

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
29 December 2005 (29.12.2005)

PCT

(10) International Publication Number
WO 2005/123409 A1

- (51) International Patent Classification⁷: **B41M 5/26, 5/28**
- (21) International Application Number:
PCT/SG2005/000162
- (22) International Filing Date: 24 May 2005 (24.05.2005)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
10/869,389 15 June 2004 (15.06.2004) US
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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**
— with international search report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.



WO 2005/123409 A1

(54) Title: FORMULATION FOR PRINTING ORGANOMETALLIC COMPOUNDS TO FORM CONDUCTIVE TRACES

(57) Abstract: A formulation able to be printed onto a substrate for use in forming a desired conductive trace layout on the substrate, the formulation including at least one organometallic compound dissolved in at least one organic solvent, whereby metal from the organometallic compound is deposited on the substrate when the organometallic compound is heated.

FORMULATION FOR PRINTING ORGANOMETALLIC COMPOUNDS
TO FORM CONDUCTIVE TRACES

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Field Of The Invention

The present invention relates to printed circuits or devices in the electronics industry, and in particular, to a formulation for printing organometallic compounds for use in forming conductive traces on substrates.

Background Of The Invention

Laser-assisted selective deposition of conductive metals is an attractive approach to the customization needs of the electronics industry. For more than about 20 years much effort has been undertaken in attempting to produce acceptable individual metal features in electronic components or circuits by a direct laser writing process. Normally, a device is prepared for subsequent direct laser writing by a spin-coating process which applies a uniform film over a surface.

Spin-coating is a known process used for applying a thin film, such as a metal, to a substrate in the manufacture of circuits. A typical spin-coating process involves depositing a small puddle of a fluid resin onto the center of the substrate and then spinning the substrate at high speed. However, spin-coating processes generally involve a relatively high cost of materials and a further washing process to remove unwanted material.

Another disadvantage of circuit manufacture by direct laser writing is that the width of a deposited metal trace is limited by thermal effects in the laser beam. Presently, even if a laser beam is focused to a diameter of about 20 μm the achievable minimum trace width is about 40 μm .

Another known circuit manufacture process involves etching. A number of variations of etching methods are known, such as wet etching (whereby material is dissolved when immersed in a chemical solution), and dry etching (whereby material is sputtered or dissolved using reactive ions or a vapor phase etchant). However, these methods have significant disadvantages such as a requirement to use a mask of the desired circuit layout pattern that can withstand the etching process. Generally, etching processes and use of masks are considered relatively expensive and require longer turn around times in the manufacture of circuitry.

US 4,574,095 discloses deposition of copper on a substrate by a process in which small palladium clusters or seeds are first deposited on a substrate. Selective deposition of the palladium seeds is accomplished by contacting the substrate with the vapor of a palladium compound and selectively irradiating the complex with light, which can be a laser. The substrate is first covered with photoresist or polymer and selectively irradiated, through a mask, with a pulsed excimer laser. Removal of the polymer occurs in the irradiated area. The film then acts as a seed for plating of copper. This method requires use of a

photoresist and a mask and is a direct laser writing process having the associated disadvantages.

US 4,853,252 discloses transfer of a printed pattern in the manufacture of printed circuit boards. A grainy carrier
5 substance of a coating agent affords a good adhesive foundation in a substrate which is controllable through the use of energy radiation. The coating agent is applied to the surface of the substrate S. A laser is utilized as an energy beam. The focussing of the laser beam L is adjustable,
10 whereby the diameter of the laser beam L at the substrate surface can be set to diameters of between approximately 50 microns to about 400 microns. The coating agent includes individual particles of metal M. The laser beam L is guided over the surface of the substrate S and creates a superficial
15 melting of the substrate. This method requires the conductor pattern to be constructed by chemical metal deposition or by chemical and subsequent galvanic metal deposition and relies on a laser heating process to adhere the coating agent to the substrate.

20 Accordingly, there is need for a printing system which overcomes or at least ameliorates the above-described problems. The present invention addresses this need.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any
25 form of suggestion that such prior art forms part of the common general knowledge.

