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(54) **MASK FOR DIGITAL OPERATION AND PRINTING, AND METHODS FOR OPERATION AND PRINTING ON A SUBSTRATE USING SAID MASK**

MASKE FÜR DIGITALEN BETRIEB UND DIGITALES DRUCKEN SOWIE VERFAHREN ZUM BETRIEB UND DRUCKEN AUF EINEM SUBSTRAT MIT DIESER MASKE

MASQUE POUR IMPRESSION ET OPÉRATION NUMÉRIQUES, ET PROCÉDÉS DE FONCTIONNEMENT ET D'IMPRESSION SUR UN SUSTRAT À PARTIR DUDIT MASQUE

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EP 3 124 244 B1

Description

TECHNICAL FIELD

[0001] The current invention relates to a mask for digital printing that represents a new concept of printing system that enables digital printing for materials not compatible with current (digital printing) systems, by using a reconfigurable mask as a digital interface. The use of a reconfigurable mask allows the digitalization of other analog processes, based on a fixed mask.

[0002] It allows in-line printing and thus its compatibility with other printing systems, bringing additional functionality to the printing line. Furthermore, the same printing concept is versatile with regard to physical and mechanical properties of the materials to be printed, being compatible with a wide range of materials.

[0003] It also relates to a method employing this mask that allows digital printing of solids and viscous materials without altering its composition, and enables 'thick' prints with high material transfer compared to traditional systems. This is particularly important in printing applications employing functional inks, as in the case of printed electronics and the use of digital printing in additive manufacturing processes (also called 3D printing), among others.

[0004] It also enables digital processes based on a pattern, such as the creation of digital embossed reliefs or patterns for thermal welding processes or transfer Printing among others.

[0005] It also allows the digitalization of other handling processes such as the digital holding by suction, applicable in processes to capture elements using a pattern, or for the separation of digitally cut materials such as dies, vinyl, etc ... among others.

STATE OF THE ART

[0006] The use of masks in analog printing systems is known, comprising:

- a porous structural mesh
- a blocking material

[0007] This is the case of screen printing , wherein a blocking material is adhered to a printing mesh , or in other cases where a pattern is disposed above a screen printing (eg, powder sifting through a stencil) .

[0008] However, there are not known embodiments comprising of :

- a porous structural layer;
- a cover layer;
- a masking material disposed between the structural layer and the covering layer

Known techniques and their disadvantages

[0009] A brief description of the most common systems and printing technologies and their limitations and drawbacks is provided. Similarly, a brief review is given to various commercial printing applications and some of their limitations are indicated.

Systems and printing technologies

[0010] Printing systems can be grouped in two main categories or families: those systems using a fixed pattern (master), analog, and those systems where the printing is digital, based on digitalized information.

<u>Analog systems</u>

[0011] Different analog printing systems have been developed throughout history to answer the needs in productivity, image quality, printing costs, compatibility with certain types of inks and/or substrates, etc...

[0012] Some of the most used technologies (analog, using a 'master' or pattern):

- Gravure-Flexography (information is defined according to a pattern of holes or reliefs)
- Offset-Lithography (information is defined according to different properties in a surface (for example surface tension, defining hydrophilic (or oleophylic) areas and hydrophobic (or oleophobic)).
- Screen printing (information is defined by means of openings in a mesh or screen).

[0013] One of the inherent **limitations** of an analog printing system is that these are designed for long printing runs, where many identical copies are to be printed, all of them based on a fixed print pattern. Although the pattern can be changed between print jobs, both the creation of the pattern and the install of the pattern in the printer are time consuming and relatively expensive and therefore the printing of unique -single- copies or very short runs are not economically viable neither time efficient.

[0014] However, and precisely, one of the advantages of the analog printing systems is the low unitary print costs due to the high productivity of the system. Similarly, due to its operational principles, they are compatible with a wide range of 'inks', with varying properties and viscosities.

<u>Digital systems</u>

[0015] On the other hand, digital printing allows printing without the need for a master because the image (ink) is transferred directly based on digital information, which may be different between prints. This was a revolution since it enabled short run printing and single prints (one offs). Today we see how these systems have been gaining popularity and start to be an economically viable alternative to print increasingly longer series and even big productions as well.

[0016] To simplify, taking a quick overview to digital printing technologies, it can be observed that there are two dominant solutions or technological families: inkjet printing and electrophotographic (or xerographic) printing (among other).

[0017] Inkjet printing consists in 'firing' or 'jetting' (hence the name of 'jet') small drops of ink through tiny openings in the so called print head. In turn, different technologies allow the jetting of drops, either in a discrete or continuous manner. The most common technologies are the piezoelectric and the thermal inkjet.

[0018] One of the **limitations** of these systems is ink viscosity (among other) making these to be of relatively low viscosity (<20-50cP). This limits the amount of solids that can be dispersed in the ink fluid and implies that a large portion of the ink has to be absorbed by the substrate or eliminated (water in the case of water-based inks or solvents, in general) since its primary function is to transport the pigments (or colorant (dyes) or the object of interest of the ink in question -for example, in the case of functional inks, metals (based on nanometric or micrometric particles), resins, ceramics, etc...-).

[0019] On the other hand, the electrophotographic printing technology (or xerographic, 'laser' printing) consists in the transfer of electrostatically charged powder onto a photoconductive surface in which an electrostatic image (latent image) has been created previously. Once the powder has been adhered to the photoconductive surface it is transferred, also by means of electrostatic attraction, onto the surface to be printed. Afterwards, by means of a thermal process (and mechanical, pressing it), the powder is melted and gets fixed on the surface to be printed (paper, for example). This type of printing is commonly called 'laser' since typically the electrostatic image is created by illuminating the photoconductive surface with a laser, locally changing (removing) its charge. More recently , the same effect can be achieved with systems based on a LED array.

[0020] One of the limitations of the xerographic printing is that the powder material (toner) needs to be charged electrostatically and therefore these materials need to be specifically designed for this type of printing systems.

[0021] In summary, digital printing has many advantages in terms of printing versatility but imposes a limitation to the materials that can be used, that need to be compatible with these technologies.

[0022] On the other hand, analog printing has some advantages in terms of the range of materials to use but they are inherently static systems that do not allow to print variable content in different copies (digital).

Valves and extruders

[0023] There is a particular printing system type worth mentioning due to its versatility with regards to the type of materials to be used for printing: those based on the extrusion or point depositing. There exist 'digital' systems in which a print head is moved by mechanical means and deposits material along its path. This type of printing, for example a mechanical extruder (either syringe-based, or fed by a filament or blown and melt), can print with solid or viscous materials but it needs to do a 'xy' sweep to move the printing head to cover an area, so the system becomes slow and difficult to integrate into online printing processes.

[0024] There are other known systems capable of dispensing viscous materials by means of the 'digital' aperture of valves or actuators. One of the limitations of these actuator-based systems is the difficulty to pack many actuators in a limited space and the cost of the system in general, function of the number of actuators, among other.

Commercial printing applications

[0025] In terms of commercial printing applications, there is a wide range of existing applications. Most of them, and for historical reasons, are based in the conventional printing of text and images and they represent the bulk of the printing industry (books, newspapers, packaging, signage, graphic arts, etc...). For these type of applications the existing technologies are the most suited and have evolved to satisfy the needs of the industry in terms of costs, productivity, image quality, inks and substrates, etc. In these type of applications, the inks used are more or less conventional and the aim of the print is mainly visual. The amount of ink transferred, both in mass and printed layer thickness is reduced (limited) for these type of applications.

[0026] On the other hand there are other printing applications, more recent, where the aim of the print is not so much visual but functional, where an important mass transfer is wanted and the ideal type of print materials are solid or highly viscous (pasty).

[0027] This is the case of applications such as printed electronics or additive manufacturing (3D printing), where the materials to be printed are metals, plastics, ceramics, resins, semiconductors, dielectrics, and functional materials in general, including bio-materials for instance.

[0028] For this type of applications, and for historical reasons and technological availability, typically liquid inks are used (using inkjet), where solids are loaded in the ink composition, or specific toners are created (to be used in electrophotography) or they use point-based deposition heads.

[0029] All these solutions imply **tradeoffs or compromises** of some kind, either in the amount of solids loaded in the ink (and the management of the solvents in the ink), the creation of a specific toner (whenever feasible) or the hit in printing speed, among other (like the thickness of the printed layer).

Let’s review briefly some of these applications

2D applications case

[0030] As it has been indicated, printed electronics is one of the markets where printing with solids r dense materials is wanted. The dominant technology is inkjet, which means that it is required to manage large volumes of solvents and vehicle in the ink that are irrelevant to the application. Typically, an ink of this type cannot carry more that 40-60% of solids in its composition, so there’s a 60-40% of residue to be managed.

[0031] As example, there are other markets where the printing of solids or dense materials can be of interest. In textile printing, screen printing allows to print with inks and viscous materials. However these processes are analog. Be able to digitalize screen printing processes would bring new competitive advantages to the textile printing sector. Another example is food printing. Currently digital printing systems are based on point-based extrusion printing heads. Once again, being able to print effectively in a line-based configuration, with solid or viscous materials would bring new opportunities to the sector.

3D applications case

[0032] Additive manufacturing, also called 3D printing, briefly, consists in the creation of three dimensional bodies from a virtual design (CAD model). There are several methods and technologies for the creation of these bodies but most of them rely on a common principle: the incremental construction of the 3D body by means of the creation and superposition of layers.

[0033] Simplifying. there are three main families of solutions for 3D printing: point-based deposition printing heads, inkjet printing heads, and systems based on selective consolidation of a material (either chemical consolidation, photo-chemical or thermal).

[0034] In the first two, the material is brought and deposited where it is needed and, either during the transfer or after the transfer is done, the material gets consolidated and gets united to the part already constructed. In the case of selective consolidation, consolidation happens at certain locations in a bed of material. During consolidation, the material gets united to the portion of the part already built in contact with the layer being consolidated, and a new layer of material is deposited on top of it which will be consolidated afterwards in the next iteration.

[0035] In the case of a point-based deposition print head (or several), as mentioned earlier, the main limitation is around the printing speed and the difficulty to integrate those systems in a continuous printing line or setup.

[0036] In the case of inkjet print heads, analogous to the case of 2d applications, there is a limitation on the type of materials to be used, the amount of solid load in the ink and the management of unwanted volatiles.

[0037] In the case of selective consolidation systems, the limitation is, besides speed limitations depending the technology used, in that only one type of material is used for the whole construction of the 3D body. The remaining material (not consolidated) will be reused, with some limitations, in following prints. The fact of printing with a single material also implies that in those geometries requiring the printing of auxiliary support structures for its construction, these structures will be created with the same material as the main part, so they will remain attached to the main 3d body and will required manual extraction afterwards. Besides the main limitation of the single material printing, it also limits the application of other local treatments, like the addition of color, due to the risk of contamination of the material not used, which would make its reusability harder and/or increase the costs of producing the 3D body (due to the waste of the non-reusable -contaminated- material).

[0038] In some cases, the printing of a 3D body requires a post processing of the printed part for it to acquire its final properties. This is the case, for instance, of ceramic parts that require firing, since after printing they have a minimum consistency (green strength) but not final. In these cases, a manual process is required to surround the ceramic part with support material prior to its firing. Since the printing is done using a single type of material, the surrounding material had to be added in a post process step (ideally, it would be preferred to print both the ceramic part and the surrounding material at once).

Other applications and operations based on a fixed master

[0039] There exist numerous applications and processes based on a fixed pattern. As example, engraving and stamp printing applications, thermal processes like welding, sealing or transfer printing. All of them, and in general all those based in a fixed pattern, are subject to the limitations of the fixed pattern printing, and the cost of replacing the pattern both in economic terms and in time.

[0040] Engraving and stamp printing. A pattern is used to create a relief in a material (for instance in the hard-cover of a book, business cards with relief, folding marks for packaging carton, ...).

[0041] Thermal processes, welding, sealing and transfer. A pattern is used, heated, to melt a material and do a sealing, create an union or a welding. Also, by means or combined with pressure transfer and adhere material onto a surface (as in the case of foil thermal printing).

[0042] There are other operations known, such as manipulation and handling, by means of a pattern. In certain industrial processes it is convenient to ’handle’ selectively (by suction) discrete elements to transport them to a later manufacturing operation station. In these cases, it is known the use of templates or stencils as a selection pattern. Other processes of selective ’picking’ can be achieved by using a series of suction elements (valve-based actuated) arranged in a matrix/grid configuration. In this case the operation can be digital but these are typically bulky systems that do not allow for high resolution integration and packing of its elements.

[0043] The documents US 2014060351 A1, EP 1491331 A2, EP 1811331 A2, US 2007167326 A1, CN 102619114 A and WO 2007026541 A1 disclose methods for digital printing that use masks or patterns.

[0044] Wikipedia "Siebdruck", in the version of 28 December 2013, discloses the principles of screen printing.

[0045] US 2012/034379 A1 (Wang Chung-Pei) discloses a coating method including providing a workpiece having a flat surface which includes a coating region and a pattern region. A tape mask having a through hole, whose shape and size conforms to the pattern region, is attached onto the flat surface of workpiece to cover the coating region, thus exposing the pattern region. A screen printing stencil is placed on the tape mask. Ink is spread over the screen printing stencil printing stencil, and squeezed into the through hole over the pattern region. The ink is solidified. The tape mask is removed from the workpiece. A metallic coating is formed on the coating region of the flat surface and the solidified ink on the pattern region is removed. JP2009051062A and EP0588399A1 are also examples of the relevant background art.

DESCRIPTION OF THE INVENTION

Reconfigurable mask

[0046] For that purpose, the present invention proposes a mask for digital operation and printing, comprising the following layers:

- A porous structural layer of support
- A cover layer
- A mask material placed in between the structural and cover layers;

characterized in that the mask material can be located relatively between the structural and cover layers in a way that constitutes a reconfigurable mask for printing.

Mask assembly

[0047] As indicated, the group configuring the mask is composed by a support substrate on which a material is placed in a way that covers certain locations in the substrate. On top (or next to it, adjacent) of this material, that will determine the geometry of the printing mask, another layer -coverage- is placed, completing the group.

[0048] Thus, we can consider the creation of a digital mask to be used in a printing process or digital operation as a sandwich (or layered structure, consisting of at least three layers) made of a support substrate, an intermediate material, and a cover layer completing the group (the order used in the construction of the sandwich and where -of the two boundary elements- is the intermediate material placed onto, is irrelevant).

Discrete or continuous mask

[0049] The sandwich mask can be created in a discrete or continuous way. In the discrete case one can think of a monolithic block where a frame of support material is opposite to another frame of cover material with intermediate mask material laying between the two. In the continuous case it can be considered that both the support substrate and the cover layer are continuous and that an effective layer is actually created in a concrete area to be used for printing, where the intermediate mask material gets confined. Also, and obviously, hybrid configurations can be envisioned in which the substrate or cover layers are continuous being the other discrete. Similarly, they can have different sizes and hence, as in the continuous case, there will be an area where the sandwich is effective and useful for printing (or for digital operation).

Support layer

[0050] The support layer will preferably be constituted by a porous material. This includes from open structures as meshes, fabrics, screens, sieve, a perforated surface, etc to surfaces and porous materials as filters, felts, membranes, papers, foams, where the size of the pores is generally smaller. In this document one refers to mesh, screen or porous material, indistinctly, considering any kind of structure permitting, even with resistance, the flow of a substance through it, independently whether the substance is in gas form, liquid, fluid or solid.

Mask material

[0051] On the other hand, the material used to create the image mask in the group configuring the printing mask, can be of diverse nature. Different cases are considered, where the mask material is made of solid particles, regardless of their size, like material in powder form, in grains, discrete particles, small spheres, etc. Also, cases where the material placed within the sandwich cases constitutes a solid profile (or several solid areas), and where the image mask is obtained by means of these profiles or preconfigured areas. One can think of pre-cut paper profiles, carton, stencils, vinyl, films, labels, sheet metal, etc. Also, the image can be made out of consolidable materials (for instance, phase-change, thermoplastic polymers, thermosets) that have reached a consolidation level (solidity) that when they are used in the mask (in the printing process). Also could viscous materials -non solid- be used, or liquids, if they permit the printing process afterwards. In general, any sort of elements that allows the creation of an impedance map (blocking image) that permits the printing process or operation.

Cover layer

[0052] Regarding the cover material, it can be either a porous material (or open), considering the same variations as in the definition of the support layer, or it can be a material that does not allow (significantly) the printing material to pass through it. In this second case we will refer to it as a film impermeable to the printing material.

Additional blocking layer (optional)

[0053] The mask can be complemented by an additional blocking layer, porous, preferably placed externally to either the structural layer or the cover layer.

Printing process

[0054] The invention also refers to a procedure for printing onto a substrate by using a reconfigurable mask according to what has been described, comprising the following steps:

- relatively place the mask material in the screen using some positioning means;
- print onto the substrate with a printing material by using the mask;
- (remove the mask material from the printing mask)
- reposition again mask material onto the screen using the positioning means;
- do a new printing

[0055] Or, in other words:
Material is placed relatively onto the screen or support substrate in a way that it constitutes a pattern or image. Afterwards a cover layer is added on top, creating the mask group (or sandwich). (The same process, creating the mask group, as mentioned, can also be done in a continuous way: material is being added on the substrate and this is then closed by the cover layer).

[0056] Either in discrete or continuous mode, the mask is then used to print with a printing material onto a substrate placed in a way that the printing can happen.

[0057] Once the printing is done, mask material is placed again to create a new printing mask, that in turn, when the sandwich mask is ready, will be used to print with a printing material as described in the previous step.

Positioning means for the mask material

[0058] The most relevant point in the creation of this mask is that the mask material is placed relatively between the layers conforming the printing mask. This step can be done by means of digital printing devices like 'inkjet', for instance, (when the mask material is liquid - that can or cannot be consolidated before using the mask assembly), by means of electrophotography (or 'laser' printing), where a toner is transferred to the substrate support, or by means of other digital printing or handling and positioning processes or devices (for instance by thermography, by point-based deposition, by micro-actuators, micro-valves, etc...), that allow the creation of a pattern made of mask material on the support substrate according to a desired pattern, or printing processes in general, consisting in one or more steps.

[0059] In particular it is also considered the use of a printing system based on a reconfigurable mask, as the one described in this invention, to 'print' mask material, constituting a chained configuration or 'cascading'.

Geometric confinement layers (optional)

[0060] Depending on the material conforming the mask, the material to be printed or the printing mode, another layer can be added next to the mask material, in a way that the mask material is partially or completely confined in it, and/or another layer can be added similarly next to the material to be printed, again, in a way that the material is partially or completely confined in it. These additional layers, the geometric confinement layers, help contain the material and control their spatial and geometric distribution.

Printing modes

[0061] Once the group is assembled as a mask, it can be used in different printing principles or modes. It can be used to work as an attraction mask, a blowing mask, a pass-through mask or a relief mask for printing. Depending on the configuration, the printed image will either be the positive or the negative of the mask (print the same image in the mask or its opposite). These different options to use the mask are detailed in the description of preferred embodiments. However, they can be briefly summarized as follows.

[0062] In the case of an attraction mask, the mask will be used to create a map of differential impedance to the pass of a fluid through it and hence a map of differential attraction (by means of suction, vacuum) can be created, which, in turn, will be used to adhere printing material to the mask group, from where it will be later transferred onto a substrate or to another place. Also, in its complementary mode, it can be used to 'remove' (by means of suction) certain parts of the print material placed on a given substrate.

[0063] In this case, both the cover layer and the structural mesh have pore sizes (or opening sizes) that can retain the elements or substances conforming the mask material and the structural mesh (or optionally the blocking layer) has, in addition, pore size (or opening size) such that it prevents the printing material from passing through it. This permits that, when suction is applied through the mask, the printing material gets blocked in the structural face (or blocking layer) of the mask and at the same time, the mask material remains confined between the two faces of the mask.

[0064] The attraction mask can also be used in processes of selective handling or picking, where the objective is to select or grab certain parts of a pre-cut material (or a material that can be separated by discrete elements). Similarly it is also possible to use complementary masks on the two sides of the material to ease or improve the separation or the attraction of its elements.

[0065] In the case of the blowing mask, the procedure is analogue to the previous case (attraction), using the very same considerations in the creation of the mask but, instead of attracting, it repels (by means of blowing through the mask) certain areas of the printing material in contact with the mask, that will determine the positive or the negative of the print, depending on the configuration chosen.

