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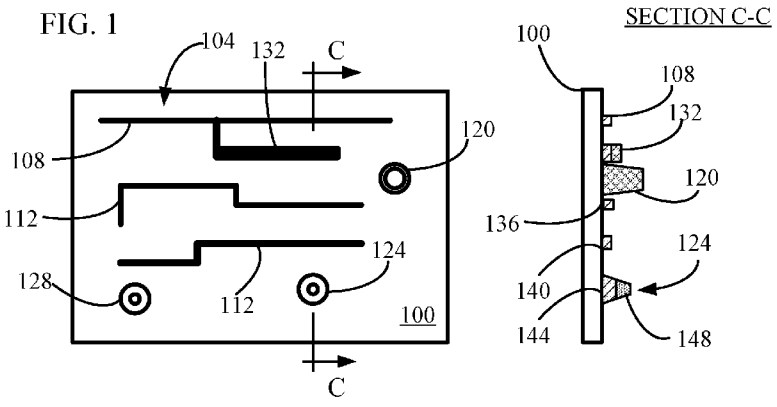
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(54) Title: PRINTING HIGH ASPECT RATIO PATTERNS

FIG. 1



(57) Abstract: Described are an apparatus and a method for printing a high aspect ratio and/or specific vertical geometry pattern. The apparatus operates in a multi-pass printing mode and includes one or more paste dispensing mechanism configured to dispense a high viscosity paste to form a pattern on a substrate. At least one paste dispensing mechanism is configured to dispense the paste to a segment of the pattern printed at an earlier pass. The paste is dispensed to the relevant segment of the pattern earlier printed before the paste printed at the earlier made pass is dry or what is termed "wet- on-wet" printing.

PRINTING HIGH ASPECT RATIO PATTERNS

TECHNOLOGY FIELD

[001] The apparatus and method relate to the field of printed electronics and in particular to printing high aspect ratio patterns of conductors and components.

BACKGROUND

[002] Printed electronics is a novel recently developed electronics production method. It is a relatively low cost production method allowing flexible placement of passive and active electronic components including resistor, capacitors, inductors and electrical current conductors or simply conductors. Different materials in paste form are used to vary properties such as for example resistance, of the printed conductors and printed components.

[003] One of the primary printing methods for producing conductive patterns on different types of substrates, particularly for features larger than about 100 microns, is screen printing. In screen printing a paste is squeezed through a stencil bearing the desired pattern. When conductive patterns are printed the paste can contain metal particles, such as silver and copper particles or organic conductive materials. Such pastes are usually applied to a substrate to form a patterned layer. The patterned layer then can be dried and transferred to another carrier or fired to remove the organic and inorganic solvents. Some of the difficulties encountered by screen printing include a poor ability to form high-aspect ratio patterns and in particular conductor lines. To get a desired cross section the conductors are increased in their width. Reduction of width of a printed conductor could enhance the density of the electronic circuits packaging, it also increases the conductor resistance and limits current carrying capability in fine conductors.

GLOSSARY

[004] Aspect ratio – as used in the current disclosure aspect ratio means a ratio between the height (h) of a printed feature to the width (w) or diameter (d) of the printed feature. High aspect ratio means that the printed pattern could have an aspect ratio of more than 0.5, 1.0, 2.0, 5.0 or more.

[005] Vertical geometry pattern - as used in the current disclosure vertical geometry pattern means a printed pattern extending from the surface of the substrate in a direction generally perpendicular to the substrate surface. Vertical geometry pattern can also be described for "point like" patterns in terms of geometric 3D shape e.g. cube, cylinder, cone, pyramid etc. or for line patterns in terms of cross section (trapezoidal, rectangular, triangular etc.).

BRIEF SUMMARY

[006] Described are an apparatus and a method for printing a high aspect ratio and/or specific vertical geometry pattern. The apparatus operates in a multi-pass printing mode and includes a paste dispensing mechanism configured to dispense a high viscosity paste to form in a first printing pass a pattern on a substrate and at least one additional paste dispensing mechanism configured to dispense on the same substrate an identical or a different paste to at least a segment of the pattern printed at the first pass such as to change in a second, usually non-contact printing pass the thickness of the segment of the pattern printed at the first pass. The paste dispensing mechanism configured to dispense the paste to a segment of the pattern printed at the first pass dispenses the paste to the relevant segment of the pattern earlier printed before the paste printed at the first pass is dry or what is termed "wet-on-wet" printing. In some examples, the apparatus could include more than two paste dispensing mechanisms with each of the mechanisms configured to dispense the same or a different paste.

