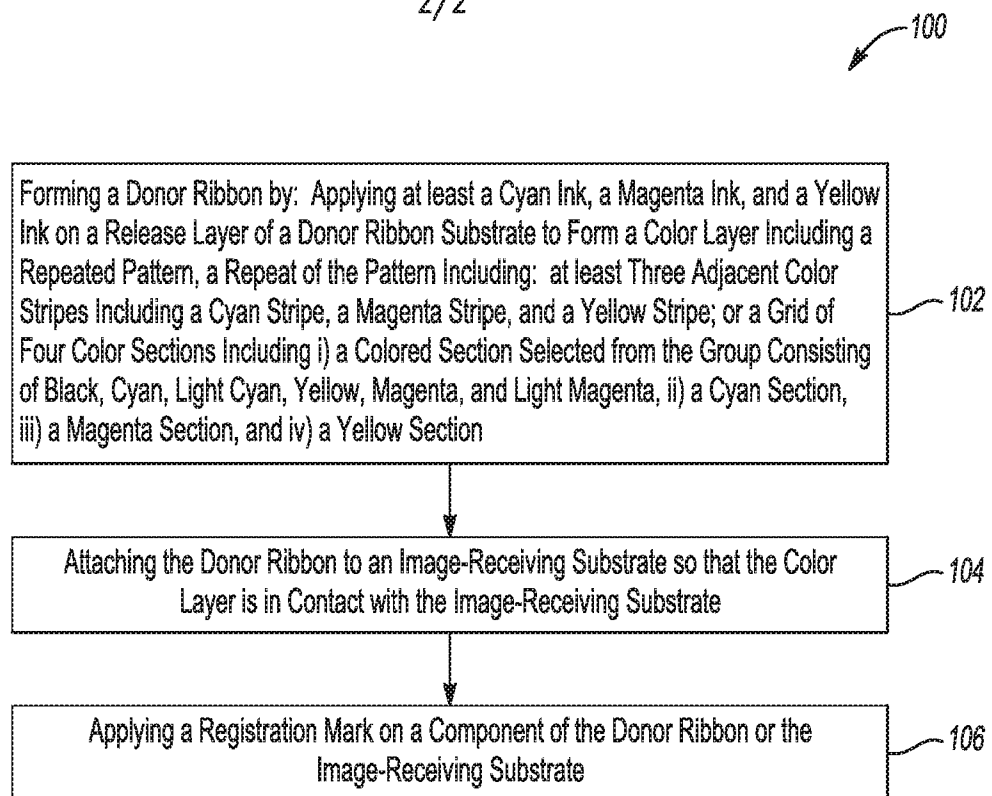
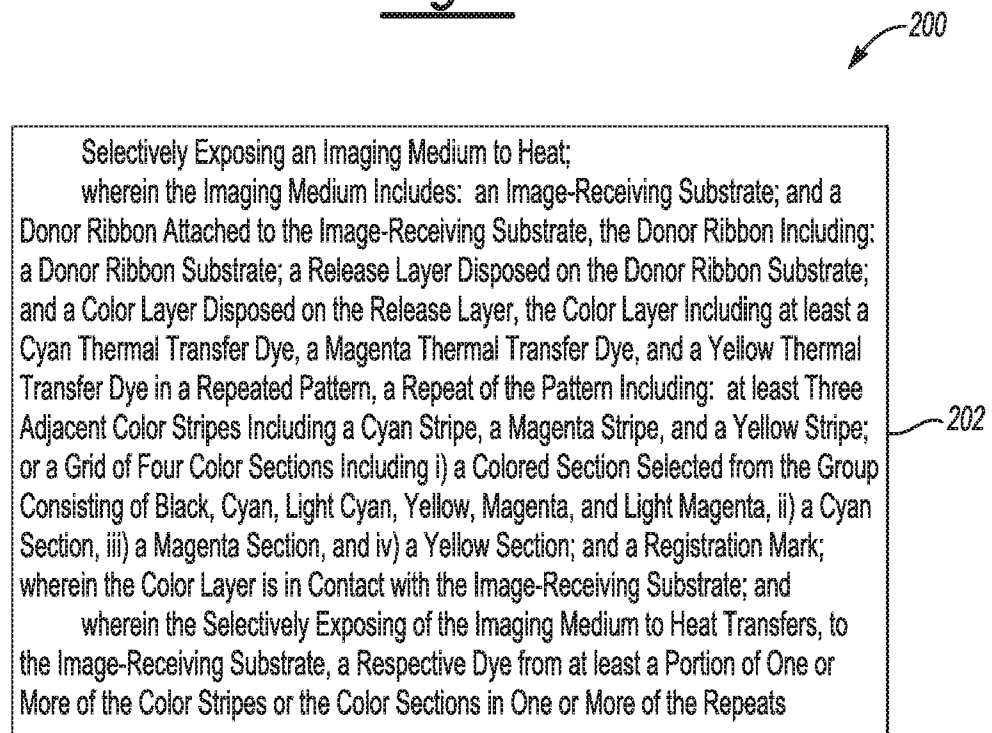
wherein the selectively exposing of the imaging medium to heat transfers, to the image-receiving substrate, a respective dye from at least a portion of one or more of the color stripes or the color sections in one or more of the repeats.

10 15. The method as defined in claim 14, further comprising aligning a thermal resistor of a thermal printhead at a location adjacent to a back side of the donor ribbon, where the location is aligned with the at least the portion of one or more of the color stripes or the color sections, and wherein the selectively exposing of the imaging medium to heat is accomplished with the thermal resistor.

1/2



2/2

Fig-3Fig-4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/027623

A. CLASSIFICATION OF SUBJECT MATTER		
<i>B41M 5/50 (2006.01)</i> <i>B41J 2/325 (2006.01)</i> <i>B41J 2/345 (2006.01)</i> <i>B41J 2/525 (2006.01)</i> According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
B41M, B41J		
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)		
PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5486857 A (MINNESOTA MINING AND MANUFACTURING COMPANY) 23.01.1996	1-15
A	US 5143904 A (OJI PAPER CO., LTD) 01.09.1992	1-15
A	US 5175139 A (DAI NIPPON INSATSU KABUSHIKI KAISHA) 29.12.1992	1-15
A	US 2009/0027472 A1 (RICON COMPANY, LTD.) 29.01.2009	1-15
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents:	"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	
"A" document defining the general state of the art which is not considered to be of particular relevance		
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"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search	Date of mailing of the international search report	
30 January 2019 (30.01.2019)	07 February 2019 (07.02.2019)	
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer S. Zhuravlev Telephone No. 8 499 240 25 91	