[0066] In the case of a configuration type pass-through mask, the process has shares many similarities with the screen printing process, where the print material is forced to pass through a mask through the openings (or areas of low relative impedance in the mask) and gets transferred onto a substrate placed on the other side of the mask. In this case, hence, both the structural mesh and the cover layer will have 'mesh' sizes (or openings) that allow the printing material to pass through it but that contain the mask material inside the mask assembly (the material mask cannot pass through neither the structural nor the cover layers).

[0067] Lastly, in the case of a relief mask, the mask will conform a relief to be used as a printing pattern, again sharing operation principles with existing analog printing processes like flexography or gravure, since the print material is transferred to a substrate after it is placed in the reliefs or hollows of the mask.

Consolidation of the printed material

[0068] It's worth mentioning that, analogous to the conventional printing and transfer systems, it is common to consolidate the printing material once it has been transferred to a substrate, being it intermediate of final, with the aim of fixing the material of conferring additional properties. This consolidation, generically speaking, can be achieved by thermic means, mechanic, chemical, or a combination of them (or by other physical properties). For instance, the printed material can be melted, dried, ironed, photo-cured, etc..). In those applications where the printing is to be used as part of a 3D layered printing process, or additive manufacturing, this consolidation may be part of the process of building the 3D body, being this consolidation zero (non-existing), partial or complete when the layer is transferred to the final part under construction.

Advantages of the invention

[0069] The advantages of this invention, or what is the same, the creation of a mask according to the described assembly, is that it allows to create a reconfigurable mask to be used in printing processes (or operation processes) that either do not exist (new processes) or to be used in processes that use a mask or pattern that is now fixed (not digitally reconfigurable between prints). It (the use of reconfigurable masks) generalizes the use of masks and patterns (or masters) in digital printing (and operation) processes, now not possible.

[0070] Also, by means of the different printing modes, it enables new approximations to digital printing for solid and pasty or viscous materials, which, depending on their characteristics will be printed by one or more of these modes, widening even more the range of options for their printing in a digital way and overcoming the limitations of the existing digital printing technologies.

Printing by transfer, embeddable and multi-material

[0071] A printing system such as the one described, independently of the printing mode approach used, can be complemented with other printing systems, equal or different, in a way that the print done in one system can be complemented with another printing process afterwards, or viceversa, and so on. Similarly as how a conventional printing system concatenates printing steps using different colored inks (for instance, typically, yellow, cyan, magenta and black), different printing steps using different materials can be concatenated as well, either by transfer on the same transport substrate or onto the final substrate, in a consecutive way. This allows compatibility with other printing systems and enables multi-material printing.

Summary of advantages

[0072] Thus we see that the use of a mask for digital printing as described herein, allows, among others:

- Generate a printing pattern digitally and with it, provide digital versatility to conventional printing processes based on a fixed pattern (conventional analog printing systems).
- Enable new digital printing methods for materials not printable digitally with the existing technologies (in particular materials in powder form of dense (viscous)).
- Transfer high proportion of solids in the printing. Either the materials being completely solid or viscous with a low content of solvent vehicle, reducing the amount of vehicle used during printing and hence improving the -mass- transfer efficiency.
- Print with solid or viscous materials without needing to alter their composition. This allows all the material to be 'functional' for the targeted application, without compromising its properties to make it compatible with an alternative printing system.
- In-line printing, allowing it to be embedded and integrated with other printing systems (either discrete or continuous). It also provides faster printing speeds than point-based deposition printing systems (xy).

- The use of existing digital printing technologies for the creation of the mask image (both inkjet and xerographic, among other).
- To obtain a digital printing system compatible with a wide range of materials, scalable in geometry, since the same printing concept is valid independently of the size of the particles of the material to be printed (solid case) or the viscosity of the fluid (fluid case).
- To scale the printing in width (with the limitations of the width of the auxiliary digital writing systems used to create the image mask).
- To scale the printing in speed (with the speed limitation of the auxiliary digital writing systems used to create the mask).

[0073] And when using this type of digital printing systems based on a variable mask or pattern we obtain the following advantages compared to existing systems:

- In 2d printing applications
    - Print digitally with materials and substances that cannot be digitally printed otherwise, thus enabling new applications and uses.
    - Multi-material printing, by consecutive printing steps, each of them using a different material.
    - Embeddable in in-line printing systems, providing relevant additional functionality to the printing line.
    - Compatibility with existing material fixing and consolidation systems, making it easy to integrate and complement other printing systems.
- In 3d printing applications
    - The use of materials that cannot be used in 3d printing with the existing systems, thus enabling new applications and uses.
    - The printing of layers or sections by transfer, providing high versatility to the design of 3d printing systems. In particular, it (the printing by transfer) enables:
        - Multi-material printing in the same layer or section, enabling the creation of heterogenic 3d bodies, with regard to the materials conforming it and to the proportions of these materials within the 3d body.
        - The use of a support material easing the step of part extraction once the 3d printing is complete (avoiding manual steps and machining operations required in mono-material systems).
        - Printing in color, either using different colored materials or by adding color to the build material prior to its consolidation.
        - The combination of the printing material with different substances during the transport period, conferring additional properties to the material or to ease the print and transfer process.
        - In certain cases, eliminate the need of a selective consolidation system, with savings in costs and complexity.
        - In those cases requiring a post consolidation of the 3D printed group, skip the step of manual extraction and repositioning it in a support bed for its consolidation (for instance when the part needs a final firing in a refractory oven or kiln).
        - In certain cases allows to add contact (and/or pressure and/or temperature) in the consolidation step of the transferred section, favoring a more compact consolidation and improving the properties of the resulting 3D body.
    - Compatible with existing consolidation systems and embeddable in existing systems.
    - Allows the development of systems relatively fast and affordable compared to some of the existing systems, in part due to the nature of the printing system and to the versatility of the compatible consolidation methods.
    - In lamination-based 3D systems, assist the process of extracting areas of the layer by means of selective attraction systems.
- The creation of digital processes, based on a digitally printed pattern.
    - Creation of a relief for printing (included in the 2d printing applications)
        - For direct or indirect printing (2D), in methods similar or close to flexography or gravure.
    - Creation of a relief for a stamping or digital marking process.
    - Digital printing in operation conditions that exceed those of the printing system used to create the pattern
        - Contact welding by means of a digitally printing pattern (having the pattern been heated after its printing), thermal transfer, etc...
- The creation of digital processes, based on a pattern, without needing to print.
    - Suction / selective attraction methods
        - Allows the digital manipulation and han-

dling of substrates obtained by other digital processes (for instance it allows the automatic separation of parts obtained by a digital cutting process or die cutting, either for 2d or 3d applications).

- ▪ It allows the creation of complementary masks for the complementary suction in both sides of a media, for a better control and efficiency of the combined shear effect.

- Pre/post conditioning of print

  ◦ It allows the prior and/or post combination of the printed material with other substances in order to obtain a combined material, add properties (for instance color) or assist to the printing process (for instance favoring the transfer and/or altering the adhesion to the transport surface).

- The creation of a printing system by means of a 'cascade' configuration, where the printing of a first step, using a first printing mask, is used to configure a second printing mask for a second printing step.

  ◦ With it, it is possible to provide to the print in the second step specific properties that could not be achieved by one step of printing, like the amount of material transferred in the print.

BRIEF DESCRIPTION OF FIGURES

[0074] For better understanding of what has been presented, several figures are added where, schematically and as nonlimiting examples, several cases of embodiment of the invention are represented.

Background of the invention

[0075]

- Figures 1 and 2 synthetically illustrate some of the different types of analog printing and its principle of operation.
- Figures 3-a and 3-b schematically show the principle of operation of the inkjet technology in discrete mode (thermal inkjet, piezo inkjet).
- Figure 4 schematically shows the operating principle of xerography or electrophotography.
- Figure 5 shows a summary table of the main printing technologies, both analog and digital.
- Figure 6 shows an example of a system using an XY extrusion-based fed by continuous filament.
- Figures 7-a and 7- b show the process of creating a 3D body by successive layers according to different dominant solutions (7-a, by selective deposition (either point-based or inkjet), by selective consolidation, 7- b) .

Description of the invention

[0076]

- Figure 8 shows the different elements conforming the mask
- Figure 9 shows the assembly of mask
- Figure 10 shows some examples of mask configuration either in discrete, continuous or hybrid mode.
- Figures 11-a, 11-b, 11-c, schematically show some examples of digital deposition of mask material (by point-based depositing, electrophotography, or by inkjet)
- Figures in 12 illustrates the concept that the cover layer can be of different types.
- Figures 13-a, 13-b show a mask set using an additional blocking layer, placed either externally or internally.
- Figure 14 shows different mask configurations and the type of printing obtained (positive or negative).
- Figure 15 shows a summary table showing how, by using a pattern or digitally reconfigurable mask, a new family of printing systems is obtained, with similarities but different to traditional analog printing systems, and to pattern-less digital printing systems.

Descriptions of preferred embodiments

Attraction - Suction

[0077]

- Figures 16-a, 16-b, 16-c illustrate the operation principle of printing by suction using the mask (preparation, attraction, transfer).
- Figure 17 shows a mask with an additional blocking layer next to the printing material.
- Figure 18 illustrates the process of consolidation of the printing material.
- Figures 19-a, 19-b illustrate the process of creating the mask in a continuous configuration. Figure 19-c shows the attraction of the print material by suction towards the mask. Figure 19-d illustrates the transfer to a substrate of the print material previously attracted.
- Figure 20 illustrates a printing material arranged as a set of independent islands.
- Figure 21 illustrates the process where the suction is used and the print material is partially contained in a fragmentation or parcel layer.
- Figure 22 shows the concept of reciprocal or complementary masks.
- Figure 23 shows how the transfer of the print material onto a porous substrate is assisted by a suction process.
- Figure 24 shows the principle of printing the negative (and by suction)
- Figure 25 shows a mask created by a fluid material

and the use of a porous layer to favor the geometric confinement of the fluid in the mask set.

- Figure 26 illustrates the concept of cleaning, conditioning and recycling of the various elements constituting the printing mask.
- Figure 27 illustrates the selective attraction of a medium consisting of previously separated or separable areas.
- Figure 28 schematically illustrates a process of automatically extracting contours of a cut material (for example adhesives) and the impossibility of removing internal elements which would require manual operation.
- Figure 29-c shows the result obtainable in the case of using a system of selective attraction based on a (digital) reconfigurable mask for the extraction of separable elements (29-a) compared to traditional systems (29-b).

Repulsion - Blow

[0078]

- Figures 30-a and 30-b illustrate the process of printing by blowing using the mask, assisted by a layer of fragmentation and structural support.

Pseudo-screen-printing

[0079]

- Figures 31-a and 31-b illustrate the concept of pseudo-screen-print printing in which the printing material passes through the mask under the action of a force.
- Figure 32 shows a pseudo-serigraphic printing system based on a reconfigurable mask, in a continuous configuration.
- Figure 33 shows the process of printing a print material onto a porous substrate assisted by suction.

Pseudo-flexoaraphy/Gravure

[0080]

- Figures 34-a and 34-b show the mask assembly and how the film is conformed to adapt to the relief created by the mask material.
- Figure 35 illustrates the process where the film conforms to the mask material, assisted by suction and temperature.
- Figure 36 shows the filling of the holes (lows) of the relief with printing material.
- Figure 37 shows the transfer of printing material from the holes (lows) onto a substrate.
- Figure 38 shows an example of a pseudo-gravure printing system in continuous mode.
- Figure 39 shows the 'inking' of the peaks (highs) of the relief with printing material.
- Figure 40 shows the transfer of printing material from the peaks onto a substrate.
- Figure 41 shows an example of a pseudo-Flexography printing system in continuous mode.
- Figure 42 illustrates the concept of indirect printing in a pseudo-gravure printing system.

Cascade configuration and other configurations

[0081]

- Figure 43 shows a system in a cascade configuration where the print resulting from the first stage of printing is used as a mask material for a second printing step also using reconfigurable masks.
- Figure 44 shows a multi-material system in which materials A and B are successively printed onto a substrate.
- Figure 45 shows some possible variations with regards to the substrate where the printing has to be done or where other components are added, illustrating that substrates can receive a treatment, receiving direct printing or the transfer of a print done on another substrate and/or support the print into a later stage of conditioning, and then, carry the print to a consolidation stage, where the print material consolidates (either complete or partial) on the substrate carrying it or at a later stage after a transfer to a final substrate (or body) is done.

3D Applications

[0082]

- Figure 46 schematically illustrates a process of creating a 3D body by superposing and consolidating different printed layers by the methods described in the document.
- Figure 47 illustrates the fabrication of a 3D body where more than one material is used in its construction.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0083] As shown for example in Figures 8 and 9, the invention relates to a mask **M** for digital printing, comprising the following layers:

- a porous support structural layer **1**;
- a cover layer **2**;
- a mask material **3** placed in between the structural **1** and the cover layer **2**;

characterized in that the mask material **3** is relatively placed between layers 1 and 2 in a way that constitutes a reconfigurable printing mask.

[0084] The structural porous layer **1** is selected from:

- meshes, fabrics, nets, filters, felts, papers, sieves, membranes, hydrophobic membranes, oleophobic membranes, porous organic materials, porous materials in general.

[0085] The mask material **3** is selected from:

- solid particles: powder, granular, discrete particles, coarse particles, cubes, spheres;
- solid profiles: templates, pre-cut profiles, vinyl, paper, cardboard, films, thin metal;
- consolidated materials that make up a solid profile, whether thermosetting, curable, thermoplastic, phase change materials;
- viscous materials;
- liquids;

[0086] In a first variation, the cover layer **2** is a porous mesh.

[0087] In a second variant, the cover layer **2** is a film **8** impermeable to the print material **6.** Optionally, the mask **M** incorporates at least one additional blocking layer **9,** either between the mask material **3** and one of the layers of the mask **1** or **2,** or, preferably, externally to one of the layers of the mask **1** or **2** .

[0088] The invention also relates to a method of printing on a substrate **5** using a mask **M** according to the invention, comprising the steps of:

a) relatively positioning the mask material **3** between the layers **1** and **2** by using positioning means **4**;
b) printing on a substrate **5** with a printing material **6** using the mask **M**;
c) repositioning mask material **3** by using positioning means **4**;
d) repeat again step b);

[0089] Printing is done in an effective zone **12** using the mask **M,** which may comprise continuous or discrete elements. Figure 10 shows some examples of mask configurations either in discrete, continuous or hybrid modes.

[0090] The positioning means **4** can be:

- digital inkjet printing systems, electrophotography, or point-based deposition
- (micro-) valves, (micro-) actuators, in a discrete arrangement or in an array (matrix)
- printing systems in general (consisting in one or more steps, also considering the digital removal)
- a printing system based on a mask **M** for digital printing (cascade configuration)

[0091] Then, optionally, a following consolidation step of the print material **6** on a substrate **5** is performed, either made by thermal, mechanical or chemical means or by a combination of them. Figure 18 illustrates a process of consolidation of the print material **6.**

[0092] Various embodiments of the process according to the invention are described, depending on their principle of operation:

- by differential pressure (suction , blowing)
- by pseudo-screen-printing
- by pseudo-flexography and/or pseudo-gravure
- by cascade configuration

[0093] The use of these systems in 2D and 3D applications is also discussed, as well of other variations.

Printing by suction option

[0094] In this case a mask is employed according to the first variant, in which both the cover layer **2** and the structural mesh **1** have pore (or grid opening) size that permits to capture the elements or substances conforming the mask material **3** and that either the structural mesh **1** or the additional blocking mesh **9** also have pore sizes (or grid openings) that hinders the passage of print material **6.**

[0095] In this case, step b comprises the following substeps:

b-1 arrange the print material **6** on the side of the mask corresponding to the structural mesh **1** or blocking mesh **9**;
b-2 create a negative pressure gradient through the mask **M,** so that a part of the printing material **6** gets adhered to the mesh **1** or **9** with a geometric distribution corresponding to the pattern determined by the mask **M.**
b-3 place the substrate **5** next to the mask **M** and apply a force to the adhered print material **6** causing it to be transferred to the substrate **5,** so that the impression is obtained.

[0096] The application of this force is by:

- Pressure gradient, ultrasounds, vibration, pressure pulses, mechanical thrust;
- Application of electrostatic, magnetic or electromagnetic forces;
- Gravity, accelerations;
- Adhesive contact; chemical attraction
- Or a combination of the above.

[0097] The printing by suction process is illustrated in Figures 16-abc. Figure 17 shows a mask configuration using a blocking mesh **9.**

[0098] Then, optionally, a subsequent step of consolidation of the print material **6** on a substrate **5** is done, which can be done by thermal, chemical, mechanical means or a combination of them.

[0099] Figure 18 shows how the media changes its structure during the consolidation process.

[0100] As discussed, printing using a mask **M,** screen, or reconfigurable pattern, can happen in a discrete or continuous way.

[0101] Figures 19-a and 19-b illustrate the process of creating the mask in a continuous configuration. Figure 19-c shows the attraction of the print material by suction into the mask .

[0102] Figure 19-d illustrates the transfer onto a substrate of the print material previously attracted.

Regarding the print material, **6**

[0103] one of the advantages that have been described in the present invention is that it generalizes the type of material to be used for printing. In the case of attraction by suction, the system is compatible mainly with solid materials composed of particles, either powders, granular preparations, etcetera. Suction of liquids and viscous and pasty materials is also considered if these are preferably arranged in small amounts isolated from each other, thereby forming a group of small items, or islands, that can be suctioned individually (provided that the suction process do not volatilize excessively the part of interest if the print material). Figure 20 illustrates a print material **6** arranged as a set of independent islands.

[0104] The difficulty in the case of liquid and pasty materials, is that if they are presented as a continuous, when applying a differential pressure on them there are many factors (including the surface tension of the fluid itself) that determine the break lines (between what gets attracted and what remains) and thus the resulting geometry adhered to the suction mask. When the print material is placed as small independent islands (or in a configuration that will help the its breakage in discrete elements), these can be totally attracted, more easily, allowing for greater control over the areas to be transferred. Preparing the material as a set of independent elements or islands can be easily obtained with analog patterns, for example. The use of a fragmentation layer **10** is also considered, which separates or confine the print material **6** in cells (or pseudo-cells) to favor the breakage of the material continuity and minimize the effects of continuity of the print material **6** when it is attracted (sucked). Figure 21 illustrates the suction process using print material **6** partially contained in a fragmentation layer **10.**

[0105] Using a fragmentation layer **10** also has advantages when preparing the print material layer **6** and its gauging **15,** or to help separate the part adhered by suction from the remaining print material **6.**

[0106] As discussed, the most common embodiment for a system using differential suction will use solid print materials, although, as indicated, other substances can be considered as well, in general.

[0107] In any case the material to be printed is previously prepared to facilitate proper transfer when the differential suction is applied through the mask. In the case of solid materials, illustratively, a uniform layer **15** of predetermined thickness will be prepared so as to improve uniformity and have greater control in the amount transferred in the suction process. Thickness may be adjusted within certain limits, depending on many factors including the size and geometry of the particles, the initial degree of compaction, relative humidity, tendency to aggregate, etc.

Regarding the suction of material

[0108] once the thickness and uniformity of the print material layer is adjusted, suction, as indicated, will be preferably produced by a pressure gradient **13** between the print material and the mask having the pattern. To facilitate the transfer and more accurately control the geometry of the sucked material it may be convenient that the surface carrying the print material **6** is also porous **14** to facilitate the uptake of material into the mask. The mask in turn, may be placed in direct contact or close enough to the print material for the transfer to be effective.

[0109] Independently of whether the mask assembly is formed by discrete elements or wehhter the mask is formed locally in a continuous mode, printing, typically, will be done in a given effective area **12,** or print zone (attraction, capture, transfer) that will be sweeping all the the mask. (This is therefore an inline process, equivalent, for this matter, to other analog printing processes where the print happens in a line (or area) of contact). In any case, the suction 'by block' of the entire mask at once can also be considered (similar to a classical stamp or print). This case (using the whole mask at once) is -of course- possible, but it poses significant challenges to 'close' the sandwich depending on the applied suction, since the physics of the process tend to open the Sandwich.