[007] The pastes dispensed or printed at different printing passes feature a viscosity sufficient to support minimal slumping between layers of pastes deposited wet-on-wet at different passes. Printed tests conducted by the author of the disclosure show that layers of paste deposited or printed at different passes feature good adhesion between themselves after drying/firing. Non-contact printing techniques support printing on "tacky" surfaces with poor adhesion.

[008] Dispensing the paste and printing the pattern "wet-on-wet" facilitates accurate placement of the second and additional paste layers, since thermal processing of the printed layer, for example drying of the paste, would inevitably generate printed pattern distortions and complicate the second printed layer registration. The wet-on-wet printing process is free of this drawback.

[009] The apparatus also includes one or more printing devices. The printing devices could print according to different printing techniques. For example, a printing device could be configured to print the pattern printed at the first printing pass by a first printing technique and to print the pattern to be printed at the second typically non-contact printing pass by a second printing technique. The first printing technique and the second printing technique could be identical or different printing techniques Additional printing passes could use the same or additional printing techniques.

[010] The apparatus includes a substrate support mechanism. The substrate support mechanism is configured to support the substrate and displace it, if desired, in course of the first and the second printing pass. For printing at the second or third or other printing passes, usually non-contact additional printing passes, the substrate support mechanism maintains the substrate in a position identical to the position of the first printing pass. Alternatively, the paste dispensing mechanisms with the corresponding printing devices could be displaced.

[011] The paste dispensing mechanisms dispense the paste in an amount sufficient to form the pattern to be printed. The paste could be an electrically conductive paste and include C, Cu, Ag, and Au particles or a conductive polymer paste. The apparatus prints the pattern at the first printing pass by a first paste and the pattern printed at the second pass by a paste different from the first paste or second paste.

The second paste could be different from the first paste in at least one paste property.

[012] The pattern to be printed could include segments and features of different aspect ratio. The segments and features of the pattern could be conductors or tracks conducting electricity and stubs of different cross section such as pyramidal, cylindrical, conical and other cross sections. Each of the features could include multiple paste layers printed at different printing passes with pastes having different properties.

LIST OF FIGURES AND THEIR BRIEF DESCRIPTION

[013] FIG. 1 is a schematic illustration of an example of a substrate with printed on it a pattern including segments of different aspect ratio;

[014] FIG. 2 is a schematic illustration of a printing apparatus according to an example; and

[015] FIG. 3 is a schematic illustration of another example of a printing apparatus.

DETAILED DESCRIPTION

[016] The ability to print high aspect ratio patterns and in particular patterns including electrically conductive patterns could support the combination of thinner, higher signal conducting conductors or tracks and thicker electric power supplying conductors or tracks printed on the same substrate. Different components could be mounted or connected to segments with different segment thickness. Segments with different segment thickness could increase the packaging density, improve thermal dissipation, lower electronic circuit assembly costs, reduce the number of interconnections and improve the product reliability.

[017] Reference is made to FIG. 1, which is a schematic illustration of an example of a substrate with a printed on it pattern including segments of different aspect ratio. Substrate 100 could include a pattern 104 of conductors or tracks 108, 112 and 116 and a number of pyramidal, conical, cylindrical or other cross section

stubs 120, 124 and 128. Each conductor 108, 112, 116 and each stub 120, 124, 128 could be of different aspect ratio or vertical geometry and could include layers of different materials. For example, the conductors could have a width of 20 – 50 micron and height of 60 – 150 micron and the stubs could have a diameter of 30 - 80 micron and height of 60-150 micron.

[018] Substrate 100 could be made from metal, plastic or other material. Substrate 100 could be a rigid or flexible substrate. A segment 132 of conductor 108 and stub 124 could include layers printed by pastes including different materials. For example, layer 136 of conductor 112 could be from a first material and layer 140 of conductor 112 could be from a second material. In a similar way layer 144 of stub 124 could be from a first material and layer 148 could be from a third material. Stub 120 could be deposited or printed entirely from the second material.