SUMMARY OF THE INVENTION

According to one broad form of the present invention, there is provided a formulation able to be printed onto a substrate for use in forming a desired conductive trace layout on the substrate, the formulation including at least one organometallic compound dissolved in at least one organic solvent, whereby metal from the organometallic compound is deposited on the substrate when the organometallic compound is heated.

10

This and other objects or advantages of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed description of the embodiments as illustrated in the drawing figures.

15

DESCRIPTION OF THE DRAWINGS

The present invention should become apparent from the following description, which is given by way of example only, of a preferred but non-limiting embodiment thereof, described in connection with the accompanying figures.

20

Fig. 1 is a schematic illustration of a possible optical system for use as part of an embodiment of the present invention.

25

Fig. 2A illustrates a cross-sectional view of an example partially formed printed electronic circuit, produced in accordance with an embodiment of the present invention, showing the substrate and organometallic compound.

Fig. 2B illustrates a cross-sectional view of an example printed electronic circuit, obtained from the partially formed printed electronic circuit illustrated in Fig. 2A, produced in accordance with an embodiment of the present invention, showing the substrate, organometallic compound and deposited conductive trace.

Fig. 3 illustrates a flowchart in accordance with an embodiment of the present invention.

Fig. 4 illustrates a possible arrangement of a system to print an organometallic compound onto a substrate according to an embodiment of the present invention.

Fig. 5 illustrates a DBOS image showing a snapshot of the moment drops are ejected from printer nozzles.

Fig. 6 illustrates print-out examples of the organometallic compound used in Fig. 5 and produced by a Hewlett-Packard deskjet printer on a polyimide substrate.

Fig. 7 illustrates an image of a copper trace formed after laser-induced decomposition, according to an embodiment of the present invention, of the organometallic compound used in Figs. 5 and 6.

Fig. 8 illustrates an image of a copper trace formed after electroless plating, according to an embodiment of the present invention, of the copper trace illustrated in Fig. 7.

25 DETAILED DESCRIPTION OF THE EMBODIMENTS

Before proceeding with the detailed description, it will be appreciated by those skilled in the art of the present invention that the foregoing description of the preferred embodiments of the invention has been presented only for the

purpose of illustration and description and is not intended to be exhaustive or to limit the invention to the precise forms described. Many modifications and variations may be made to the embodiments shown in the Figures without
5 departing from the spirit and scope of the invention.

In a first broad form of the present invention, there is provided a formulation able to be printed onto a substrate for use in forming a desired conductive trace layout on the substrate, the formulation including at least one
10 organometallic compound dissolved in at least one organic solvent, whereby metal from the organometallic compound is deposited on the substrate when the organometallic compound is heated. In an embodiment, the at least one organic solvent is water-miscible and the organometallic compound is
15 water soluble. The organometallic compound is in the form of at least one of an acetate, carboxylate or amine complex. Furthermore, the organometallic compound contains at least one of silver, gold, aluminium, copper or palladium. Additionally, the organometallic compound can include an
20 organic solvent wherein the organic solvent is at least one of a ketone, pentandiol or triol.

In another embodiment, there is provided a chemical solution able to be printed onto a substrate using an inkjet printer and for use in forming a desired metallic trace
25 layout on the substrate, the chemical solution including at least one organometallic compound dissolved in at least one water-miscible organic solvent, whereby metal from the organometallic compound is deposited on the substrate as a result of heating of the substrate by laser light absorbed

near or at an interface between the printed chemical solution and the substrate.

In a third embodiment, there is provided a formulation able to be printed onto a substrate for use in forming a
5 desired conductive trace layout on the substrate. The formulation includes an organometallic compound being less than 50% of the formulation by weight, at least one organic solvent being less than 50% of the formulation by weight and water being more than 50% of the formulation by weight
10 whereby metal from the organometallic compound is deposited on the substrate when the organometallic compound is heated.

In another aspect, inkjet technology is utilised as a microprinting tool. An inkjet printer is used to print organometallic compounds on substrates, such as, but not
15 limited to, glass, polyimide, ceramic, paper, etc. According to this aspect of the invention, a relatively narrow conductive trace width can be achieved, for example, less than or equal to 20 μm . Additionally, the width of the conductive trace is independent from the diameter of a laser
20 beam used to effect deposition of the conductive material, for example, a metal such as copper. By removing the requirement of a mask or a washing process the cost of manufacture of a circuit is significantly reduced. Consequently, the complete circuit manufacture process is
25 simplified and is a cheaper and more convenient dry process.