[0110] In general the closing of the sandwich is guaranteed by the geometry the tension in the meshes conforming the assembly. In certain configurations, there may be additional reinforcing structures to prevent the opening of the sandwich or the meshes themselves can confer sufficient structural rigidity to prevent unwanted openings.

[0111] Also, for greater geometric accuracy during the suction of the print material **6,** one can think of a reciprocal or complementary system of suction masks on both sides of the print material for more control over the transferred geometry and to minimize transfers in unwanted areas. In this case, the complementary masks are related to the negative of one another. Figure 22 shows the concept of reciprocal or complementary masks where each mask attracts a part of the print material **6.** It can be thought of two masks using the same mask 'image' and that there's only aspiration in one of the two masks, being the other passive (redundant) but contributing to a better 'cut' of the transferred image.

[0112] Once adhered to the mask **M,** the print material **6** can go through another gaugeing step **16** to ensure uniformity and thickness of the material before it is transferred. (gaugeing, if necessary, could be given once the material has been consolidated).

[0113] With regard to the transfer to a substrate **5,** be it final or intermediate, as indicated, the process can be done by various means. In particular, the same principle of relative suction can be reused in case the substrate material is porous and allows suction through it **17.** Figure 23 shows how the transfer of the print material **6** to a porous substrate **5** is assisted by a suction process 17.

'negative' printing

[0114] Another variant of the same principle of operation is to consider that the material portion attracted by the mask is not the one to be transferred to a substrate but its complement. That is, in this case the print material **6** is already on a substrate **5** and by using the mask **M** certain parts of the print material are 'removed', leaving the desired image (print) on the substrate **5.** Figure 24 shows the principle of negative printing (and by suction).

Regarding the type of mask material **3** and its nature

[0115] As indicated, the material that forms the mask **3** can be very diverse in nature. It is worth mentioning a couple of special cases for their uniqueness and interest.

Case solid particles

[0116] It's worth remembering that the same principle of operation is valid regardless of the resolution or size to print. The same principle may be valid, independently of whether we are working with materials with small (dust, order of microns) or large particles (granules, order of millimeters or centimeters).

[0117] Depending on this resolution we may use different methods **4** for placing the mask material **3** on the porous support **1.** A case of particular interest, in the 'micro' case, is the use of an electrophotographic system to place a blocking 'toner', as the mask material **3.** The advantage is that this toner may be specifically designed to fit well to the requirements of the printing mask. In this sense one can think of toners made of plastic, elastomer, metal, ceramic, glass, or any other substance, adapted, with their corresponding charging agents, etc ... so that it can be used in this (electrophotographic) process. Thus, this provides great flexibility to the system design since a single toner mask, the system will allow printing with a wide range of powders, that (the powders) will not need to be modified to be digitally printable.

[0118] In cases of lower printing resolution (larger particle size in the mask material) it may be thought of other electromechanical elements **4** (for example electrovalves) to place the mask material **3** (eg metal spheres).

Case where the mask material is a fluid

[0119] This is another special case of great interest because, in the case of working in a 'micro' context, the liquid that forms the printing mask can be dispensed by an inkjet system.

[0120] The fact that the mask material **3** is a fluid implies some specificity of the materials forming the mask and the suction process itself.

[0121] Following the general definition of the mask **M** in the case of printing by suction, it (the mask) must let a fluid (typically air) to pass through so that pressure difference is created between its sides and, at the same time, should retain the liquid that defines the mask **3** and must also block the print material **6** to pass through when it is attracted.

[0122] To illustrate the phenomenon, consider the case that the mask material **3** is a fluid (eg water) dispensed with inkjet technology heads. On both sides of this fluid there will be membranes **1 2** (a particular case of porous material) that allow air to pass through (although with significant losses) but not the fluid. (As an example, membranes can be similar to those commonly used technical sports fabrics, breathable and waterproof at the same time).

[0123] In a mask **M** of this type, when applying a pressure difference, and because of the breathability of the membrane, the mask material **3** will tend to evaporate and then escape through the membrane **2,** and therefore , the ' image' created by the mask will fade in time. The fade rate is a function, among others, of the vapor pressure of the liquid used as mask material **3,** the porosity of the membrane 1 **2** and the applied pressure gradient. However it is conceivable that there is a time in which the mask image is functional for what is intended (to be used to selectively attract media **6**), and therefore feasible if the attraction and transfer occur within the time window where these conditions exist.

[0124] Another point to be considered is the geometric containment of the dispensed liquid **3.** If liquid is deposited on top of the support membrane **1,** if nothing else, it can freely change it shape and position when the sandwich is closed and/or when a pressure difference is applied. To avoid this, an absorption layer can be used to keep the fluid in place during the printing process. Again, depending on the absorption substrate and the printing time, the liquid may tend to migrate through the substrate in the same way that a drop of water expands and spreads in a porous material (e.g. paper). Different methods of confinement that provide a balance between porosity and geometric control can be envisioned. A valid option is to use as 'porous' material some kind of mesh or structure **11** that creates 'cells' or parcels in which the liquid **3** remains more or less confined during the effective time of printing. Figure 25 shows a mask formed by a fluid material where a porous parceling layer 11 is used to favor the geometric confinement of the mask fluid.

[0125] Although, as shown, using a liquid as masking material **3** poses a substantial complexity in the design and operation of the printing mask, being able to use inkjet technology for its deposition makes it an excellent choice for its intrinsic versatility.

Post printing - recycling and new print

[0126] Once printing is complete, usually but not mandatory, the mask set **M** is disassembled to reuse its components.

[0127] In the case that a system of independent frames is used, the set would separate for, first clean the mesh support **1** (on its inner side may contain residual mask material **3**), recalling the mask material **3,** and clean the cover mesh **2,** which may contain residual mask material **3** on its inner side and print material **6** in its outer face.

[0128] In the case of a continuous printing system, the process is similar except that meshes **1 2** will be closed (like a continuous belt) or rolls (that can be 'cleaned' and rewind to be reloaded in the future).

[0129] The cleaning process will depend on each case, the nature of mask material and the printing method, the type of meshes used, the resolution and accuracy of the system, and so on. This document refers to cleaning in a broad sense, considering cleanings, conditionings, maintenance treatments, etc. , and whatever required to reasonably reuse elements of the mask in future printings (can range from a simple sweeping and blowing / aspiration to a complex cleaning system, separation, sorting, etc...).

[0130] Figure 26 illustrates the concept of cleaning, conditioning and recycling of the various elements of configuring the printing mask, for its reuse in the printing system.

[0131] The concept of cleaning , conditioning , reuse and/or recycling of the elements of the mask **M** apply to whatever printing method embodiment, either by vacuum (suction) -the option just described- or by any other process described herein. For simplicity and text savings, it is mentioned in this section but is common to the other methods.

The use of an additional blocking layer (optional) **9**

[0132] In the description of the invention it was mentioned the use, optionally, of an additional blocking layer **9** to complete the mask set **M.** This provides flexibility in the design of the printing system since that the same mask set **M** can be used, comprising a backing layer or suport layer **1,** mask material **3** and covering layer **2,** and only by changing the blocking layer **9** printing can happen with different types of print material **6.** As indicated, it is required that the mask assembly is able to retain the mask material **3** therein, and at the same time prevent the print material **6** from passing through it. Therefore, it only takes a blocking layer **9** preventing the print material **6** to pass through, to be able to print without needing to change the basic elements (not optional) in the mask set **M,** which can be kept constant. (Consider a a system where, depending on the print material **6** a given blocking mask is chosen **9** (or omitted). Or, as an element of additional protection for the system against small particles if the print material **6** has a particle size distribution where some particles could come into contact with the mask material **3**).

Use of a fragmentation layer, structural and of geometric control (optional) 10

[0133] As mentioned, depending on the nature of the print material **6,** whether liquid or solid , and also depending on the thickness of layer of print material to be printed, an additional mesh **10** can be placed on the outer surface of the print material layer to better control the transfer of material. This additional mesh **10** may cover the entire height of the layer of material or partially, preferably 'sitting' on the outer part of the layer of material, as it will determine the final geometry during transfer.

[0134] In the case of negative printing (and by suction) the fragmentation layer **10** will be properly removed before transfer to another substrate and/or before the consolidation of the (remaining) printed material **6.**

Case of operation by selective attraction

[0135] A particular case in the use of a digital mask **M** by suction is by 'selective attraction', where, instead of 'attracting' discrete particles of a print material, what is done is to apply the attraction mask to a material with the aim of handling it.

[0136] For example, one can think of a pre-cut part where certain areas of interest **19** need to be separated from the rest **18.** By means of a system of selective attraction the interest portion **19** can be attracted attract so that it separates from the rest of the material **18.**

[0137] Figure 27 illustrates the selective attraction of a medium consisting of previously separated areas (**18, 19**).

[0138] As mentioned, one can think of systems with complementary or reciprocal masks on both sides of the material to be selectively separated to improve the shear effect in the contours.

[0139] Figure 28 schematically illustrates a process of automatically extraction of contours of a pre-cut material (for example adhesives) and the impossibility of removing internal elements which require manual operation.

[0140] Figure 29-c shows the obtainable result in the case of using a selective attraction System based on a reconfigurable mask (digital) for extracting pre-cut contours consisting in areas of interest **19** and rejection **18** (figure 29-a) and the difference from the results obtainable with existing systems (figure 29-b) .

Printing by blowing option

[0141] In this case, as in the previous case (printing by suction), a mask is used according to the first variant, where both the cover layer **2** and the structural mesh **1** have grid openings or pore dimensions that allow to capture the substances or elements that make up the mask material **3** and where either the structural mesh **1** or the additional blocking mesh **9** also have openings or pore size that hinders the passage of print material **6.**

[0142] In this case, step b comprises the following sub-steps:

b-1 place the print material **6** next to the structural mesh **1** or the additional blocking mesh **9.**

b-2 Place the substrate **5** opposite to the printing material **6** by its free side.

b-3 Create a positive gradient pressure **20** through the mask **M,** so that the printing material **6** is displaced and separated from the mesh **1** or **9** according to a geometric distribution pattern determined by the mask **M.**

b-4 apply a force to the displaced print material **6** causing the transfer of print material **6** onto the substrate **5,** therefore obtaining the impression.

[0143] The application of this force is done by:

- Pressure gradient, ultrasounds, vibration, pressure pulses, mechanical thrust;
- applying electrostatic, magnetic or electromagnetic forces;
- gravity, accelerations;
- adhesive contact; chemical attraction
- Or a combination of the above.

[0144] Or, in the reverse configuration (negative), step b comprises the following sub-steps:

b-1 Placing the print material **6** in the side of the mesh corresponding to either the structural mesh **1** or the additional blocking mesh **9,** that, in turn, will work as substrate **5.**

b-2 Create a positive pressure gradient through the mask **M,** so that a portion of the print material **6** is displaced and separated from the mesh **1** or **9** according to a geometric distribution pattern determined by the mask **M** and the rest stays in the substrate **5,** therefore obtaining the impression.

[0145] The printing by blowing case is a variant of printing by suction option, since the same type of mask is used, and instead of applying a negative pressure gradient of a positive gradient **20** is applied.

[0146] Its most common configuration will be the inverse (or negative) in which the print material **6** is 'removed' in certain areas by blowing, leaving only the print material (not eliminated) in the areas forming the image or geometry of interest. The print material **6** will initially be on a final substrate **5** or it will be transferred afterwards for its final use. However, it is also considered the case where the part 'blown' is the one of interest and the print material **6** is transferred (blow) to a substrate 5 to create there the desired geometry (direct configuration). In this case, if the substrate is porous, the attraction of the print material on the substrate can be assisted by suction **17** through the substrate. The process, in this case, is the reverse of the printing by suction where the part containing the material allows air to pass through **14** to help the transfer (it can be considered that there is a blow on the material transport part and suction through the mask). In the case described it would be equivalent but placing the mask behind the material transport substrate.

[0147] Figures 30-a and 30- b illustrate the printing by blowing process using the mask, assisted by a fragmentation layer **10** for better geometric control of the cut and to help keep the rest of the print material **6** in contact with the mask **M.**

[0148] Being this case a variant of the process by suction, the same criteria apply for the components and configuration of the mask.

<u>Case of operation by selective repulsion</u>

[0149] Similarly to the case of operation by selective attraction (suction), handling and separation operations can be done by using a positive pressure gradient **20.** For example, in a die-cut selective blowing can be used to separate its different areas.

Operation by suction-blow

[0150] There may exist various combinations of blowing and suction masks, where they work in cooperation (complementing one another's action). As shown, one can think of operations by suction assisted by blow, blow assisted by suction or using either blowing or suction in both sides. Similarly, it is contemplated that there is only a reconfigurable mask on one side of the material to be operated and be assisted by a (non-selective) method on the other side, or being reconfigurable masks on both sides of the material (which may be similar or complementary (one is based on the negative of the other)).

<u>Option pseudo-screen-printing</u>

[0151] In this case, both the structural mesh **1** and the cover layer **2** have grid dimensions that allow the print material **6** to pass through but retain the mask material and where the b step comprises the following sub-steps:

b-1 place on a side of the mask **M** the print material **6** and the substrate **5** on the other side.

b-2 force the print material **6** to pass through the mask **M** to obtain the print.

[0152] The b-2 step is done by gravity, by pressure gradient, mechanical thrust, vibration, ultrasounds, pressure pulses, by electromagnetic forces or a combination thereof.

[0153] Figures 31-a and 31-b illustrate the concept of pseudo-screen-printing where the print material passes through the mask under the action of a force.

[0154] The process in this case is analogous to a screen printing process except that instead of a solid pattern consolidated in a screen printing mesh a reconfigurable mask M is used, consisting on a set of layers as described.

[0155] Again, the method is valid for printing with solids and fluid printing materials **6.** An important difference is in cleaning of the mask set **M** for its reuse, since in the case that liquids are used, these will be in contact with mask material **3** potentially causing contamination, making it more difficult to clean and reuse. (However, it is noteworthy that depending on the application it may be acceptable to bear the cost of disposing (waste) of the elements used during printing (eg mask material) if that allows to print digitally with certain materials).

[0156] The simplest configuration would be to use a solid material for the mask material **3** and also (much thinner) use solid print material **6** so that the subsequent separation and recycling of the components is relatively simple since it consists in dry cleaning and separation and because, by definition, the size of the particles of mask material **3** and print material **6** are different, thus facilitating their separation or classification.

[0157] However, as a generalization, one can think of any combination of solid or viscous materials, both for the mask material **3** and the print material **6.** (It may be used a fluid material for the mask **3** as long as the impedance it generates to the passage of a material **6** (be it liquid or solid) is much greater than the effort needed by the printing material **6** to pass through the free openings of the mask **M.** Or, what is the same, the blocking force that the mask material **3** is able to make is significantly greater than the required force for the print material **6** to pass through the mask **M**).

[0158] To force the print material **6** to pass through the mask **M** different methods or principles can be used, from mechanisms **21** that physically push the material **6** (equivalent to screen printing) and/or complement these with other means (eg vibrations) that favor the fluid behavior of the material (in the case solid particles) through the mask **M,** while trying not to distort the geometry of the resulting print. Figure 32 shows a system in a continuous configuration of pseudo-screen printing based on a reconfigurable mask **M.**

[0159] Again, depending on the type of Surface or substrate **5** receiving the print, one can think on applying some sort of attraction **17** to improve the transfer process (for instance, suction if the receiving substrate is porous). Figure 33 shows the process of pseudo-screenprinting of a printing material **6** onto a porous substrate **5,** assisted by suction **17.**

Option relief mask - Flexo / Gravure

[0160] In this case, a mask is used according to the the second variant (cover layer is a film **8**), where step b) has the following sub-steps:

b-1) deform the film **8** so that it adopts the relief determined by the mask material **3** in a way that cavities **7** (or relief) are created according to the printing pattern or its negative (inverse).

b-2) apply print material **6** to the mask **M**

b-3) place the substrate next to the mask **M** on the side having the film **8** and the print material **6** to produce the print.

[0161] Optionally, in sub-step b-1) the film **8** is thermoconformed (temperature and suction) against the relief created by the mask material **3.**

[0162] In step b-3) the adhesion of the printing material **6** to the substrate **5** is obtained by:

- By adhesive contact, surface energy and tension;
- Inversion of a pressure gradient;
- By electrostatic or magnetic forces;
- By gravity, accelerations;
- Mechanical means, pressure, temperature,...
- Or a combination of the above.

[0163] Figures 34-a and 34-b show a mask set **M** and how the film **8** is deformed in a way that it copies the geometry of the relief created by the mask material **3.**

[0164] The process has some similarities with analog printing processes such as flexography (similar to using a stamp) or the gravure.

[0165] In this case, the mask set is created with a support layer **1,** the masking material **3,** and the masking material **3** is covered with a deformable film **8,** with the aim of helping to fix the masking material **3** in place during printing and also to avoid direct contact between the masking material **3** and the printing material **6** (since it will make it more difficult to recycle and the reuse the components of the mask **M** in future prints).

[0166] In principle, there's no limitation on the type of material **3** used to create the mask. Obviously a solid material will make it easier for the film **8** to adopt its relief and would show better mechanical stability during printing. However, the methodology is compatible with other type of material 3 to create the mask, being it possible to use fluid materials, viscous, phase-change materials, etc.

[0167] With regards to the film **8** used to complete the mask set **M,** it can be of different types, Depending on the printing resolution, the height of the relief, the mechanical requirements during printing, the chemical compatibility with the print material **6,** adhesion criteria, etc, different type of materials can be used (thermoplastic, metallic, pseudo-porous, ..), different thicknesses or with specific surface properties.

[0168] As an example, it can be the case that a thermoplastic film **8** goes through a thermal process **22** right before getting in contact with the relief, and assisted by a suction system **13** on the other side of the mask, gets deformed and copies the geometry of the masking material **3.** Afterwards it can be cooled to provide additional consistency to the mask set **M** before it is used for printing. Figure 35 shows the process of conforming the film to the masking material, assisted by suction **13** and temperature **22.**

[0169] In general, different methods can be considered to force the attraction of the film **8** towards the porous mesh **1,** such as electrostatic attraction, compression, etc..

[0170] It has been mentioned that the film **8** is impermeable to the printing material **6,** but it doesn't mean it cannot be somehow porous. What's important is that it is enough impermeable so that there is no substantial contamination with the masking material **3,** so that it can be reused. Depending on the how critical is the reuse of the masking material **3** and/or the film **8,** different impermeability levels can be used for the film **8.** One porous material, for instance, can help keep the printing material **6** in the cavities **7** during the printing process, if it assisted by suction.

Option pseudoGravure using lows (gaps)

[0171] In this case the sub-step b-2 consists in filling the printing cavities **7** with printing material **6.**

[0172] Figure 36 shows the filling of the gaps **7** (lows) of the relief with printing material **6** and figure 37 shows the transfer of the printing material 6 from the lows **7** to the substrate **5.**

[0173] With regard to the printable materials **6** using this method, there is no limitation as they can be either pasty or solid materials, however it seems better suited for viscous materials. (in the case of solid materials it could be use if the film **8** was porous and the process was assisted by suction **13,** or without it, in the case that the printing material **6** stays in the cavities **7** due to the gravity (for instance in an horizontal configuration) and the transfer to a substrate **5** is done by contact and/or change in orientation).

[0174] To fill the lows **7** in the relief, depending on the configuration there can be used systems of pressure and rectification similar to those used in equivalent analog printing systems **23.** Figure 38 shows and example of printing by pseudo-gravure in continuous mode.

Option pseudoFlexoqraphv using highs (crests)

[0175] In this case step b-2 consists in adhering printing material **6** on the highs **7'** on the film **8** on top of the masking material **3** in the mask **M.**

[0176] Figure 39 shows the 'inking' of the highs **7'** (crests) of the relief with printing material **6** and figure 40 shows the transfer of the print material **6** from the highs **7'** to a substrate **5.**

[0177] In this case, the printing materials **6** compatible with this configuration are those materials that allow to be adhered to the highs **7'** of the relief, so in general it will be viscous or liquid materials that will adhere to the film **8** on its external side. The adhesion will result from a combination of surface tensions of the film **8** and material **6,** its viscosity, printing conditions (speed, contact pressure, etc). In the case that the masking material **3** had other properties that allow its attraction (magnetic, electrostatic, etc..) other materials **6** beyond viscous could be considered as well.