[019] FIG. 2 is a schematic illustration of a printing apparatus according to an example. Apparatus 200 is configured for printing a high aspect ratio and/or specific vertical geometry patterns and generally prints the high aspect ratio and/or specific vertical geometry patterns in a number of printing passes. Apparatus 200 could use a similar or different printing techniques and mechanisms for each pass. Apparatus 200 includes a paste dispensing mechanism 204 configured to dispense a high viscosity paste to form in a first printing pass a pattern 104 or a different pattern on substrate 100. Apparatus 200 includes an additional paste dispensing mechanism 208 configured to dispense on substrate 100 a paste to at least a segment of pattern 104, for example, segment 132 or stub 124 (FIG. 1) of pattern 104 printed at the first pass to change in a second typically non-contact printing pass the thickness of the segment of the pattern printed at the first pass. A substrate support mechanism 212 is configured to support substrate 100 and displace it, if desired, in course of the first and the second printing pass and the entire printing process. Practically, the height of the conductors and stubs i.e. printed features is a function of the number of printing passes made. Generally, a relatively large number of passes could be made and the different high aspect ratio features could be printed.

[020] Apparatus 200 is configured to print segments of pattern 104 or the entire pattern 104 printed at the first printing pass by a printing device 216 operating or printing according to a first printing technique. The printing technique could be for example, such as screen printing, PTP technique disclosed in US Patent # 8,652,872 and US pending patent application No. 2011/0197965 to the same assignee and the same inventor and a modification of the PTP technique, LIFT ((Laser Induced Forward Transfer) or MAPLE (matrix-assisted pulsed laser evaporation) transfer printing techniques. For the second printing pass, substrate support mechanism 212 maintains substrate 100 in a position identical to the position of the first printing pass. In one example, maintenance of substrate 100 in a position identical to the position of the first printing pass could be achieved by displacing support 212 with fixed on it substrate 100 between unit 224 containing paste dispensing mechanism 204 and printing device 216 and unit 228 containing paste dispensing mechanism 208 and printing device 220. In another example, support 212 with fixed on it substrate 100 remains static in course of the first and second printing pass and units 224 and 228 are displaced to print pattern 104. The accuracy of units 224 and 228 displacement and registration between different printing passes could be supported by known in the art methods.

[021] Apparatus 200 is configured to print segments of pattern 104 printed at the second typically non-contact printing pass by a second printing device 220 operating or printing according to a second printing technique. The second printing technique could be for example, such as PTP technique disclosed in US Patent No. 8,652,872 and US pending patent application No. 2011/0197965 to the same assignee and the same inventor, LIFT or MAPLE transfer printing.

[022] FIG. 2 illustrates the first paste dispensing mechanism 204 and second printing device 216 and paste dispensing mechanism 204 and second printing device 220 being different from each other and accordingly printing employing a first printing technique and a second printing technique, which could be different printing techniques. In some examples the first printing technique and the second printing technique could be identical printing techniques and printing devices 216 and 220 could be identical printing devices.

[023] The paste dispensing mechanism 208 configured to dispense on substrate 100 a paste to at least a segment of the pattern printed at the first pass dispenses the paste to the segment of the pattern earlier printed before the paste printed at the first pass is dry or what is known as "wet-on-wet" printing. The printing pastes used in the current process typically, have a viscosity of 200 cps to 1000 cps and feature minimal slumping between the first printing pass and the second printing pass. Printed tests conducted by the author of the disclosure show that layers of paste deposited or printed at different passes still feature good adhesion between the substrate and the paste layers printed or deposited in successive prints.

[024] Dispensing the paste and printing the pattern in accordance with the wet-on-wet printing technique, facilitates accurate placement of the second and additional paste layers, since thermal processing of the printed layer, for example drying of the paste, would inevitably generate printed pattern distortions and complicate the second printed layer registration. The wet-on-wet printing process is free of this drawback. Registration of the second and additional paste layers is performed through simple movements in X – Y directions of the paste dispensing mechanisms 204 and 208 and printing mechanisms 216, 220 since substrate 100 maintains its fixed position through the whole printing process. Although in some examples, support 112 with substrate 100 is displaced, units 224 and 228 maintain their fixed position.

[025] The paste dispensing mechanism 204 of apparatus 200 is configured to dispense the paste for the first printing pass in amount sufficient to form a pattern with a thickness in the range of 5 to 50 micron and to form a pattern of lines that have a width in the range 10 to 150 micron. Typically, the paste is a conductive paste and it is selected from a group of pastes consisting of C, Cu, Ag, Au and Conductive polymer pastes. In one example, apparatus 200 could print pattern 104 at the first and the second pass by using identical paste. In some examples, apparatus 200 could prints pattern 104 at the first printing pass by a first paste and the whole pattern 104 or some segments of the pattern 104 could be printed at the second typically non-contact pass by a paste different from the first paste or second paste. The second paste could be different from the first paste in at least one

property. For example, it could have a different conductive material or different filler.