Furthermore, the total turn around time for the manufacture of a circuit is reduced and the reliability of circuits manufactured by such a dry process is improved. Additionally, a relatively fine or narrow conductive trace

width can be achieved without reliance on masks and etching processes.

According to yet another aspect, by precisely controlling the height of deposited conductive material, the remaining thin film of the organometallic compound can be used as a protective layer to prevent the deposited conductive trace layer from oxidising due to contact with the ambient atmosphere.

Environmental advantages are also realized such as a reduction in the amount or type of various chemicals required to be deposited of, and a reduction in the volume of water required during the manufacturing process.

Furthermore, the deposited conductive trace layouts can be used to perform the function of a wide variety of circuits. For example, a radio-frequency identification (RF ID) coil can be manufactured and deposited on a variety of substrates. This leads to a reduction in the cost of manufacturing RF ID coils, as well as an increase in the flexibility to accelerate the design cycle time.

In an embodiment, the organometallic compound is water soluble and includes a metal such as, silver (Ag), gold (Au), aluminium (Al), copper (Cu), or palladium (Pd). The formulation to dissolve the organometallic compound is a mixture of water-miscible organic solvents.

The following examples provide a more detailed discussion of various embodiments of the present invention. The examples are intended to be merely illustrative and not limiting to the scope of the present invention.

Illustrated in Fig. 1 is a possible, but non-limiting, optical system 10 in accordance with an embodiment. Fig. 2A illustrates a cross-sectional view of an example partially formed printed electronic circuit 20a, produced in accordance with an embodiment of the present invention, showing the substrate 24 and printed organometallic compound 22. Fig. 2B illustrates a cross-sectional view of an example printed electronic circuit 20b, obtained from the partially formed printed electronic circuit 20a illustrated in Fig. 2A, showing the substrate 24, organometallic compound 22 and deposited conductive trace 28. Fig. 2B shows a cross-sectional view of a desired conductive trace layout on a substrate 24 that can be used as an electronic circuit. Referring to Fig. 2A, an organometallic compound is printed as a thin film 22 onto a substrate 24 in the desired conductive trace layout. The organometallic compound is then subjected to irradiation 14 resulting in heating of the substrate 24 illustrated as region 26. Referring to Fig. 2B, heating of thin film 22 subsequently results in separate thin film layers 22 and 28 after irradiation of the printed organometallic compound. The irradiation process results in formation of the conductive layer 28 and original organometallic compound material remains as residual thin film layer 22. A laser source 12 generates a laser light beam 14 that irradiates the organometallic compound 22 (prior to formation of conductive layer 28) and the substrate 24. This results in heating of the substrate 24 near or at an interface area 26 of the organometallic compound 22 and the substrate 24. Consequently, deposition of conductive layer 28

results, being at least part of the desired conductive trace layout, on the substrate 24 near or at the heated interface area 26. This is due to the laser light beam 14 being at least partially absorbed by the substrate 24, or until all
5 the organometallic compound 22 is decomposed.

The laser light beam 14 or the substrate 24 are then moved so that the laser light beam 14 irradiates other interface areas (not illustrated) resulting in deposition of other layers of conductive traces (also shown as layers 28)
10 on the substrate 24 near or at the other interface areas as they are heated. The laser light beam 14 may be scanned over the desired conductive trace layout in any manner that achieves heating of the substrate 24 in all of the desired interface areas between the printed organometallic compound
15 22 and the substrate 24.

In an embodiment, the organometallic compound is substantially transparent to the laser light so that the laser light beam 14 is substantially transmitted by the printed organometallic compound 22 and is substantially
20 absorbed by the substrate material 24. Different organometallic compounds may react better with different laser light sources 12 producing different wavelengths of laser light.