[0178] To transfer the printing material **6** to the highs **7'** there can be used methods similar to those used in equivalent analog printing systems, like, for example, the use of a cylinder or transfer roller **24.** Figure 41 shows an example of a printing system using pseudofexography in a continuous mode.

Case indirect printing - temporary relief

[0179] The methods of lows and highs described also have their indirect printing version. This is, create, by means of the relief mask **M,** a relief on an auxiliary surface **25,** that will be the one receiving and then transferring the printing material **6,** either in a 'low' or 'high' configuration.

[0180] In this case, the auxiliary surface used in indirect printing **25** can be cleaned and/or conditioned for its later reuse. Figure 42 shows the concept of indirect printing in a pseudo-gravure system.

Option cascade configuration

[0181] It's worth mentioning that the masking material **3'** of a reconfigurable mask **M'** can be obtained by a print method using another reconfigurable mask **M** (that is the mean to position the mask material **3'** in the mask **M'.** The printing material **6** of the mask **M** is the masking material **3'** in the mask **M**').

[0182] With a cascade configuration, or sequential, one can obtain printing properties that go beyond what would be posible with just using one printing mask step (like, for instance, the size of the printable particles, amount of material transferred, thickness of the relief or aother type of incompatibilities).

[0183] For instance, in the case that an electro-photographic system is used to generate a first mask set **M,** the size of the particles of the material **3** (toner) used to create the mask will be limited and may not be big enough to create a mask compatible with the printing of a material **6** made of large particles. By using a cascade configuration, not only this could be achieved but it also saves the costs of using a digital deposition system for the creation of the mask (that because of the size of the particles would be made of an array of micro-valves or micro-actuators).

[0184] The concept of printing by cascade configuration is shown in figure 43, where the resulting print **6** of a first stage using a mask **M** is used as masking material **3'** for a second stage of printing using a mask **M'** and a printing material **6'.**

Case usage in 2D printing applications

[0185] The advantages of using a transfer-based printing system have been mentioned, among them, it allow printing with more than one material in succesive phases and allows for the mixing of the printing material with other substances, either present in the substrate where the print material is tranferred to or that can be added later on (figures 44 and 45 ilustrate schematically these advantages).

[0186] Bseides these advantages, it's worth mentioning some concrete cases of application, in particular those digital processes based on a digitally printed pattern according to some of the methods described in this document.

[0187] As an example one can think of welding systems or termal transfer processes based on a digitally printed pattern, where the pattern goes through a high temperatura heating cycle and then is put in contact with the materials to be welded or transferred.

[0188] Similarly one can think of the digital creation of relief patterns for stamping processes.

Case usage in 3D printing applications - additive manufacturing

[0189] Being able to print with a system that allows to transfer powder or viscous materials is particularly convenient in the case of additive manufacturing (also commonly known as 3D printing).

[0190] As it has been summarized previously in this document, there are three main families of solutions for 3D printing: point-based deposition heads, inkjet-based deposition and systems of selective consolidation (being it chemical, photochemical, or thermal).

[0191] In the case of using a transfer-based printing system brings some advantages compared to the existing 3D printing systems. In particular it allows for a system such that:

- A section is printed with printing material onto a substrate. The substrate can be preconditioned (or impregnated) with a substance that either alters the composition of the printed material or helps in the transfer of the material later on (in general, one can think of many type of conditionings for many possible purposes).
- Once on the transport Surface, the printed material can be colored (inked) or other substances can be applied. Other processes can be applied as well: thermal, chemical, photochemical, so that the material gets partially consolidated, thus favoring its integrity during the transfer process towards the 3D body under construction.
- Afterwards the section is transferred to the 3D body and gets consolidated according to the type of material. As mentioned, the consolidation can happen in parallel (or start soon before) with the transfer to the 3D body or in a posterior step.

[0192] It is observed that due to the nature of the transfer process, the same concept can be applied but instead of using a single material to build the 3D body, different materials can be used (one print step per material) to print a given layer of the 3d body. (multi-material printing allows to build heterogenic bodies in terms of the materials and the properties of the materials making up the 3D body, and also allows to print 'support' material needed for the creation of suspended structures).

[0193] The conditioning or consolidation steps can happen with several materials at the same time (all of them transferred to a temporary surface and then transferred all at the same time to the part under construction) or by sequentially printing and consolidating the portion corresponding to each material in an independent fashion (or any other combination).

[0194] This method is generic and valid in general for any type of transferred material (solid or viscous).

[0195] The fact that the transferred section already has the right geometry allows to simplify or use alternative consolidation methods tan those used on the systems where the consolidation step also defines the geometry (for example in the case of a photo-curable material, the consolidation is done by selectively illuminating the coordinates of the points to be consolidated (with a laser or a projector). In the case of transferring a section with the right geometry, the consolidation can happen with a lamp instead of a laser or projector, thus simpler. In the case of a thermoplastic material it can be fused by contact, for example, avoiding the complexity and the cost of a high power laser system to fuse the material).

[0196] The printing of the material can be done in a final surface or a temporary surface (or transport surface) and if other components are added these can be added while the material is on the temporary or final surface.

[0197] Figures 44 and 45 describe the versatility when printing the layers or sections of a 3D body and figure 46 schematically shows the process of creating a 3D body by means of the superposition and consolidation of different printed layers. Figure 47 illustrates the construction of a 3D body where more than one material has been used.

Claims

1. Mask (M) for digital operation and printing, comprising the following layers:

- a porous structural support layer (1);
- a cover layer (2);
- a mask material (3) placed in between the structural layer (1) and the cover layer (2)

characterized in that the mask material (3) can be positioned relatively in between the layers (1) and

(2) thus constituting a reconfigurable mask.

2. Mask (M) according to claim 1, where the porous structural layer (1) is selected among:

- meshes, fabrics, grids, filters, felts, papers, sieves, membranes, porous organic materials, porous materials in general and materials having openings;
- array of active elements or actionable valves.

3. Mask (M) according to claim 1, where the mask material (3) is selected from:

- solid particles, powder material, granular, discrete particles in general, independently of their size, geometry or composition;
- pre-cut profiles: stencils, vinyl, adhesives, paper, carton, film, foils, sheet metal, filters, fabrics;
- consolidable materials configuring a solid profile, being them thermostable, curable, thermoplastics, phase change materials;
- viscous materials;
- liquids.

4. Mask (M) according to any of the previous claims, where the cover layer (2) is a porous mesh.

5. Method of printing on a substrate (5) using a mask (M) according to any of the claims 1 to 4, consisting in the steps:

a) position relatively the mask material (3) between layers (1) and (2) using positioning means (4);
b) print onto a substrate (5) a printing material (6) using the mask (M);
c) position again the mask material (3) using the positioning means (4);
d) repeat step b).

6. Printing method according to claim 5, where the positioning means (4) are among:

- digital printing systems, inkjet, electrophotography, or by point-based single or multiple deposition;
- valves, actuators, in discrete or multiple mode;
- printing systems in general;
- means of positioning discrete elements;
- printing system based on a mask (M) for digital printing.

7. Print method according to claim 5, where the mask (M) is used according to claim 4, where both the cover layer (2) and the structural layer (1) have pore or opening dimensions such that allow the containment of the substances or elements composing the mask material (3) and where either the structural layer (1) or an additional blocking mesh (9) have a pore or opening size that prevents the print material (6) from passing through, wherein the additional blocking mesh (9) is positioned either between the mask material (3) and one of the layers of the mask (1) or (2), or, preferably, externally to one of the layers of the mask (1) or (2).

8. Method according to claim 7, where the step b) consist in the following sub-steps:

b-1) arrange the print material (6) on the side of the mask corresponding to the structural layer (1) or blocking mesh (9);
b-2) create an attraction force towards the mask (M) so that a part of the printing material (6) gets adhered to the structural layer (1) or blocking mesh (9) with a geometric distribution corresponding to the pattern determined by the mask (M);
b-3) place the substrate (5) on the side of the mask (M) corresponding to the structural layer (1) or blocking mesh (9) and apply a force to the adhered print material (6) causing it to be transferred to the substrate (5), so that the impression is obtained.

9. Method according to claim 7, where the step b) has the following sub-steps:

b-1) place the printing material (6) on the side of the mask having the structural mesh (1) or blocking mesh (9);
b-2) Place the substrate (5) close to the printing material (6) on the surface of the printing material which is not in contact with the mask;
b-3) Apply a thrust force through the mask (M), in a way that the print material (6) is moved away from the mesh (1) or (9) with a geometric distribution corresponding to the pattern created by the mask (M);
b-4) Apply a force to the displaced print material (6) in a way that the print material (6) is transferred to the substrate (5), thus obtaining the print.

10. Method according to claim 5 where a mask (M) is used as per claim 4 and where both the structural mesh (1) and the cover layer (2) have grid dimensions that allow the print material (6) to pass through but retains the mask material (3) and where the b) step comprises the following sub-steps:

b-1) place on a side of the mask (M) the print material (6) and the substrate (5) on the other side;

b-2) force the print material (6) to pass through the mask (M) to obtain the print.

11. Method, according to claims 8 to 10, where b2) step is done by gravity, by pressure gradient, mechanical thrust, vibration, ultrasounds, pressure pulses, by electromagnetic forces or a combination thereof.

Patentansprüche

1. Maske (M) für digitalen Betrieb und digitales Drucken, welches die folgenden Schichten umfasst:

• eine poröse Strukturträgerschicht (1);
• eine Deckschicht (2);
• ein Maskenmaterial (3), das zwischen der Strukturschicht (1) und der Deckschicht (2) platziert ist,

dadurch gekennzeichnet, dass das Maskenmaterial (3) relativ zwischen den Schichten (1) und (2) positioniert werden kann und somit eine rekonfigurierbare Maske.

2. Maske (M) nach Anspruch 1, wobei die poröse Strukturschicht (1) ausgewählt ist aus:

- Netzen, Textilwaren, Gittern, Filtern, Filzen, Papieren, Sieben, Membranen, porösen organischen Materialien, porösen Materialien im Allgemeinen und Materialien mit Öffnungen;
- Anordnung aktiver Elemente oder aktivierbarer Ventile.

3. Maske (M) nach Anspruch 1, wobei das Maskenmaterial (3) ausgewählt ist aus:

- festen Partikeln, Pulvermaterial, körnigen, diskreten Partikeln im Allgemeinen, unabhängig von deren Größe, Geometrie oder Zusammensetzung;
- vorgeschnittene Profile: Schablonen, Vinyl, Klebstoffe, Papier, Karton, Film, Folien, bahnförmigen Materialien, Filtern, Textilwaren;
- verfestigbaren Materialien, die ein festes Profil bilden, wobei es sich um thermostabile, härtbare, thermoplastische Materialien, Phasenwechselmaterialien handelt;
- viskose Materialien;
- Flüssigkeiten.

4. Maske (M) nach einem der vorhergehenden Ansprüche, wobei die Deckschicht (2) ein poröses Netz ist.

5. Verfahren zum Bedrucken eines Substrats (5) unter Verwendung einer Maske (M) nach einem der Ansprüche 1 bis 4, bestehend aus den Schritten:

a) relatives Positionieren des Maskenmaterials (3) zwischen den Schichten (1) und (2) unter Verwendung eines Positionierungsmittels (4);
b) Bedrucken eines Substrats (5) mit einem Druckmaterial (6) unter Verwendung der Maske (M);
c) erneutes Positionieren des Maskenmaterials (3) unter Verwendung des Positioniermittels (4);
d) Wiederholen des Schritts b).

6. Druckverfahren nach Anspruch 5, wobei das Positionierungsmittel (4) unter anderem ist:

- digitale Drucksysteme, Tintenstrahl, Elektrofotografie oder auf punktbasierte Einzel- oder Mehrfachabscheidung;
- Ventile, Aktuatoren, im Einzel- oder Mehrfachmodus;
- Drucksysteme im Allgemeinen;
- Mittel zum Positionieren diskreter Elemente;
- Drucksystem basierend auf einer Maske (M) für Digitaldruck.

7. Druckverfahren nach Anspruch 5, wobei die Maske (M) nach Anspruch 4 verwendet wird, wobei sowohl die Deckschicht (2) als auch die Strukturschicht (1) Poren- oder Öffnungsabmessungen aufweisen, die eine Aufnahme der Substanzen oder Elemente, aus denen das Maskenmaterial (3) zusammengesetzt ist, ermöglichen, und, wobei entweder die Strukturschicht (1) oder ein zusätzliches Sperrgitter (9) eine Poren- oder Öffnungsgröße aufweisen, die das Durchdringen des Druckmaterials (6) verhindert, wobei das zusätzliche Sperrgitter (9) entweder zwischen dem Maskenmaterial (3) und einer der Schichten der Maske (1) oder (2) oder vorzugsweise außerhalb einer der Schichten der Maske (1) oder (2) angeordnet ist.

8. Verfahren nach Anspruch 7, wobei der Schritt b) aus folgenden Teilschritten besteht:

b-1) Anordnen des Druckmaterials (6) auf der Seite der Maske, die der Strukturschicht (1) oder dem Sperrgitter (9) entspricht;
b-2) Erzeugen einer Anziehungskraft in Richtung der Maske (M) erzeugen, so dass ein Teil des Druckmaterials (6) an der Strukturschicht (1) oder dem Sperrgitter (9) mit einer geometrischen Verteilung anhaftet, die dem durch die Maske (M) bestimmten Muster entspricht;
b-3) Platzieren des Substrats (5) auf der Seite der Maske (M), die der Strukturschicht (1) oder dem Blockierungsgitter (9) entspricht, und Ausüben einer Kraft auf das anhaftende Druckmaterial (6), um dessen Übertragung auf das Substrat (5) zu bewirken, so dass der Druck erhalten wird.

9. Verfahren nach Anspruch 7, wobei der Schritt b) folgende Teilschritte umfasst:

b-1) Aufbringen des Druckmaterials (6) auf die Seite der Maske mit dem Strukturgitter (1) oder Sperrgitter (9);
b-2) Platzieren des Substrats (5) nahe dem Druckmaterial (6) auf der Oberfläche des Druckmaterials, das sich nicht in Kontakt mit der Maske befindet;
b-3) Aufbringen einer Schubkraft durch die Maske (M), so dass das Druckmaterial (6) mit einer geometrischen Verteilung, die dem durch die Maske (M) erzeugten Muster entspricht, von dem Sieb (1) oder (9) wegbewegt wird;
b-4) Anwenden einer Kraft auf das verschobene Druckmaterial (6) in einer Weise, dass das Druckmaterial (6) auf das Substrat (5) übertragen wird, wodurch der Druck erhalten wird.

10. Verfahren nach Anspruch 5, wobei eine Maske (M) nach Anspruch 4 verwendet wird, und, wobei sowohl das Strukturgewebe (1) als auch die Deckschicht (2) Rastermaße aufweisen, die den Durchtritt des Druckmaterials (6) zulassen, aber das Maskenmaterial (3) zurückhält, und, wobei der Schritt b) die folgenden Unterschritte umfasst:

b-1) Platzieren des Druckmaterials (6) auf einer Seite der Maske (M) und des Substrats (5) auf der anderen Seite;
b-2) Forcieren des Druckmaterials (6), durch die Maske (M) hindurchzutreten, um den Druck zu erhalten.

11. Verfahren nach den Ansprüchen 8 bis 10, wobei Schritt b2) durch Schwerkraft, durch Druckgradienten, mechanischen Schub, Vibration, Ultraschall, Druckimpulse, durch elektromagnetische Kräfte oder eine Kombination davon erfolgt.

Revendications

1. Masque (M) pour impression et opération numériques, comprenant les couches suivantes :

• une couche structurelle poreuse de support (1) ;
• une couche de recouvrement (2) ;
• un matériau de masque (3) placé entre la couche structurelle (1) et la couche de recouvrement (2)

caractérisé en ce que le matériau de masque (3) peut être positionné de façon relative entre les couches (1) et (2), constituant ainsi un masque reconfigurable.

2. Masque (M) selon la revendication 1, où la couche structurelle poreuse (1) est choisie parmi :

- des treillis, des tissus, des grilles, des filtres, des feutres, des papiers, des tamis, des membranes, des matériaux organiques poreux, des matériaux poreux en général et des matériaux présentant des ouvertures ;
- un réseau d'éléments actifs ou de valves actionnables.

3. Masque (M) selon la revendication 1, où le matériau de masque (3) est choisi parmi :

- des particules solides, des matériaux en poudre, les particules granuleuses discrètes en général, indépendamment de leur taille, de leur géométrie ou de leur composition ;
- des profils prédécoupés : des pochoirs, du vinyle, des adhésifs, du papier, du carton, un film, des feuilles, une tôle métallique, des filtres, des tissus ;
- des matériaux consolidables qui forment un profil solide, qu'ils soient thermostables, durcissables, thermoplastiques, des matériaux à changement de phase ;
- des matériaux visqueux ;
- des liquides.

4. Masque (M) selon l'une quelconque des revendications précédentes, où la couche de recouvrement (2) est un treillis poreux.

5. Procédé d'impression sur un substrat (5) à l'aide d'un masque (M) selon l'une quelconque des revendications 1 à 4, consistant en les étapes suivantes :

a) positionner de façon relative le matériau de masque (3) entre les couches (1) et (2) à l'aide de moyens de positionnement (4) ;
b) imprimer sur un substrat (5) un matériau d'impression (6) à l'aide du masque (M) ;
c) positionner à nouveau le matériau de masque (3) à l'aide des moyens de positionnement (4) ;
d) répéter l'étape b).

6. Procédé d'impression selon la revendication 5, où les moyens de positionnement (4) sont parmi :

- des systèmes d'impression numérique, un jet d'encre, une électrophotographie, ou par dépôt ponctuel unique ou multiple ;
- des valves, des actionneurs, en mode discret ou multiple ;
- des systèmes d'impression en général ;
- des moyens de positionnement d'éléments discrets ;
- un système d'impression basé sur un masque

(M) pour une impression numérique.

7. Procédé d'impression selon la revendication 5, où le masque (M) est utilisé selon la revendication 4, où aussi bien la couche de recouvrement (2) que la couche structurelle (1) ont des dimensions de pore ou d'ouverture qui permettent de contenir les substances ou les éléments composant le matériau de masque (3), et où soit la couche structurelle (1) soit un treillis de blocage supplémentaire (9) ont des dimensions de pore ou d'ouverture qui empêchent le matériau d'impression (6) de passer à travers, le treillis de blocage supplémentaire (9) étant placé soit entre le matériau de masque (3) et l'une des couches du masque (1) ou (2), soit, de préférence, à l'extérieur de l'une des couches du masque (1) ou (2).

8. Procédé selon la revendication 7, où l'étape b) consiste dans les sous-étapes suivantes :

b-1) disposer le matériau d'impression (6) sur la face du masque correspondant à la couche structurelle (1) ou au treillis de blocage (9) ;
b-2) créer une force d'attraction vers le masque (M) de sorte qu'une partie du matériau d'impression (6) adhère à la couche structurelle (1) ou au treillis de blocage (9) avec une distribution géométrique correspondant au motif déterminé par le masque (M) ;
b-3) placer le substrat (5) sur le côté du masque (M) correspondant à la couche structurelle (1) ou au treillis de blocage (9) et appliquer une force au matériau d'impression qui a adhéré (6) de manière à le transférer sur le substrat (5), de sorte à obtenir l'impression.

9. Procédé selon la revendication 7, où l'étape b) comporte les sous-étapes suivantes :

b-1) placer le matériau d'impression (6) sur le côté du masque comportant le treillis structurel (1) ou le treillis de blocage (9) ;
b-2) placer le substrat (5) à proximité du matériau d'impression (6) sur la surface du matériau d'impression qui n'est pas en contact avec le masque ;
b-3) Appliquer une force de poussée à travers le masque (M), de manière à écarter le matériau d'impression (6) du treillis (1) ou (9) avec une distribution géométrique correspondant au motif créé par le masque (M) ;
b-4) Appliquer une force au matériau d'impression (6) déplacé de manière à transférer le matériau d'impression (6) sur le substrat (5), obtenant ainsi l'impression.

10. Procédé selon la revendication 5, où un masque (M) est utilisé conformément à la revendication 4 et où aussi bien le treillis structurel (1) que la couche de recouvrement (2) ont des dimensions de grille qui permettent au matériau d'impression (6) de passer à travers, mais retiennent le matériau de masque (3), et où l'étape b) comprend les sous-étapes suivantes :

b-1) placer sur un côté du masque (M) le matériau d'impression (6) et le substrat (5) sur l'autre côté ;
b-2) forcer le matériau d'impression (6) à passer à travers le masque (M) afin d'obtenir l'impression.