[026] In one example, apparatus 200 could print at the second usually non-contact printing pass a pattern 104 which is identical to the pattern printed at the first printing pass, i.e. the layout of the conductors and stubs and their width would be identical to the width of the pattern printed at the first printing pass. In another example, apparatus 200 could print at the second printing pass a pattern which is different from the pattern printed at the first printing pass, i.e. the layout of the conductors and stubs and their width could be different from the pattern printed at the first printing pass.

[027] The method of printing a high aspect ratio and/or specific vertical geometry pattern will be described now. Initially, a substrate 100 to be printed upon is provided and mounted on support 212 of printer 200 (Block 304). At the first printing pass, paste dispensing mechanism 204 applies a high viscosity paste to substrate 100 in an amount sufficient to form pattern 104 on substrate 100 (Block 308). Printing device 216 becomes operative (Block 312) to print or form pattern 104 on substrate 100. Printing device 216 could print pattern 104 at the first printing pass by a first printing technique. The first printing technique could be for example, such as screen printing, PTP technique disclosed in US Patent No. 8,652,872 and US pending patent application No.2011/0197965 to the same assignee and the same inventor, LIFT or MAPLE transfer printing techniques and their modifications.

[028] Following completion of the first printing pass, paste dispensing mechanism 208 applies a high viscosity paste in an amount sufficient to form a second printing pass (Block 316). Paste dispensing mechanism 208 deposits an additional layer on at least a segment of pattern 104 printed at the first pass, such as to change the thickness of the segment of the pattern printed at the first pass. The change in thickness will increase the aspect ratio of the segment and a higher aspect ratio pattern will be printed. Paste dispensing mechanism 208 applies or dispenses the paste to the segment of the pattern earlier printed, before the paste printed at the first pass becomes dry or what is termed as wet-on-wet" printing technique.

[029] The advantage of using the wet-on-wet printing technique is in that it facilitates accurate placement of the second and additional paste layers, since thermal processing of the printed layer, for example drying of the paste, would inevitably generate printed pattern distortions and complicate the second printed layer registration. The wet-on-wet printing process is free of this drawback. Registration of the second and additional paste layers could be performed, if necessary, through simple movements in X – Y directions of the paste dispensing mechanisms 204 and 208 and printing mechanisms 216, 220 since substrate 100 maintains its fixed position through the whole printing process.

[030] Printing device 220 becomes operative (Block 320) to print or form a high aspect ratio segment 132 (FIG. 1) of pattern 104 on substrate 100. Printing device 220 could print segment 132 of pattern 104 by a printing technique identical to the first pass printing technique or a technique different from the first pass printing technique. The second typically non-contact printing technique could be for example, such as PTP technique disclosed in US Patent No. 8,652,872 and US pending patent application No. 2011/0197965 to the same assignee and the same inventor or a modification or the PTP technique, LIFT or MAPLE transfer printing techniques or a modification of LIFT and MAPLE transfer printing techniques.

[031] The pattern printed at the first printing pass could have a thickness in the range of 5 to 50 micron and form conductor lines with a width in the range 10 to 150 micron. At the second and further typically non-contact printing passes the printed features could be of identical width or a smaller width, for example, a smaller width could assist to form point like bumps with trapezoidal or conical vertical cross section.

[032] According to the method, different conductive pastes could be used for printing at the first and the second printing passes. These could be pastes consisting of C, Cu, Ag, Au particles and conductive polymer pastes. In one example, the pattern printed at the first and the second pass could be printed by identical paste. In another example, the pattern printed at the first pass is printed by a first paste and the pattern printed at the second pass is printed by a paste different from the first paste or second paste. The second and other pastes used in

subsequent printing passes could be different from the first paste in at least one property.

[033] According to the method, the pattern printed at the second printing pass could be identical or at least partially overlap the pattern printed at the first printing pass. According to another example the pattern printed at the second printing pass could be different from the pattern printed at the first printing pass. According to the printing method disclosed the additional printed layer (or plurality of layers) printed at the second or additional printing passes over a segment of the earlier printed pattern change the thickness of the resulting printed pattern and increases the aspect ratio of the printed pattern.

[034] The method and apparatus disclosed support printing of high aspect ratio of different patterns. Optimizing the combination of a number of printing techniques and suitable viscous printing paste supports realization of high-aspect ratio pattern printing. The printing method is "wet on wet" and among others it is facilitated by proper selection paste viscosity to provide minimal slumping between the successive prints. The advantage of the wet-on-wet printing process is in that the registration between successive paste dispensing and printing processes is a simple operation. In spite of multiple printing passes the method supports good adhesion between the different pastes and material printed in successive prints, including printing on "tacky" surfaces with low adhesion.