According to one particular aspect, relative movement of
25 the laser light beam 14 and the substrate 24 can be achieved by moving the laser light beam 14 using a galvanometer 16 and/or moving the substrate 24 using a x-y stage 18. The laser light beam 14 is manipulated by optical components illustrated in Fig. 1. The 45° mirror 15a directs laser

light 14 to beam expander 15b which passes the laser light 14 to split mirror 15c, this results in a portion of laser light 14 being directed to galvanometer 16 and another portion of laser light 14 being directed to detector 15d, which detects
5 light and passes laser light 14 to focusing lens 15e which focuses laser light 14 onto screen 15f so that the relative position of the laser light 14 on the substrate 24 can be observed by an observer 17. In one particular embodiment observer 17 may be provided with control electronics able to
10 control parameters of the optical system 10, such as movement of the laser light beam 14 via the galvanometer 16 and an f-theta lens 19 or movement of the substrate 24 via movement of the x-y stage 18. Significantly different optical systems can be employed and fall within the scope of the present
15 invention.

It should be noted that although reference to laser light 14 is made, it is possible that other forms of electromagnetic radiation could be utilised to effectively heat the interface area 26 of the substrate 24. All that is
20 desired is that the electromagnetic radiation can pass through the organometallic compound 22 and release energy in the substrate material 24 to heat the interface region 26.

It should also be noted that it is not essential that organometallic compound layer 22 remains after heating. It is
25 possible, for heating of the organometallic compound to result in complete deposition of available conductive material 28. Hence, no organometallic compound layer 22 would remain overlaying the conductive trace layer 28 after heating.

Fig. 3 illustrates the steps of a method 30 according to an embodiment. At step 32 the organometallic compound is printed onto the substrate 24 in the desired conductive trace layout using a printer, for example a Hewlett-Packard thermal inkjet printer. At step 34 heating of the substrate near or at the interface area 26 of the organometallic compound 22 and the substrate 24 occurs using laser light 14. At step 36, as a result of heating of the interface area 26, a conductive trace 28 is deposited on the substrate 24 near or at the heated interface area 26. At step 37 the laser light beam 14 or the substrate 24 are moved so that the laser light beam 14 heats other interface areas between the printed organometallic compound 22 and the substrate 24, thereby resulting in other areas of deposited conductive traces. Steps 34, 36 and 37 are repeated until the desired conductive trace layout is fully formed on the substrate 24, after which method 30 can progress to completion at step 38. Optionally, an additional step 39 of electroless plating can be used to increase the height of the conductive trace 28. This is an optional step according to one possible embodiment, but is not an essential step of the present invention.

In Fig. 4 is illustrated a system 40 for transmitting a desired conductive trace layout to a printer 42. The desired conductive trace layout may be stored as a data file in database or computer memory 44 which is in communication with computer system 46. An operator of computer system 46 can create a desired conductive trace layout and transmit the desired conductive trace layout to the printer 42 which prints the organometallic compound onto the substrate in the

desired conductive trace layout. For example, the desired conductive trace layout may be stored as an Autocad drawing.

The following discussion should not be construed as limiting to the scope of the present invention. Referring
5 back to Figures 1 and 2, the wavelength of the laser light 14 may be 532 nm or 514.5 nm, for example generated by a Nd:YAG laser or Argon laser. When the temperature of the interface between the substrate 24 and the organometallic thin film 22 reaches a threshold temperature, decomposition of the
10 organometallic compound occurs and the conductive metal trace is deposited locally on the surface of the substrate 24. The organometallic compound may be $\text{Cu}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$. The laser-induced decomposition of this organometallic compound can be described as follows:

- 15 i. $\text{Cu}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O} \rightarrow \text{Cu}(\text{HCOO})_2 + 2\text{H}_2\text{O}$
 ii. $\text{Cu}(\text{HCOO})_2 \rightarrow \text{Cu} + \text{H}_2 + 2\text{CO}_2$

The resulting hydrogen (H_2) and carbon dioxide (CO_2) can be absorbed by an exhaust system to capture these by-product
20 gases. The metallic trace is deposited copper (Cu). In one form, the printer is a thermal inkjet printer, for example the Hewlett-Packard deskjet printer. Other types of inkjet printers may be used, for example a piezo inkjet printer.

It is possible that the thickness of the conductive
25 trace 28 may not satisfy the conductivity requirement for certain electronic products. As such, it is possible to use electroless plating as an additional step in order to build up a thicker conductive trace layer 28. For example, the

conductive trace layer can be built up to a height of about 1 to 3 μm .