11. Procédé selon les revendications 8 à 10, où l'étape b2) est réalisée par gravité, par gradient de pression, par poussée mécanique, par vibration, par ultrasons, par impulsions de pression, par forces électromagnétiques ou par une combinaison de celles-ci.

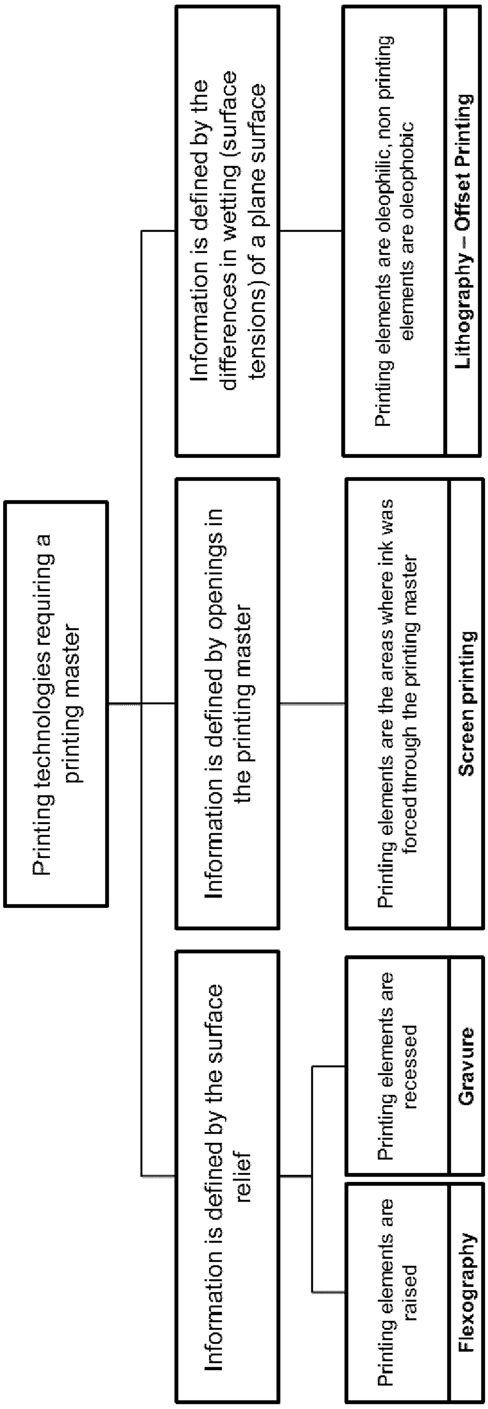

Printing technologies requiring a printing master
Information is defined by the surface relief
Information is defined by openings in the printing master
Information is defined by the differences in wetting (surface tensions) of a plane surface
Printing elements are raised
Flexography
Printing elements are recessed
Gravure
Printing elements are the areas where ink was forced through the printing master
Screen printing
Printing elements are oleophilic, non printing elements are oleophobic
Lithography – Offset Printing