[035] The method and apparatus support printing at lower costs, along with higher productivity.

[036] The disclosure provided a number of examples of the method and apparatus, however, it should be noted that the method and apparatus can be practiced otherwise than as specifically illustrated and described without departing from the spirit or scope of the claims.

What is claimed is:

1. A method of printing a high aspect ratio and/or specific vertical geometry pattern comprising:

applying in a first printing pass a high viscosity paste to form a pattern on a substrate;

applying in a second non-contact printing pass a high viscosity paste to at least a segment of the pattern printed at the first pass to change thickness of the at least the segment of the pattern printed at the first pass; and

wherein applying a paste to at least a segment of the pattern earlier printed is, before applying any thermal process on the paste printed at the first pass.

2. The method according to claim 1 wherein the pattern printed at the first printing pass is printed by a first printing technique.

3. The method according to claim 1 wherein the pattern printed at the second non-contact printing pass is printed by a second printing technique.

4. The method according to any one of claims 2 and 3 wherein the first printing technique and the second printing technique are identical printing techniques.

5. The method according to any one of claims 2 and 3 wherein at least one of the printing techniques is a modification of LIFT (laser induced forward transfer) printing technique.

6. The method according to any one of claims 2 and 3 wherein at least one printing technique is a modification of PTP (Pattern Transfer Printing) technique.

7. The method according to claim 1 wherein the pattern printed at the first printing pass has a thickness in range of 5 to 50 micron.

8. The method according to claim 1 wherein the pattern printed at the first printing pass includes lines (conductors) with a width in range 10 to 150 micron.

9. The method according to claim 1 wherein the pattern includes "point like" bumps.

10. The method according to claim 9 wherein the bumps have a conical shape.

11. The method according to claim 1 wherein the paste is a conductive paste.

12. A method according to claim 11 where the paste is at least one of a group of pastes consisting of C, Cu, Ag, Au and conductive polymer pastes.

13. The method according to claim 1 wherein the pattern printed at the first and the second pass is printed by identical paste.

14. The method according to claim 1 wherein the pattern printed at the first pass is printed by a first paste and the pattern printed at the second pass is printed by a paste different from the first paste (or second paste).

15. The method according to claim 1 wherein a first paste and the paste different from the first paste (second paste) are different in at least one property.

16. The method according to claim 1 wherein the pattern printed at the second printing pass has a width different from the width of the pattern printed at the first printing pass.

17. The method according to claim 1 wherein the pattern printed at the second printing pass has a width identical to the width of the pattern printed at the first printing pass.

18. The method according to claim 1 wherein the pattern printed at the second printing pass at least partially overlaps the pattern printed at the first printing pass.

19. The method according to claim 1further comprising printing at least one additional layer (a plurality of layers) over at least a segment of the pattern printed at the second printing pass to change thickness of earlier printed layers.

20. The method according to claim 19 wherein the at least one additional layer is printed by one of a group of printing techniques consisting of a printing technique identical to first and second printing technique and a printing technique different from the first and second printing techniques.

21. An apparatus for printing a high aspect ratio and/or specific vertical geometry pattern comprising:

a paste dispensing mechanism configured to dispense a high viscosity paste to forma pattern on a substrate at a first printing pass;

a substrate support mechanism configured to support the substrate.

a mechanism for relative displacement of the substrate and/or the paste dispensing mechanism; and

wherein a second printing pass is performed without registration as the substrate support mechanism maintains the substrate in a position identical to the position of the first printing pass.

22. The apparatus according to claim 21 wherein the paste dispensing mechanism configured to dispense on the substrate a paste to at least a segment of the pattern printed at the first pass dispenses the paste to at least a segment of the pattern earlier printed before the paste printed at the first pass is dry.

23. The apparatus according to claim 21 wherein the apparatus is configured to print the pattern printed at the first printing pass by a first printing technique.

24. The apparatus according to claim 21 wherein the apparatus is configured to print the pattern printed at the second printing pass by a second printing technique.

25. The apparatus according to any one of claims 23 and 24 wherein the first printing technique and the second printing technique are identical printing techniques.

26. The apparatus according to any one of claims 23 and 24 wherein the first printing technique and the second printing technique are different printing techniques.