Fig. 1

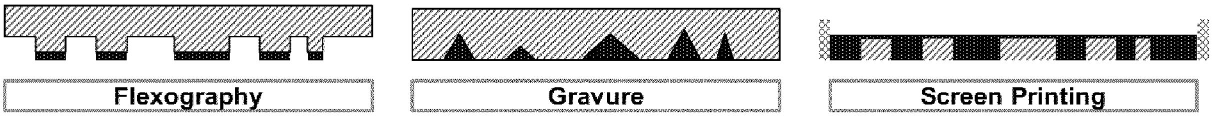


Fig. 2

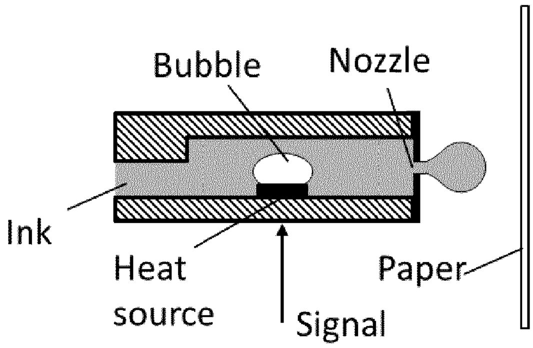


Fig. 3-a

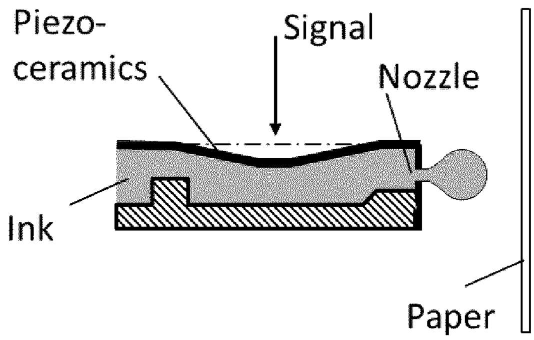


Fig. 3-b

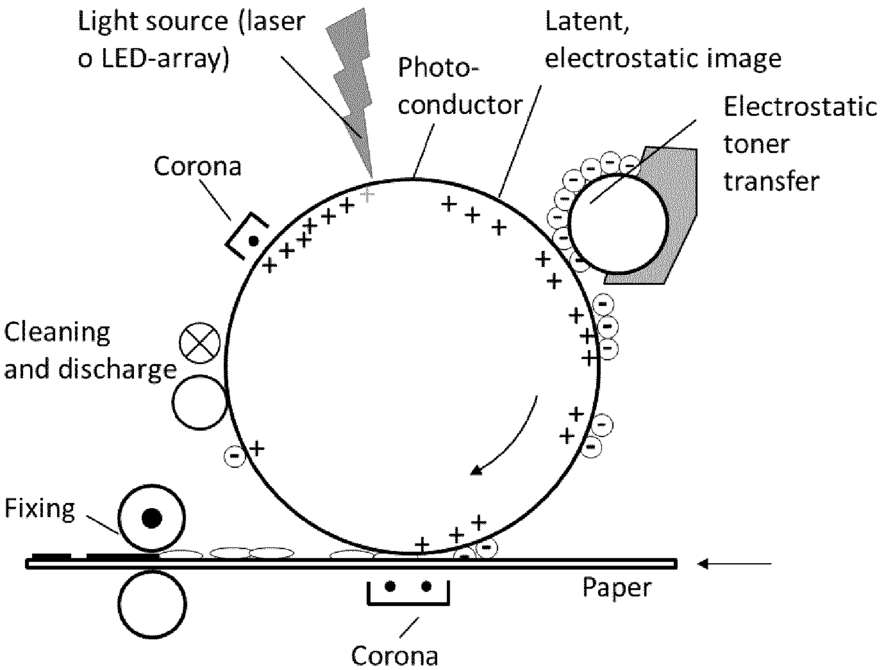


Fig. 4

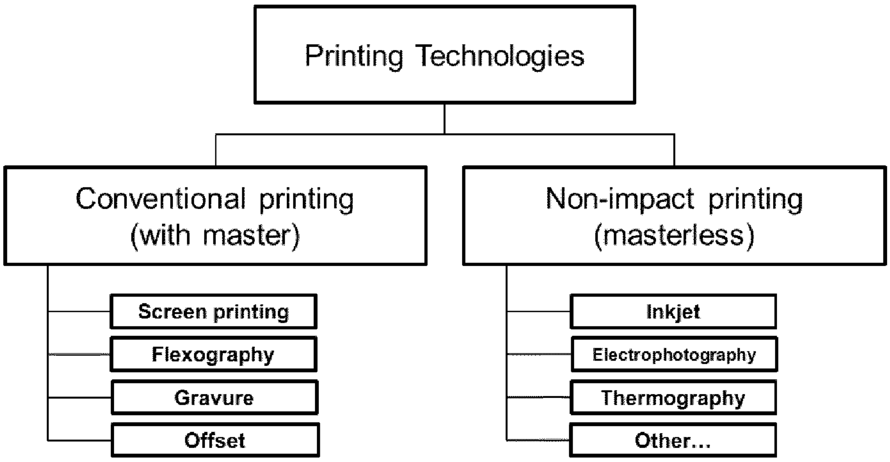


Fig. 5

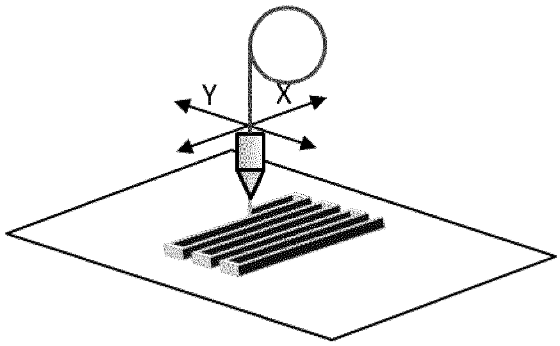


Fig. 6

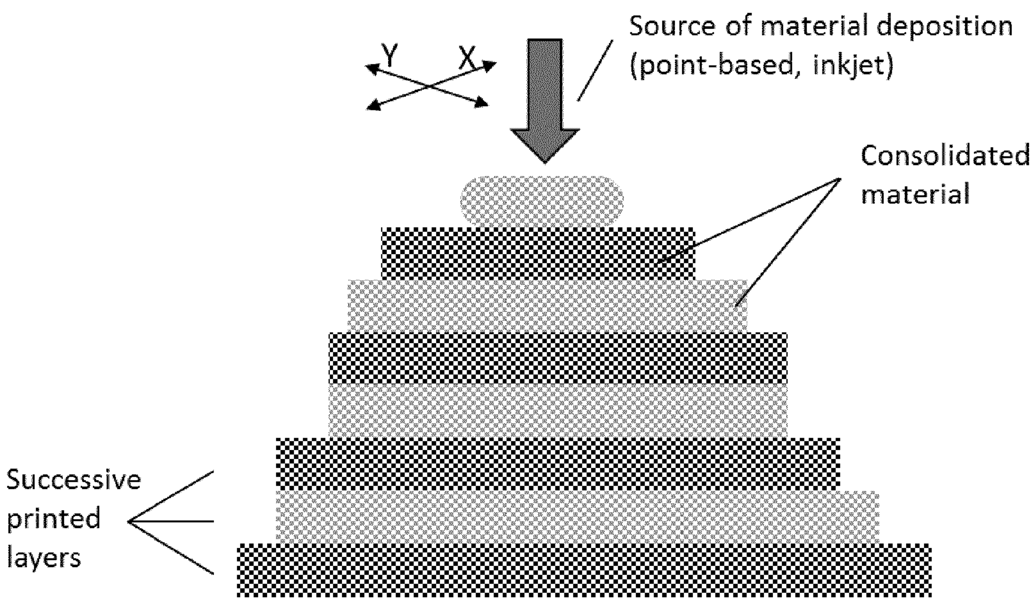


Fig. 7-a

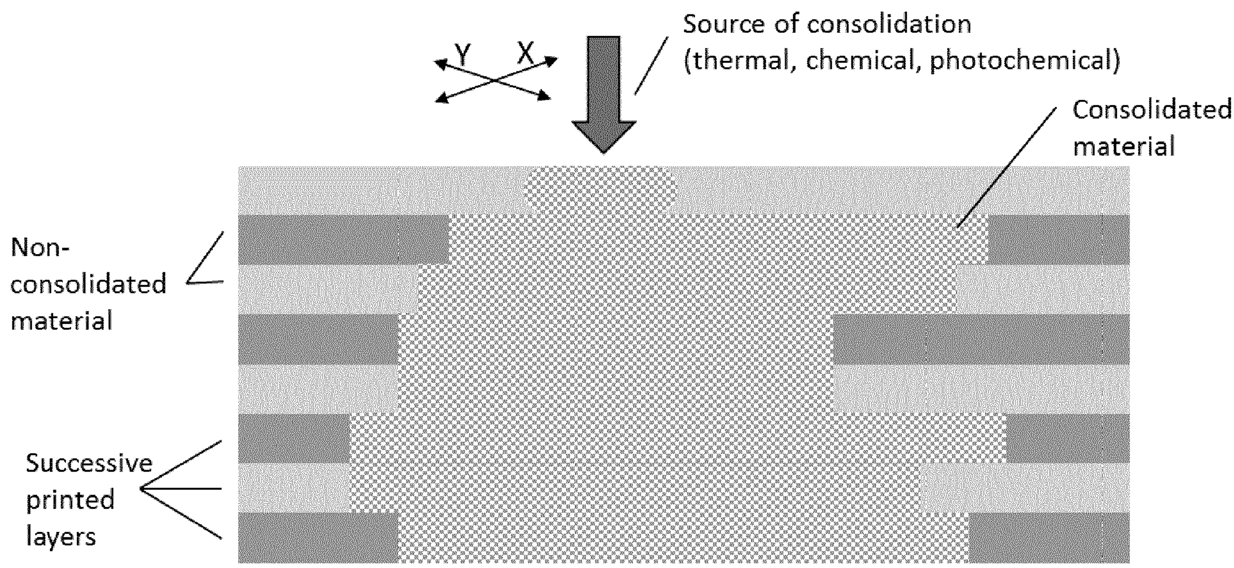


Fig. 7-b

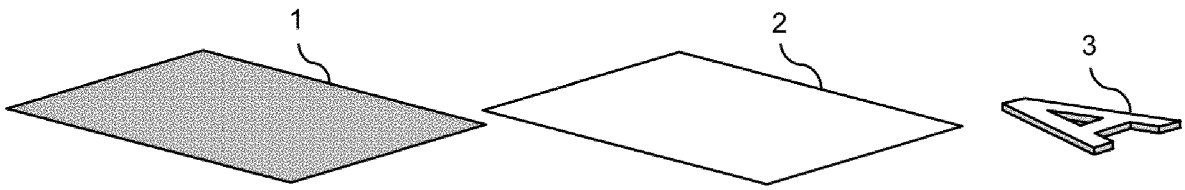


Fig. 8

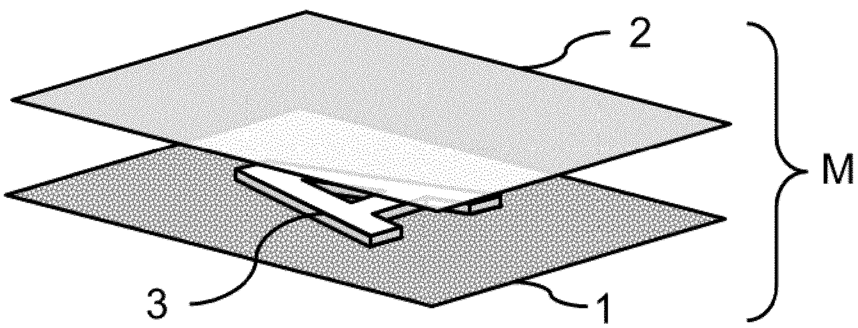


Fig. 9

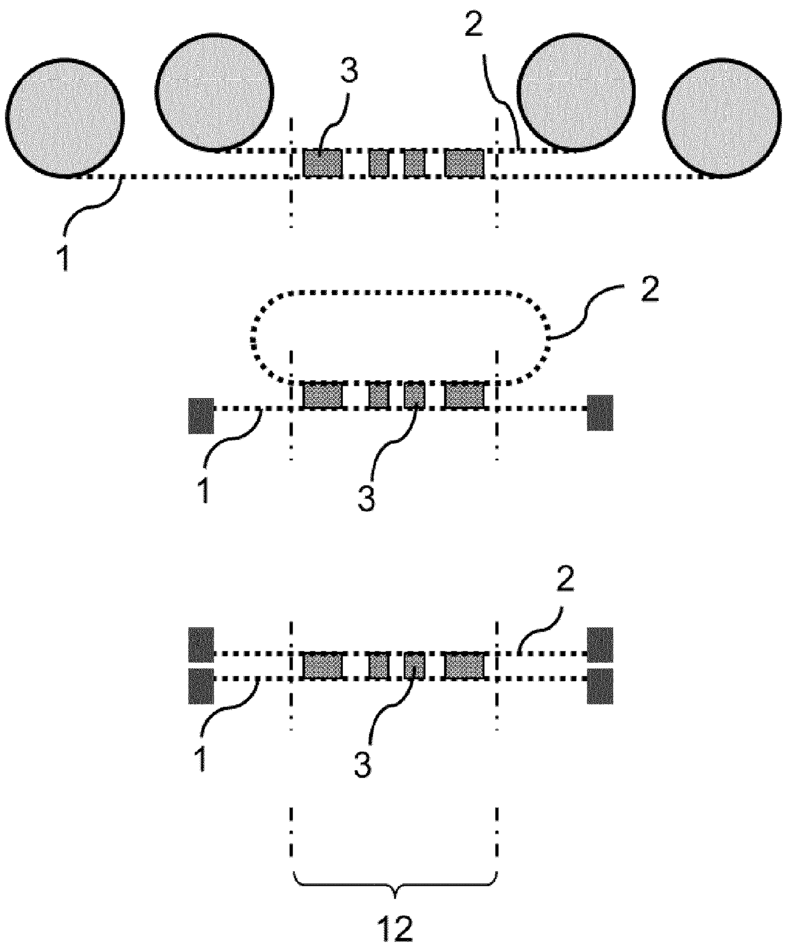


Fig. 10

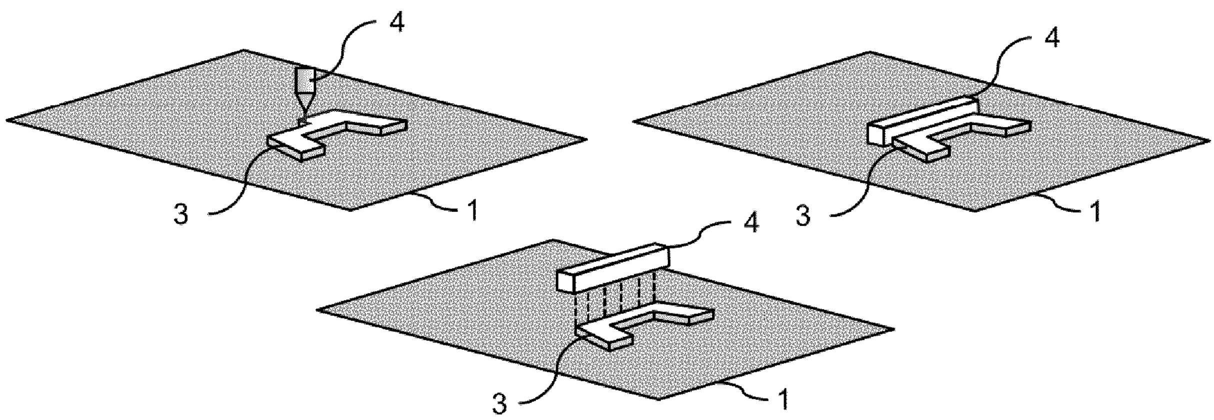


Fig. 11-a Fig. 11-c Fig. 11-b

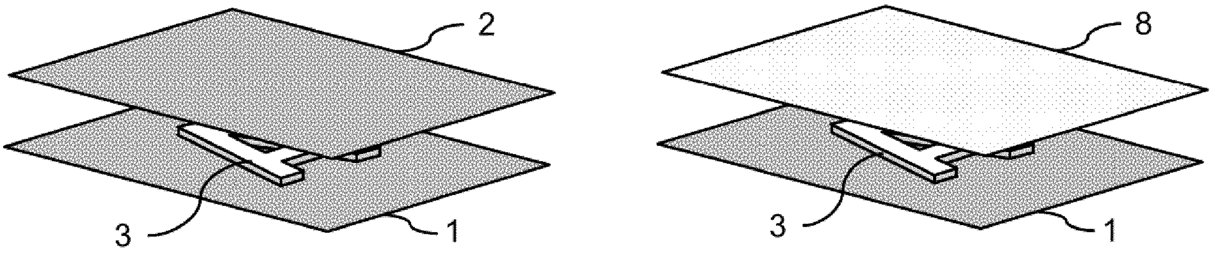


Fig. 12

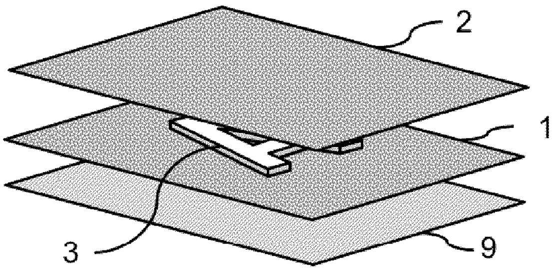


Fig. 13-a

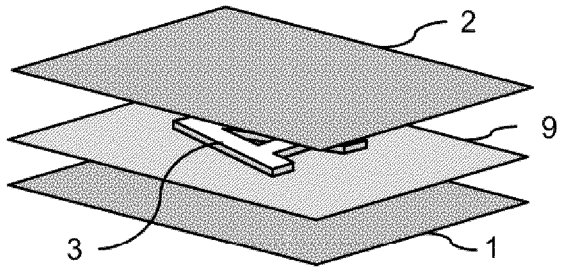


Fig. 13-b

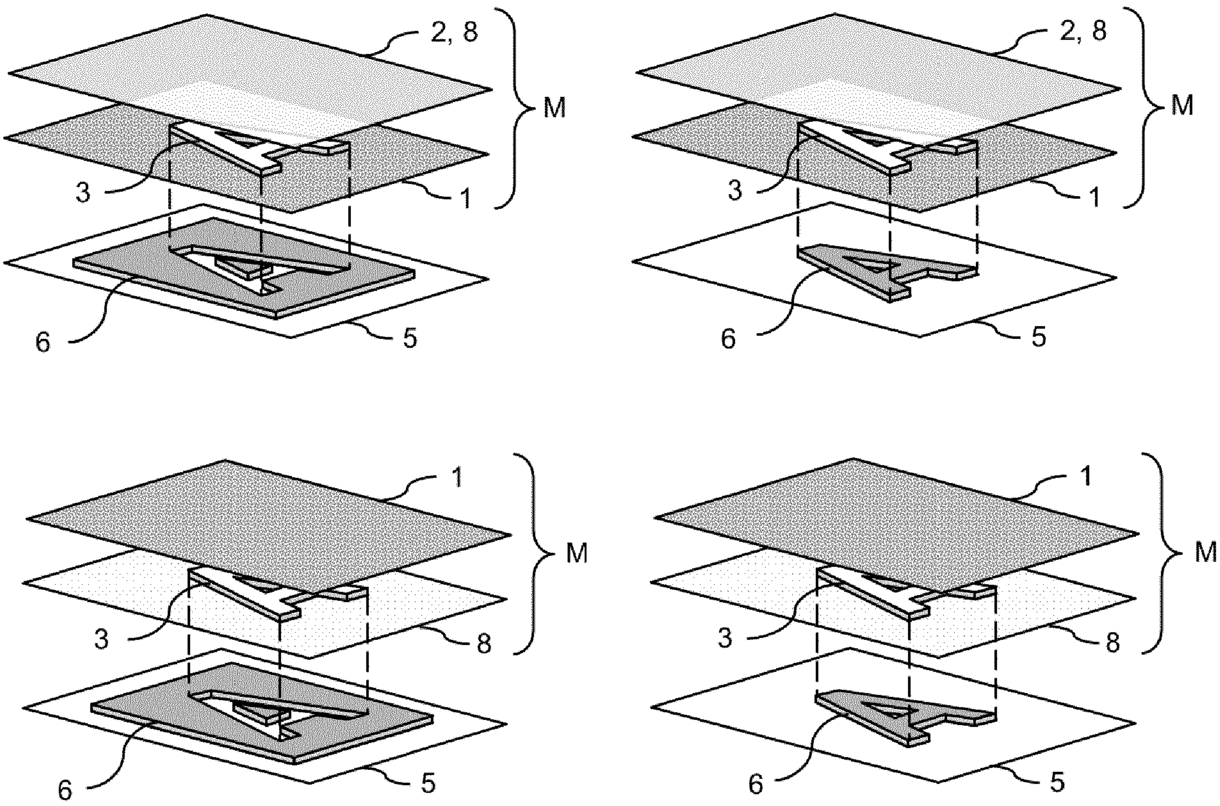


Fig. 14

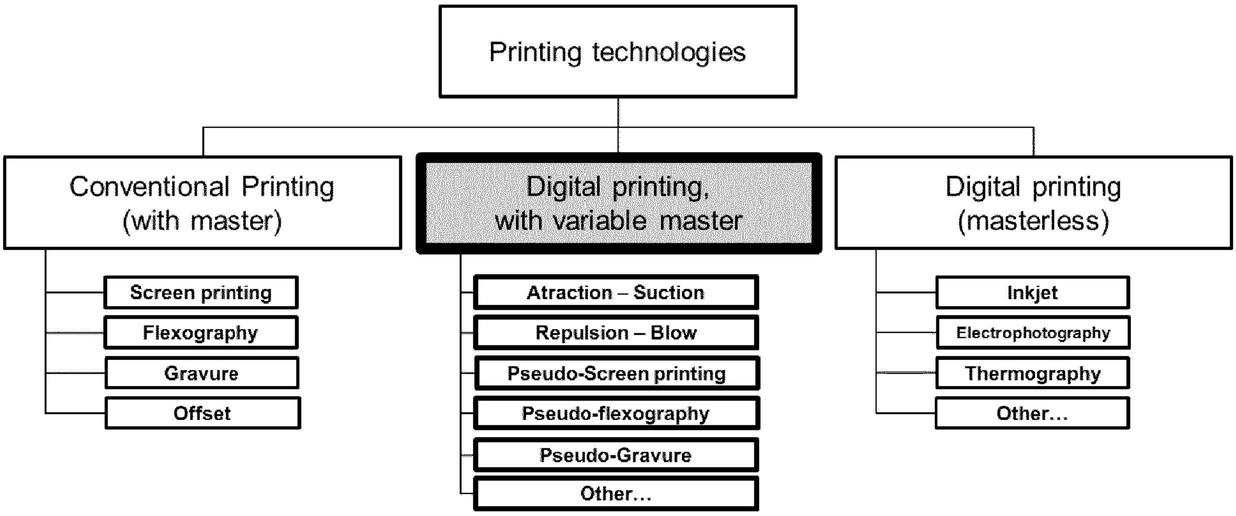


Fig. 15

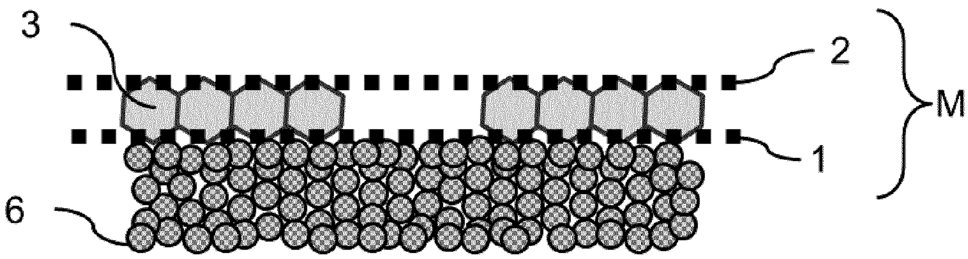


Fig. 16-a

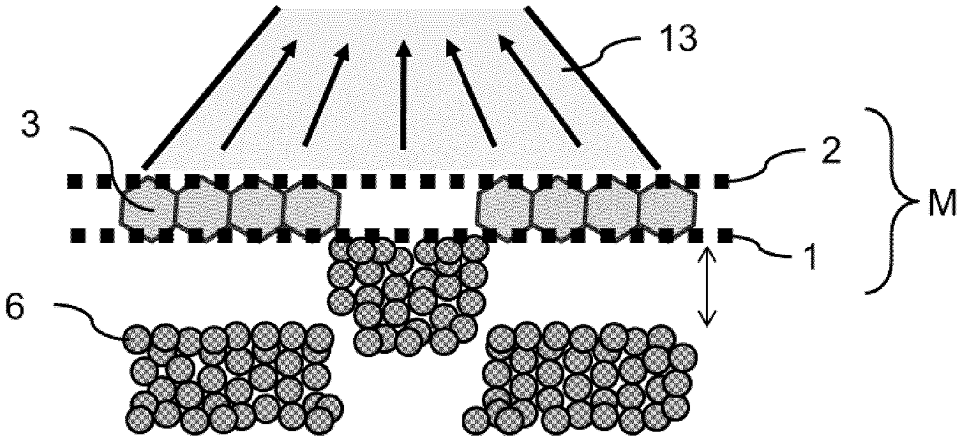


Fig. 16-b

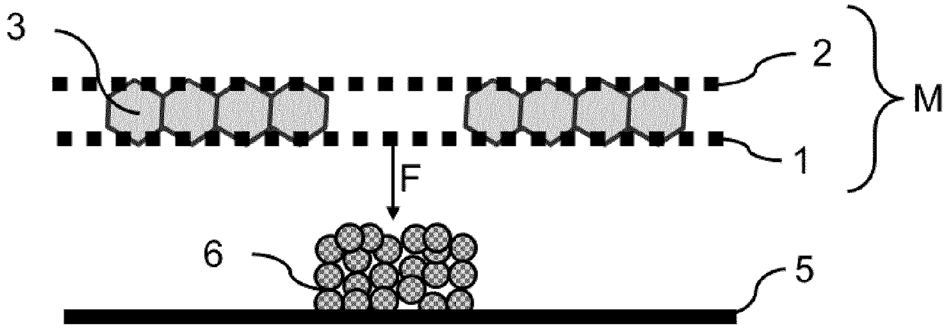


Fig. 16-c

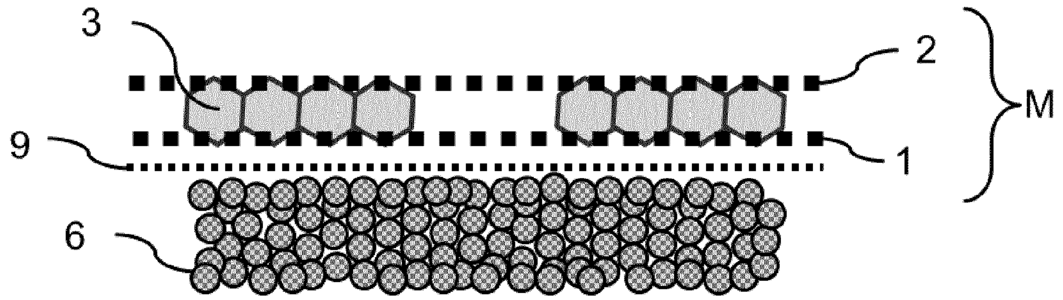


Fig. 17

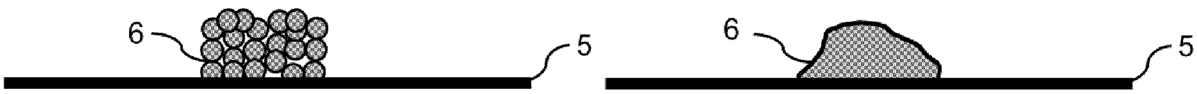


Fig. 18

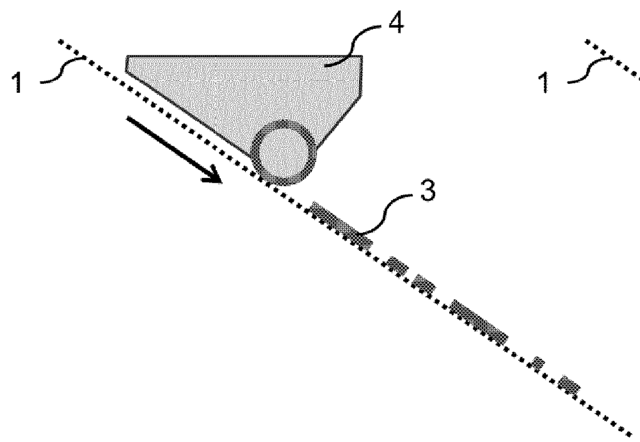


Fig. 19-a

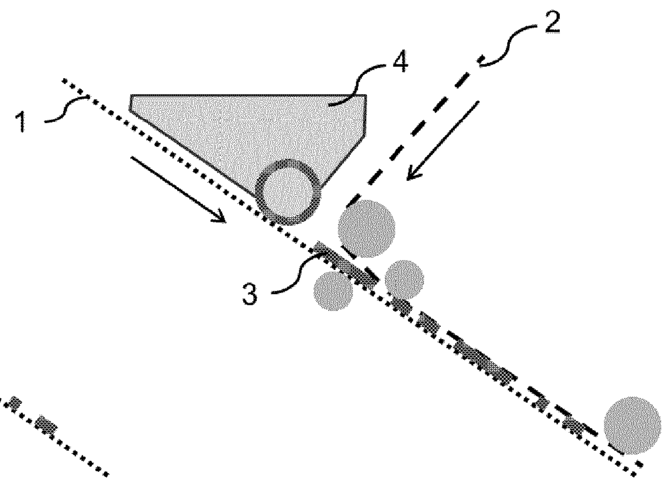


Fig. 19-b

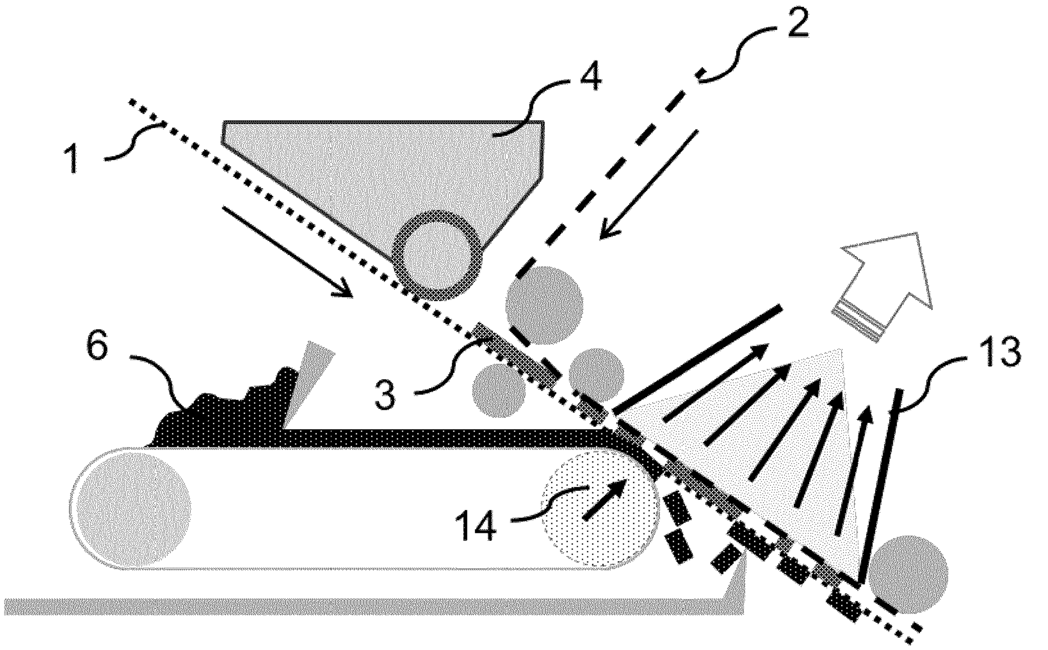


Fig. 19-c

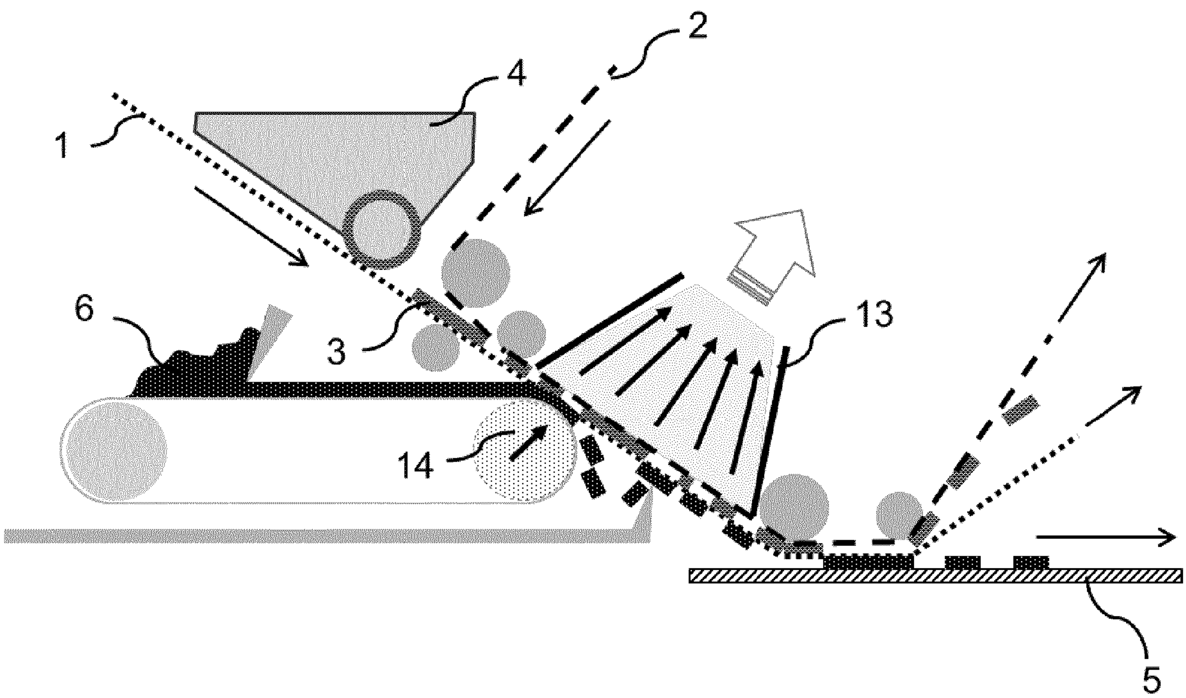


Fig. 19-d

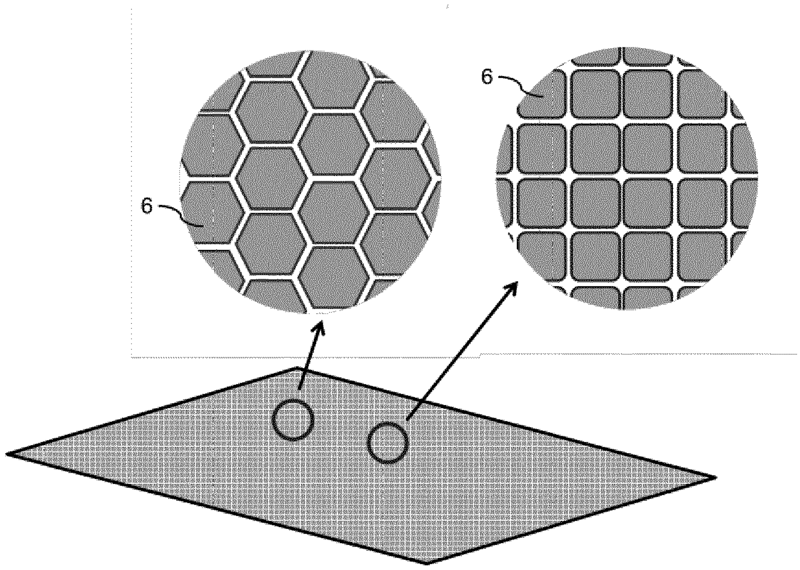
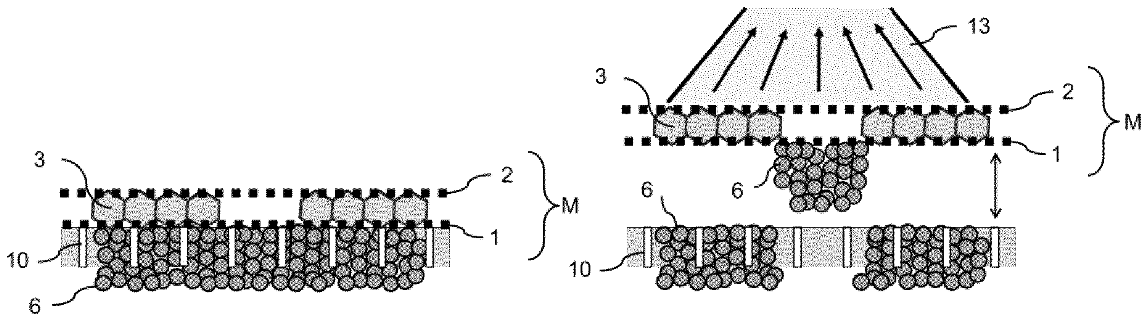


Fig. 20



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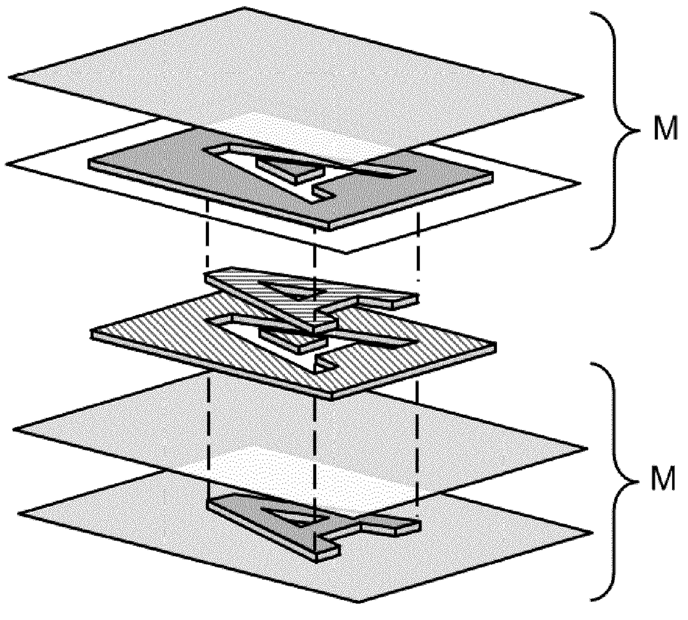
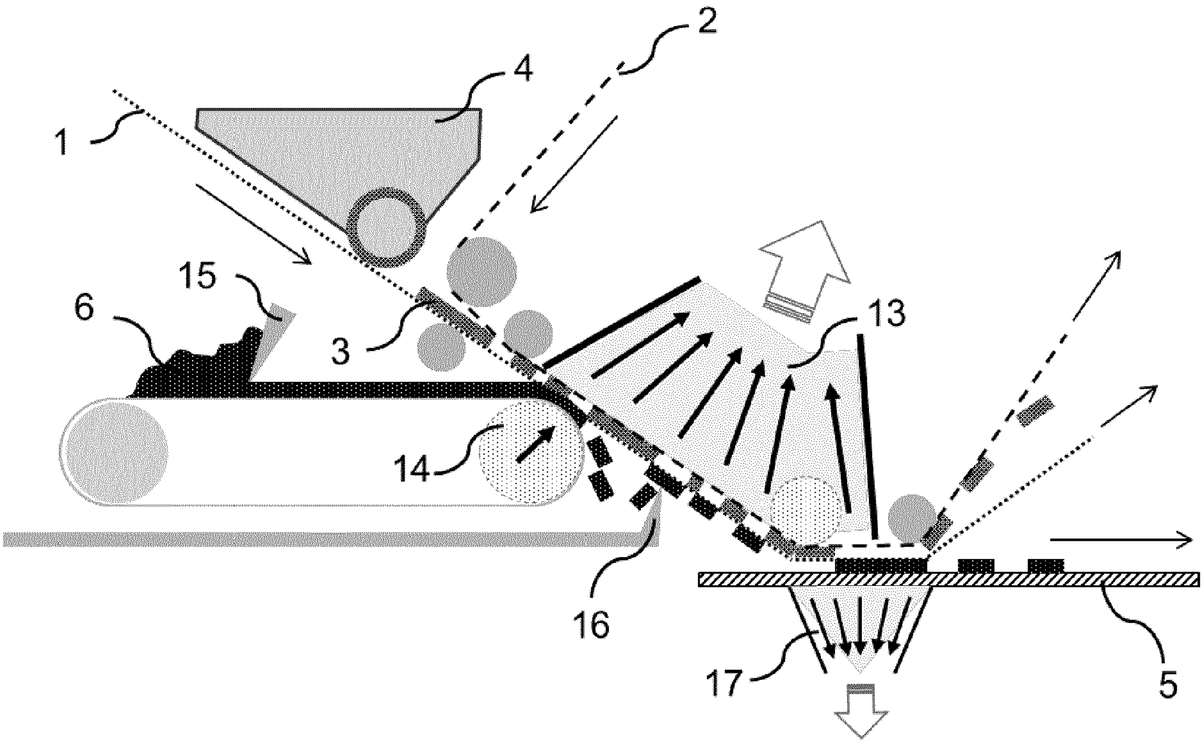


Fig. 22



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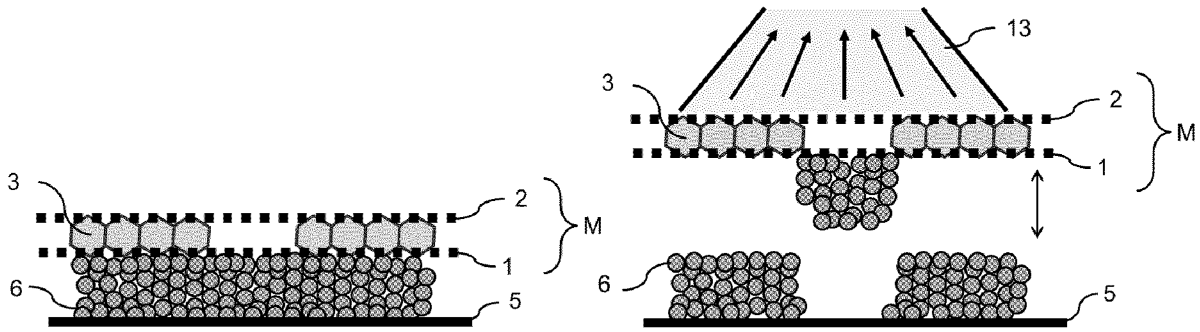

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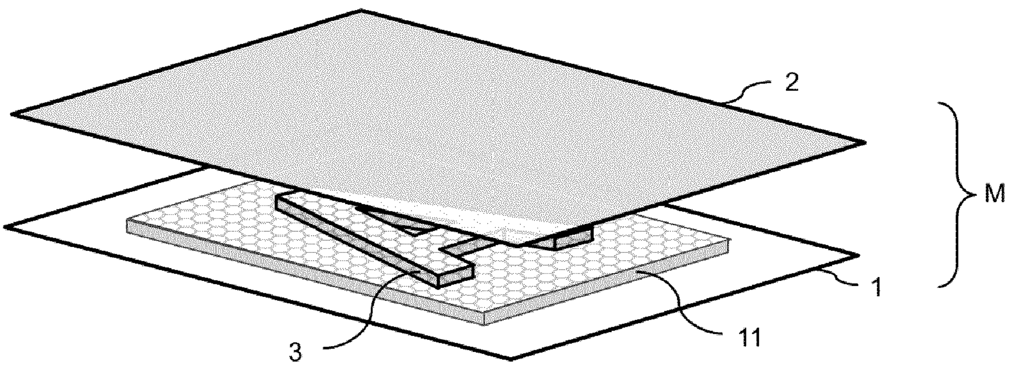

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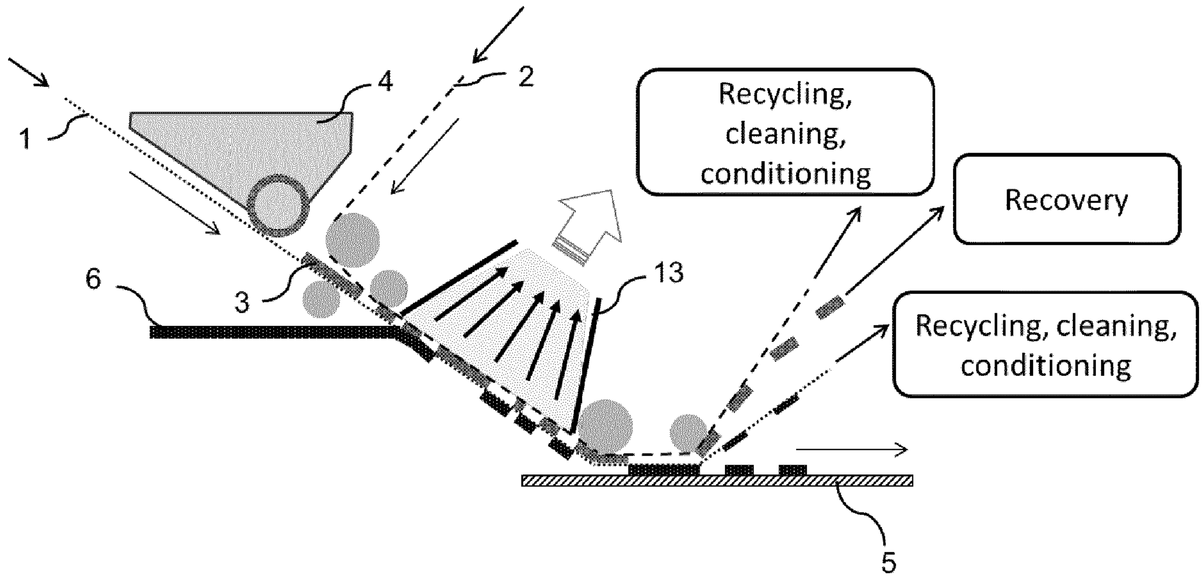
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Recycling, cleaning, conditioning
Recovery
Recycling, cleaning, conditioning

Fig. 26

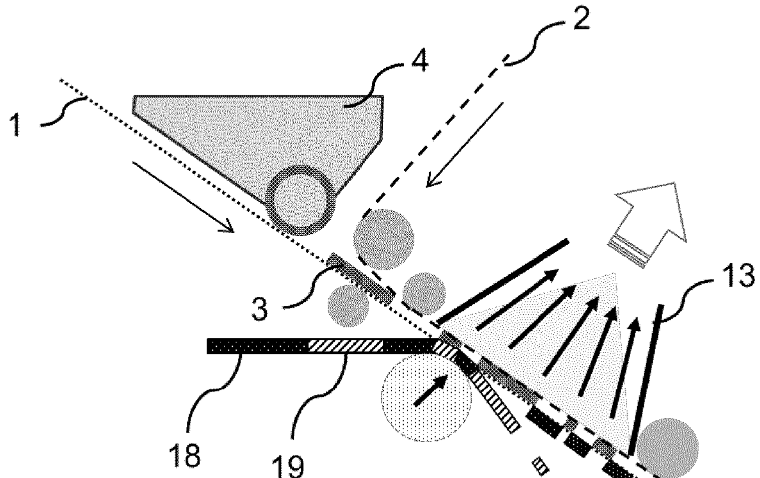
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Fig.27