27. The apparatus according to claim 21 wherein the paste dispensing mechanism configured to dispense the paste for the first printing pass dispenses the paste sufficient to form a pattern with thickness in range of 5 to 50 micron.

28. The apparatus according to claim 21 wherein the paste dispensing mechanism configured to dispense the paste for the first printing pass dispenses the paste sufficient to form a pattern of lines that have a width in range 10 to 150 micron.

29. The apparatus according to claim 21 wherein the (conductive) paste is selected from a group of pastes consisting of C, Cu, Ag, Au and Conductive polymer pastes.

30. The apparatus according to claim 21 wherein the apparatus prints the pattern at the first and the second pass by identical paste.

31. The apparatus according to claim 21 wherein the apparatus prints the pattern at the first printing pass by a first paste and the pattern printed at the second pass by a paste different from the first paste (different paste; second paste).

32. The apparatus according to claim 31, wherein the first paste and the paste different from the first paste (second paste) are different in at least one paste property.

33. The apparatus according to claim 21 wherein the apparatus prints the pattern at the second printing pass has a width different from the width of the pattern printed at the first printing pass.

34. The apparatus according to claim 21 wherein the pattern printed at the second printing pass has a width identical to the width of the pattern printed at the first printing pass.

35. The apparatus according to claim 21 wherein the pattern includes "point like" bumps.

36. The apparatus according to claim 35 wherein the bumps have a conical shape.

37. An apparatus for printing a high aspect ratio and/or specific vertical geometry pattern comprising:

at least one paste dispensing mechanism configured to dispense a high viscosity paste to forma pattern on a substrate at a first and subsequent printing passes; and

wherein in order to avoid distortions caused by thermal processing of the paste and the substrate the paste dispensing mechanism dispenses the paste for the subsequent printing passes over the wet paste dispensed at a previous printing pass.

38. The apparatus according to claim 37 further comprising a printing mechanism configured to print the pattern printed at the first printing pass by a first printing technique.

39. The apparatus according to claim 37 further comprising at least one additional printing mechanism configured to print the pattern printed at the subsequent printing passes by a printing technique different from the first printing technique.

40. The apparatus according to claim 37 further comprising:

a substrate support mechanism configured to support the substrate; and a mechanism for relative displacement of the substrate and/or the paste dispensing mechanism.

41. A method for printing a high aspect ratio and/or specific vertical geometry pattern comprising:

providing a substrate and at least one paste dispensing mechanism configured to dispense a high viscosity paste to form a pattern on a substrate at a first and subsequent printing passes; and

in order to avoid distortions caused by thermal processing of the paste and the substrate the paste dispensing mechanism dispensing the paste for the subsequent printing passes over the wet paste dispensed at a previous printing pass.

42. The method according to claim 41 further comprising employing a printing mechanism configured to print the pattern printed at the first printing pass by a first printing technique.

43. The apparatus according to claim 41 further comprising employing at least one additional printing mechanism configured to print the pattern printed at the subsequent printing passes by a printing technique different from the first printing technique.

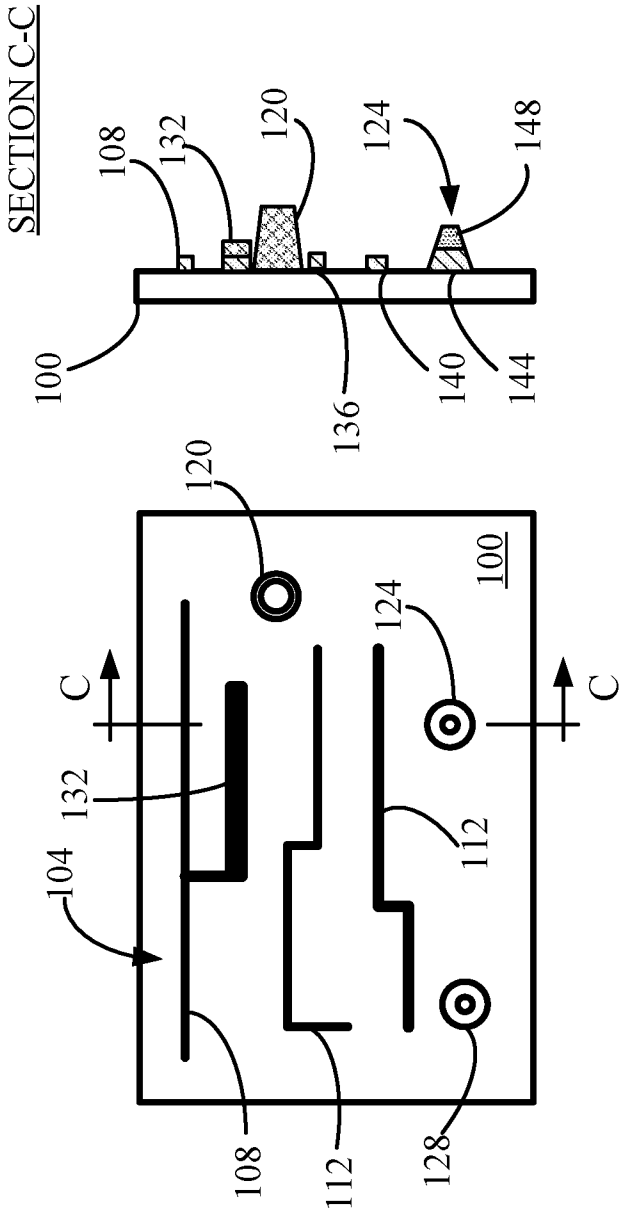

SECTION C-C
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FIG. 1

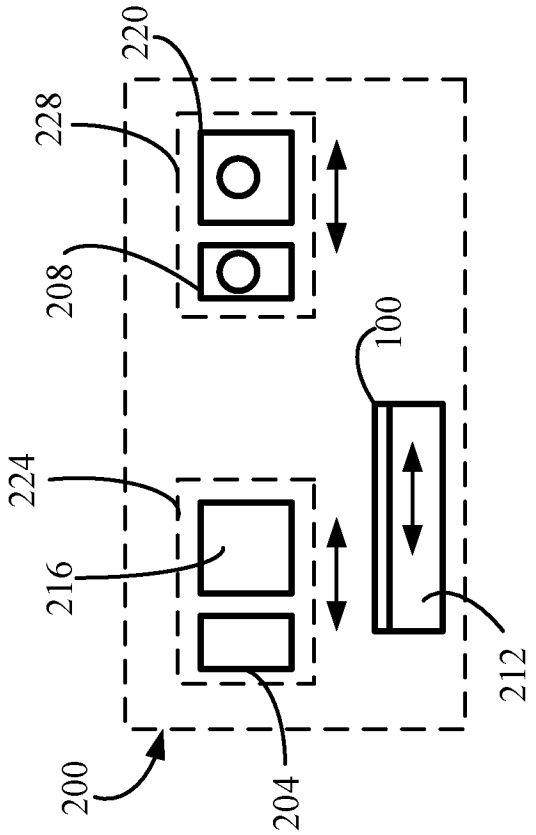


FIG. 2

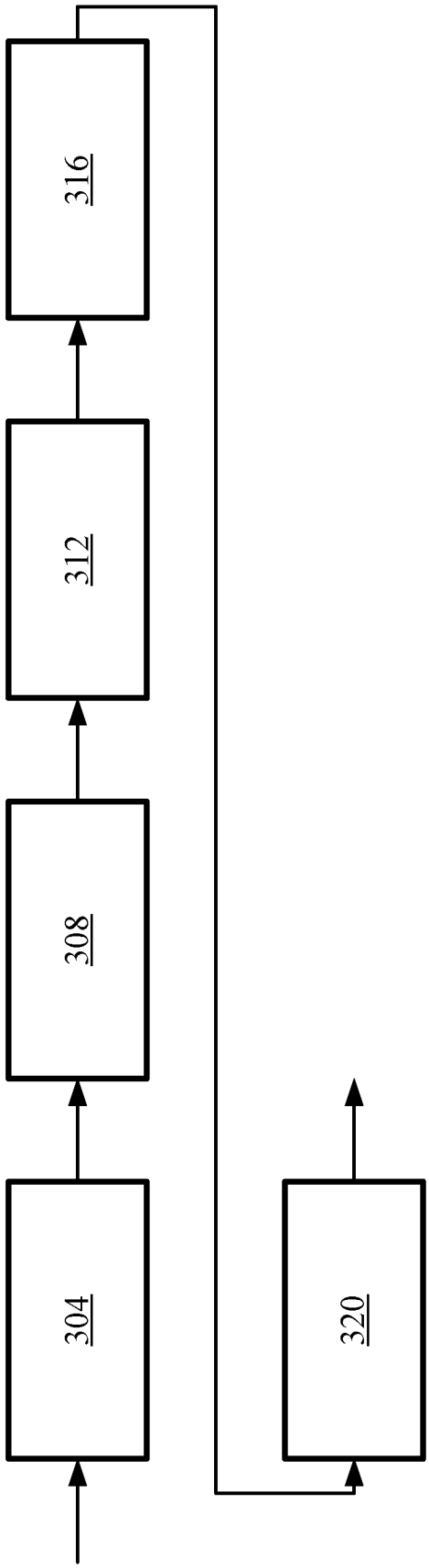


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL 15/00013

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B05D 1/38, B41M 5/40, C09D 17/00, H05K 3/12 (2015.01)
CPC - B05D 1/38, B41M 5/40, B41M 7/0054, C09D 17/00, H05K 3/12
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8)- B05D 1/38, B41M 5/40, C09D 17/00, H05K 3/12 (2015.01);
CPC- B05D 1/38, B41M 5/40, B41M 7/0054, C09D 17/00, H05K 3/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC- 8/445, 106/241, 136/256, 427/96.1, 427/466, 428/32.6, 428/195.1, 428/201, 428/901, 429/122;
Patents and NPL (classification, keyword; search terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Pub West (US EP JP WO), Pat Base (AU BE BR CA CH CN DE DK EP ES FI FR GB IN JP KR SE TH TW US WO), Google Patent, Google Scholar, Free Patents Online; search terms: print, paste, viscosity, pass, transfer, pattern, thermal, heat, cure, dry, temperature, pattern, line, circuit, conductor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/0252105 A1 (FORK et al.) 07 October 2010 (07.10.2010), Figs. 10, 15, Table 1; para [0027]-[0033], [0035], [0041]-[0047], [0057], [0058], [0066]-[0070], [0076], [0080]	1-20, 41-43
Y	US 2013/0176699 A1 (TONCHEV et al.) 11 July 2013 (11.07.2013), para [0011]-[0098]	1-20, 41-43
Y	US 2009/0104383 A1 (TERAO et al.) 23 April 2009 (23.04.2009), para [0012]-[0165]	1-20, 41-43
Y	US 2001/0029665 A1 (HASHIMOTO et al.) 18 October 2001 (18.10.2001), para [0022]-[0072]	1-20, 41-43
Y	US 5,362,513 A (SHIMADA et al.) 08 November 1994 (08.11.1994), col 1, ln 52 to col 9, ln 14	1-20, 41-43

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 July 2015 (30.07.2015)	19 AUG 2015

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL 15/00013

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-20 and 41-43, drawn to a method.

Group II: Claims 21-40, drawn to an apparatus.

-- Please See Extra Sheet --

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-20, 41-43

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL 15/00013

Box No. III, Observations where unity of invention are lacking,

Special Technical Features