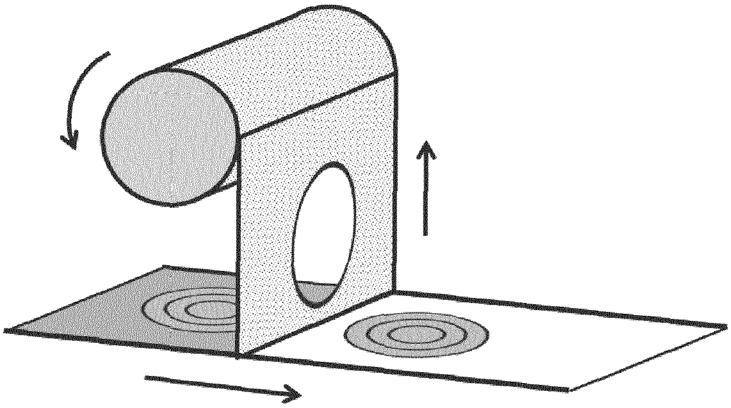


Fig. 28

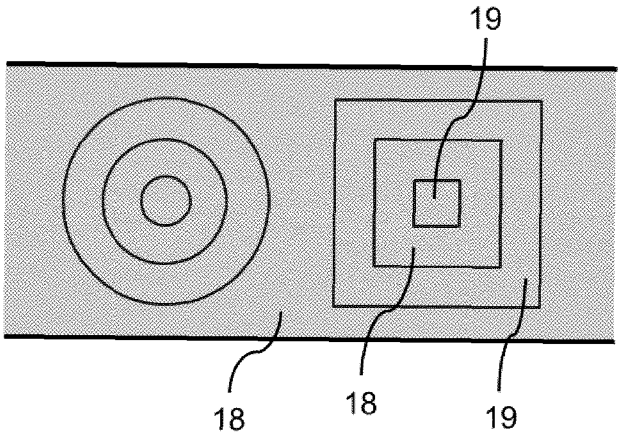


Fig. 29-a

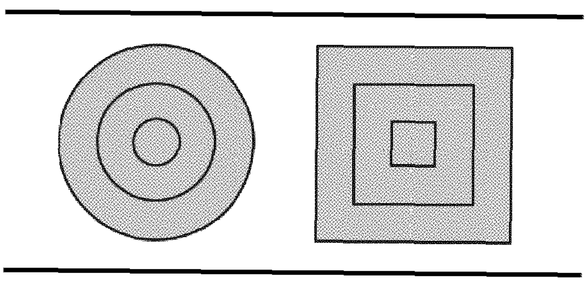


Fig. 29-b

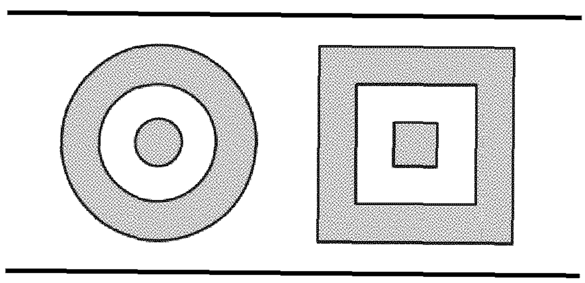


Fig.29-c

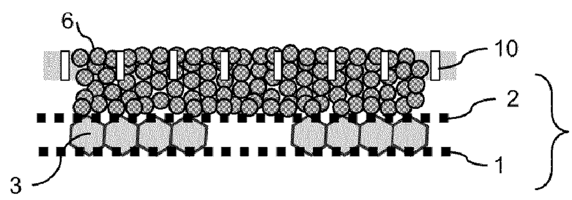


Fig. 30-a

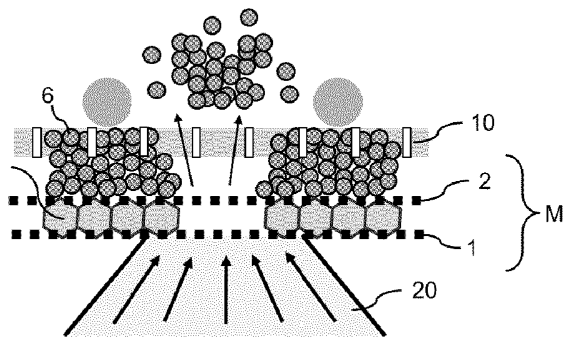


Fig.30-b

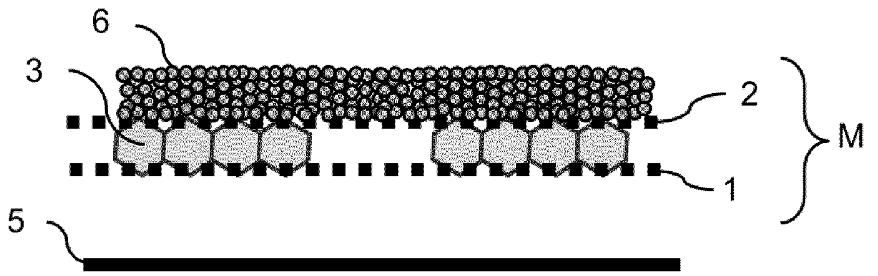


Fig. 31-a

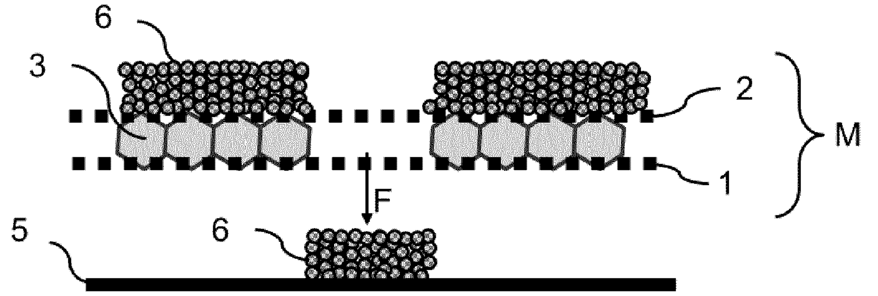


Fig. 31-b

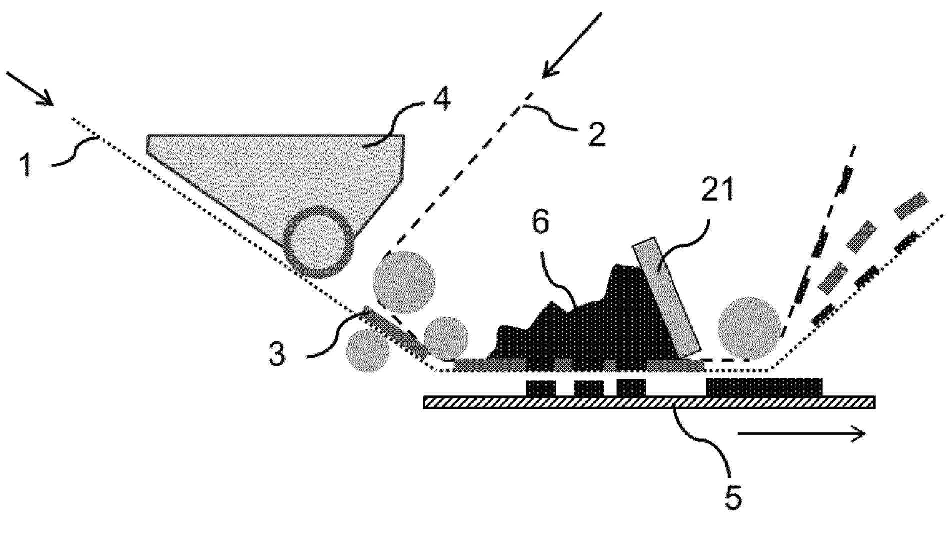


Fig. 32

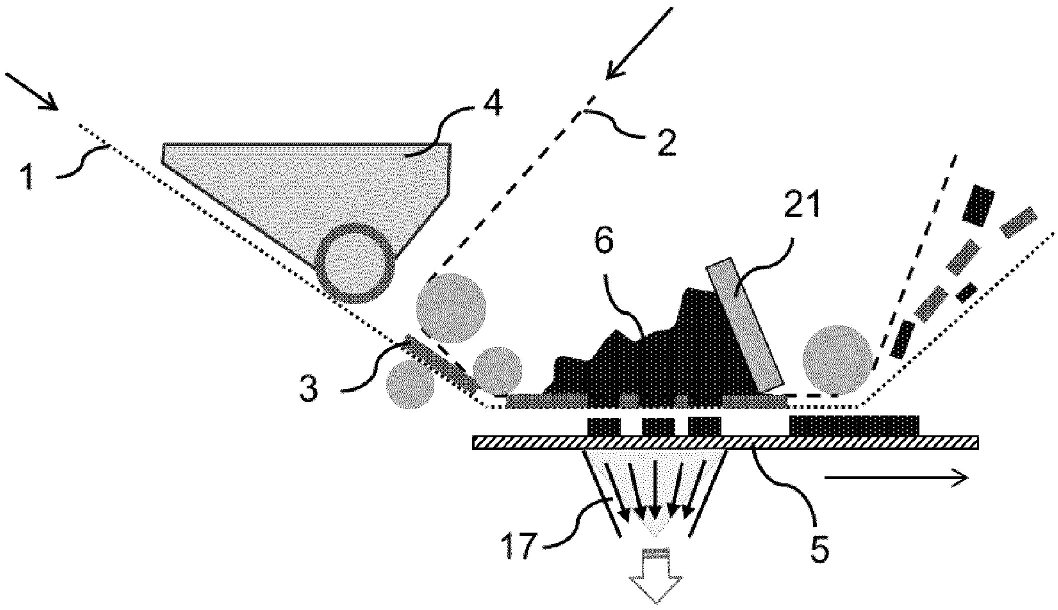


Fig. 33

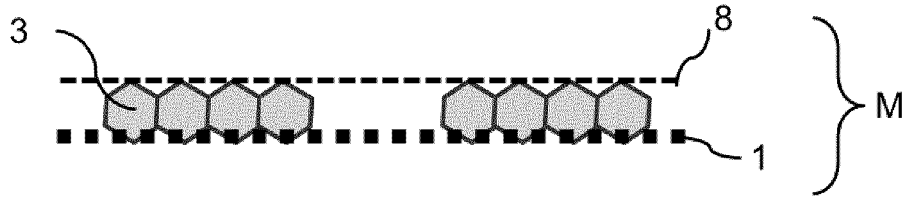


Fig. 34-a

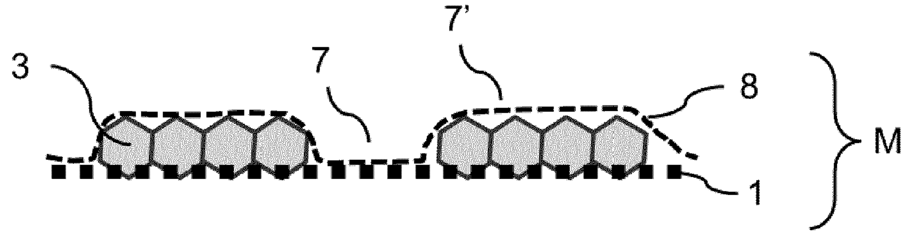


Fig. 34-b

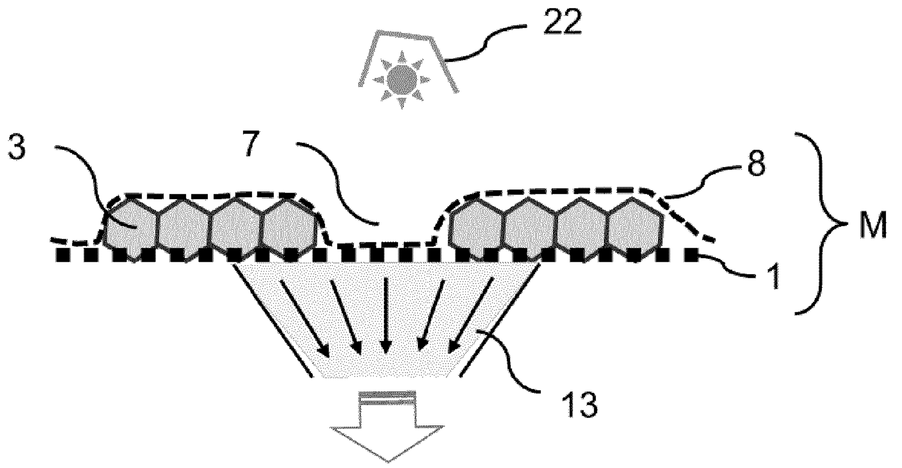
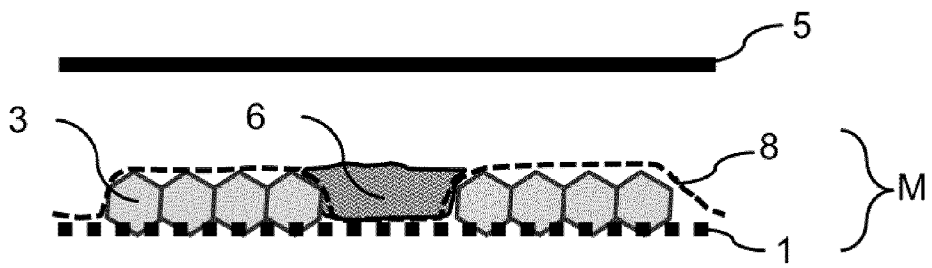


Fig. 35



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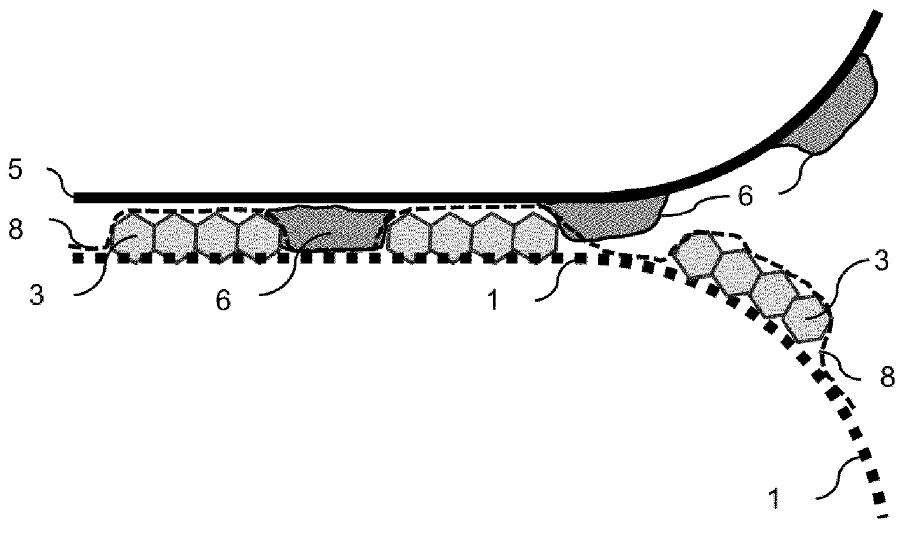


Fig. 37

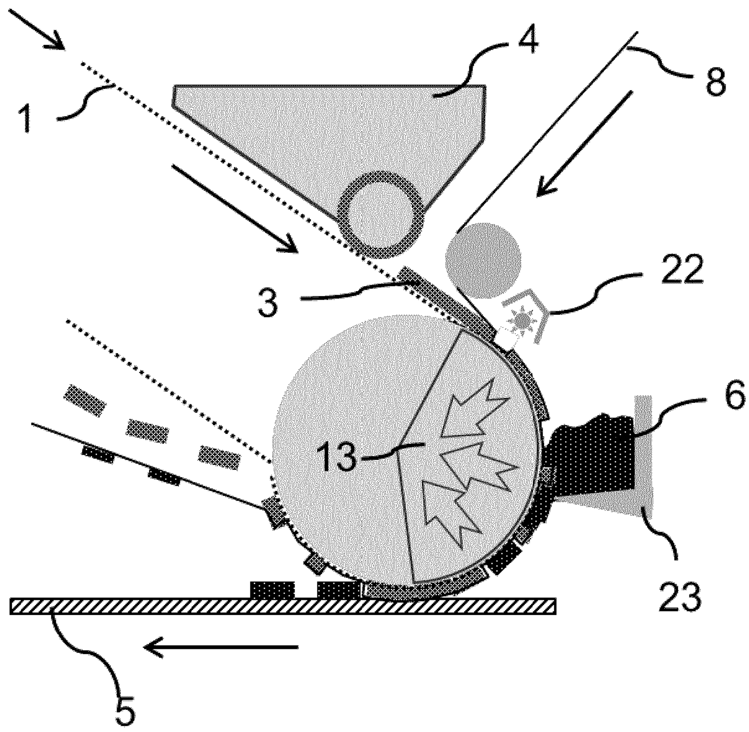


Fig.38

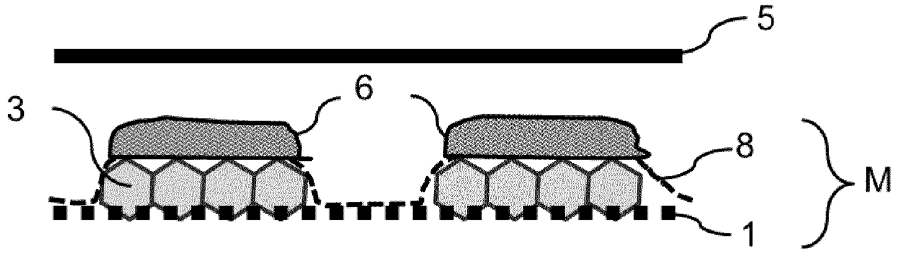


Fig.39

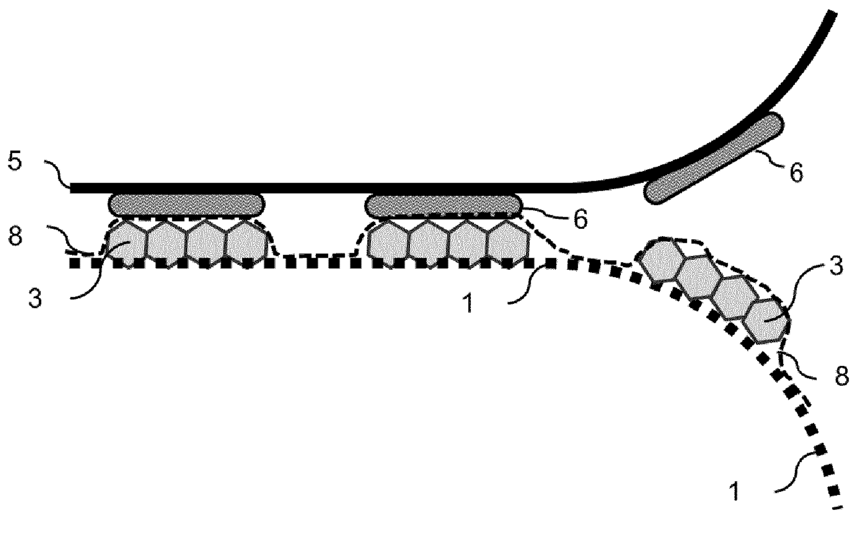


Fig. 40

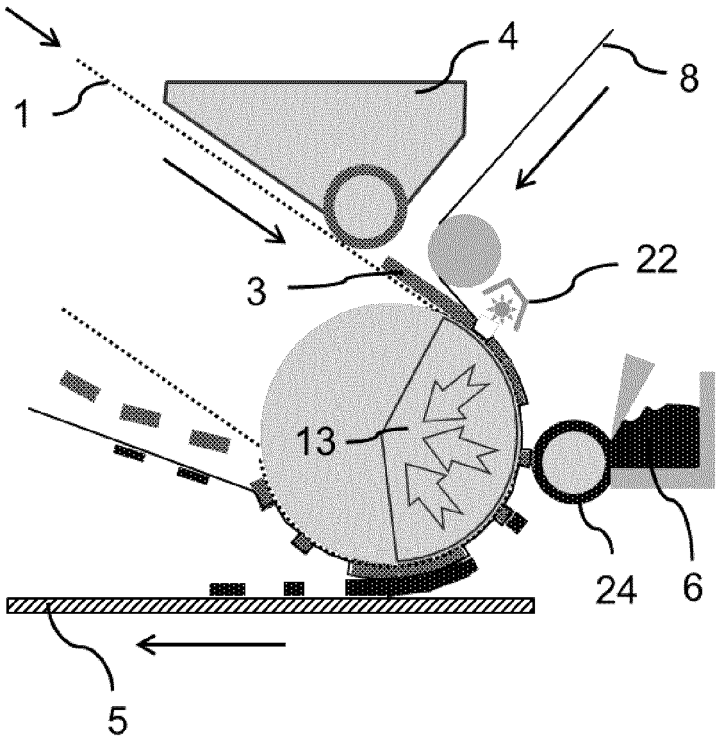
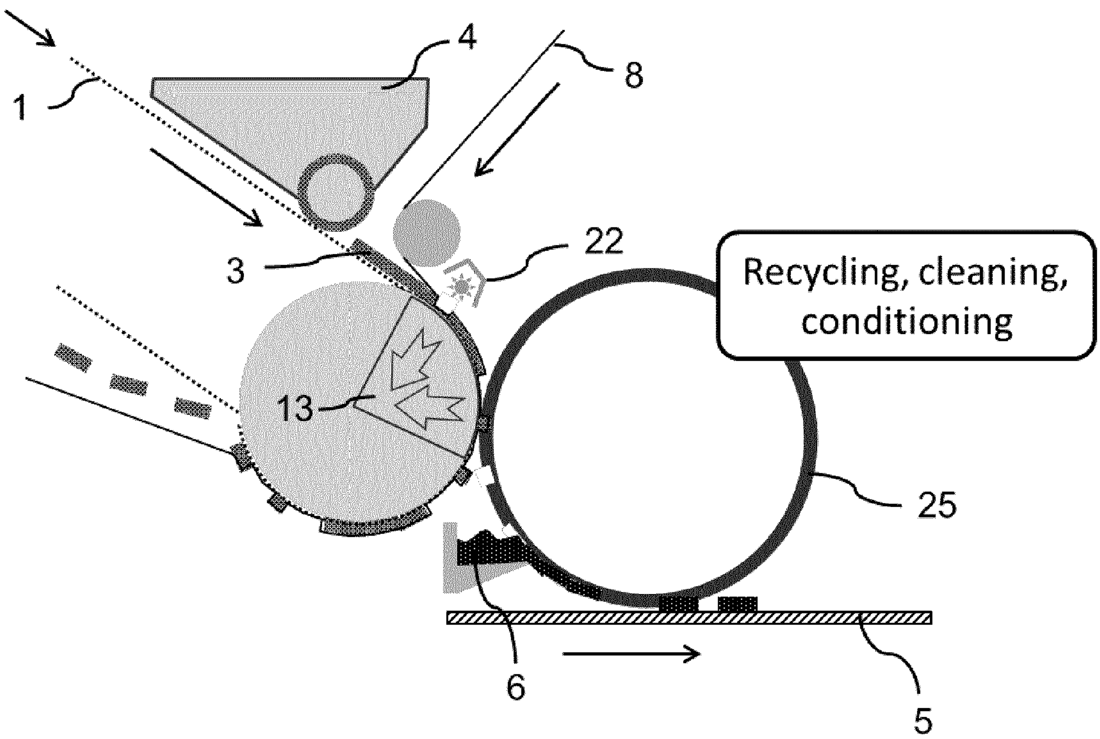


Fig. 41


4
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Recycling, cleaning, conditioning
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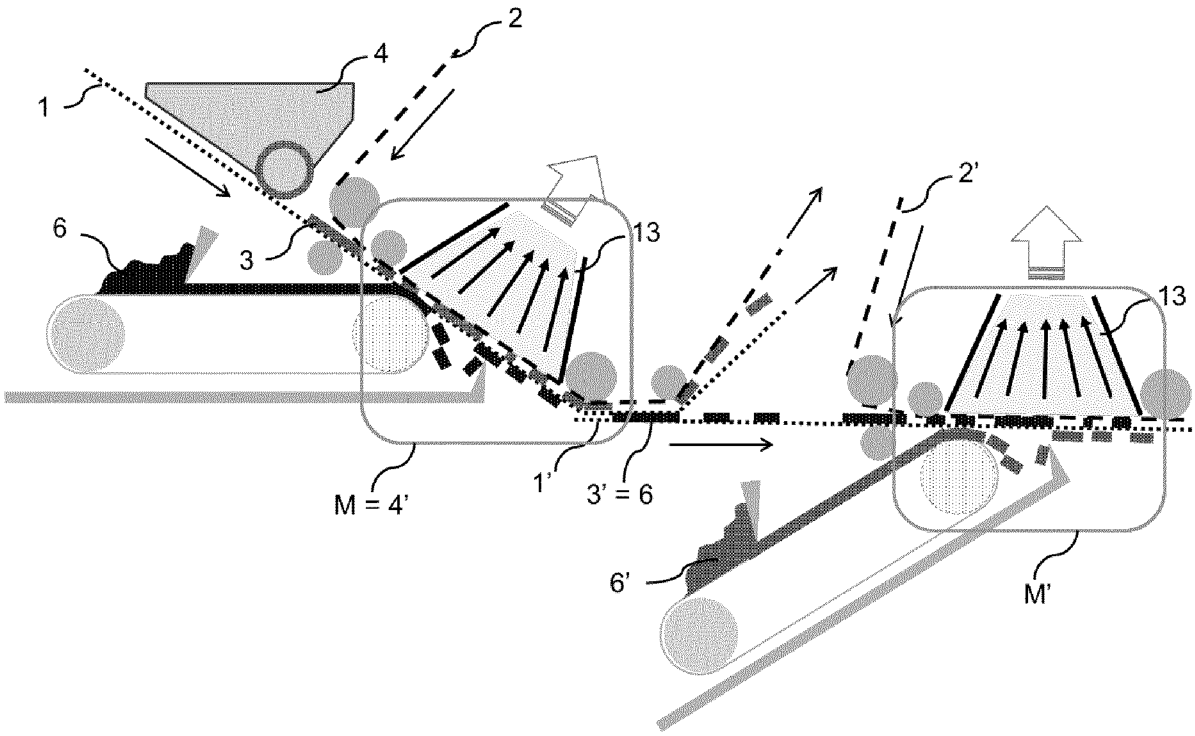
Fig. 42


2
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1
2'
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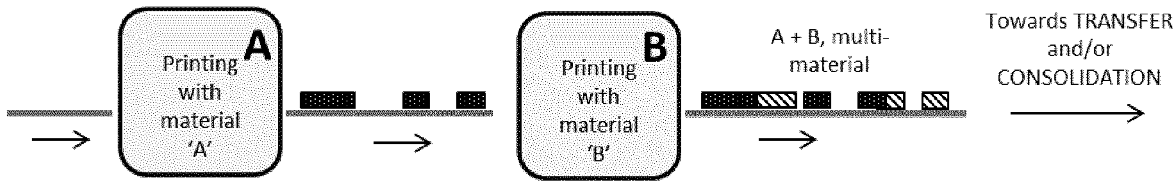
3
13
13
M = 4'
1'
3' = 6
6'
M'

Fig. 43



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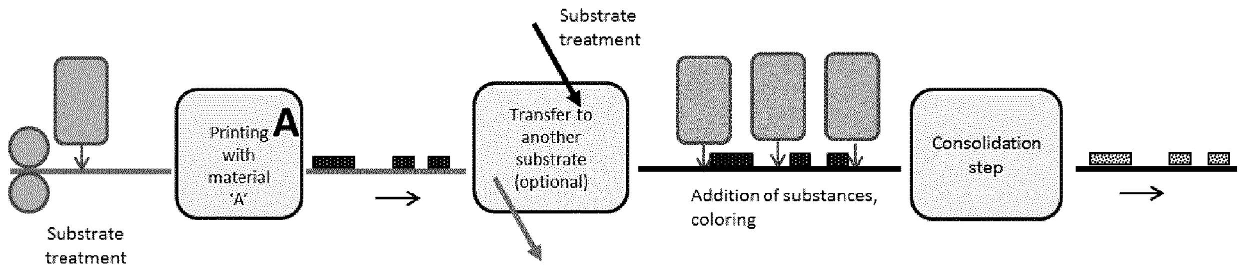
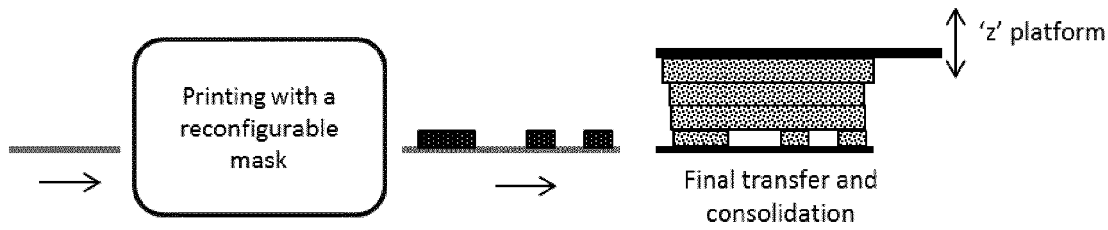


Fig. 45



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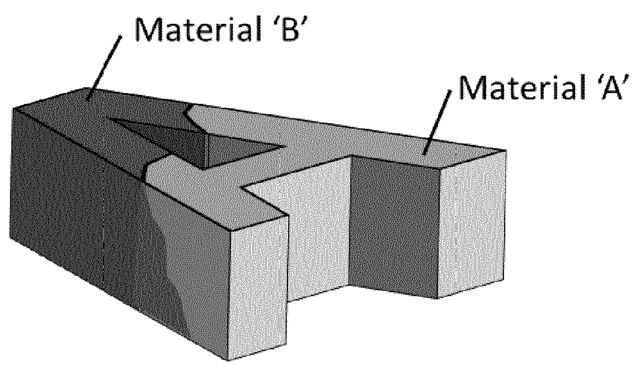

Fig. 47

REFERENCES CITED IN THE DESCRIPTION

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- WO 2007026541 A1 **[0043]**
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