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group II does not require a method comprising applying in a second non-contact printing pass a high viscosity paste to at least a segment of the pattern printed at the first pass to change thickness of the at least the segment of the pattern printed at the first pass; and wherein applying a paste to at least a segment of the pattern earlier printed is, before applying any thermal process on the paste printed at the first pass, as required by Group I.

Group I does not require an apparatus comprising a substrate support mechanism configured to support the substrate; a mechanism for relative displacement of the substrate; a second printing pass is performed without registration as the substrate support mechanism maintains the substrate in a position identical to the position of the first printing pass, as required by Group II.

Shared Common Features

The only feature shared by Groups I and II that would otherwise unify the groups is printing a high aspect ratio and/or specific vertical geometry pattern; applying in a first printing pass and a second printing pass a high viscosity paste to form a pattern on a substrate; wherein in order to avoid distortions caused by thermal processing of the paste and the substrate the paste dispensing mechanism dispenses the paste for the subsequent printing passes over the wet paste dispensed at a previous printing pass. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated US 2010/0252105 A1 to Fork, et al. (hereinafter 'Fork').

Fork discloses printing a high aspect ratio and/or specific vertical geometry pattern (para [0006], [0045], [0072]), comprising: applying in a first printing pass and a second printing pass a high viscosity paste to form a pattern on a substrate (para [0028], [0043], [0073]); wherein in order to avoid distortions caused by thermal processing of the paste and the substrate (para [0036], [0072], pitch of each dispensed material adjusted to compensate.) the paste dispensing mechanism dispenses the paste for the subsequent printing passes over the wet paste dispensed at a previous printing pass (Fig. 15; para [0061], [0074], [0076], multilayer stack of paste dispensed from individual outlets, 126... wherein the dispensed pastes are exposed to heat treatment such as drying... thus the dispensed multilayer stack of pastes are wet.).

As the technical feature was known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups.

Groups I and II therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.