An electroless plating step may utilise the same type of metal deposited from the organometallic compound or a different type of metal, for example combinations such as copper and copper, copper and gold, copper and palladium, etc, are possible. Any circuit that can be printed on a particular substrate can be produced according to the above-described embodiments.

10 If the quantity or height of deposited conductive trace 28 is precisely controlled by the level of heating at the interface 26, then a thin layer of organometallic compound 22 can be allowed to remain and overlay the deposited metal 28. This can be desirable as the remaining organometallic 15 compound film 22 can provide a protective layer to prevent the underlying conductive layer 28 from oxidising in ambient air.

According to another aspect, a radio-frequency identification (RF ID) coil can be manufactured according to 20 the present invention. The current process to produce a RF ID coil in the prior art includes chemical etching and CNC milling. This prior art technique includes significant problems, for example: higher costs due to waste of copper material, higher costs due to disposing of the chemical acid 25 solution, higher costs due to specialised equipment requirements, environmental disadvantages that may result from the improper disposing of waste materials such as copper and contaminated water, and a longer design cycle time due to the requirement to design masks.

By using a normal inkjet printer with a suitable organometallic compound, such as a copper formate, once the RF ID coil design has been prepared, the design can be promptly printed onto any desired and suitable substrate. A
5 Nd:YAG laser with a wavelength of 532 nanometres can be used to decompose the copper formate so as to form a copper trace layout that is the same as the designed RF ID coil printed on the substrate. A wide variety of substrates can be used such as glass, plastics, ceramics, paper, etc. Such a process
10 leads to significant cost savings, is more environmental friendly, and allows faster design times and circuit prototyping.

According to yet another embodiment, an organometallic compound that can be utilised as part of an inkjet
15 formulation that can be introduced into a printer cartridge. In order to achieve proper drop ejection of the solution (i.e. formulation) from printer nozzles, physical properties of the solution should be optimized, such as the surface tension and viscosity of the solution. Quality drops from
20 nozzles translate into quality conductive traces.

In order to achieve a higher density of organometallic compound on a substrate after each print, higher concentration of organometallic compound is desired. However, this can pose a challenge when considering solubility of the
25 organometallic compound in solution when printing. The higher the concentration of the organometallic compound, the higher the tendency that burnt residues may be left over on the heater surface after printing. The presence of residue will degrade the quality and stability of subsequent drops.

Hence, the type of solvents and their concentrations need to be optimized.

The formulation contains at least one water soluble organometallic compound. The organometallic compound can be in the form of an acetate, carboxylate or an amine complex. The metal component of the organometallic compound can include silver (Ag), gold (Au), aluminium (Al), copper (Cu), and/or palladium (Pd). The vehicle to dissolve the organometallic compound may include at least one water-miscible organic solvent such as nitrogen-containing ketones (e.g. 2-pyrrolidone, N-methyl-pyrrolid-2-one (NMP)), pentandiols (e.g. 1,2-pentandiol, 1,5-pentandiol) and/or triols (e.g. glycerol).

A specific example provided below in Table 1 however, numerous other organometallic compounds and inkjet formulations are possible.

Table 1

Component	WL %
Cu formate hydrate, Cu(HCOO) ₂ 2H ₂ O	9
Triol	15
Diol	8
Nitrogen heterocyclic ketone	7.5
Balance water	60.5
Total	100
Solubility	Clear blue
pH	4.87
Viscosity (centipoise)	2.77
Surface tension (dye/cm)	50.7
Conductivity (mmho/cm) (i.e. "milli-Ohms per cm")	4.46

DBOS Observation	<ul style="list-style-type: none"> • Nozzles can continue firing • Straight drops. • Able to have multiple fires (i.e. on/off/on/off etc.) • No puddling • No crystal formation on orifice plate surface
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It should be noted with reference to Table 1 that DBOS ("Drop Break-off Observation System") is a tool used to observe drops fired from inkjet cartridge nozzles. A DBOS image 50 shows a snapshot of the moment drops are ejected from the nozzles, as illustrated in Fig. 5. A Hewlett-Packard deskjet 6122 was used to generate a printout on a substrate. The substrate used was normal printing paper and polyimide film treated by oxygen plasma ash before use. An image 70 of a copper trace 72 formed after laser-induced decomposition, as previously described. Shown in Fig. 8 is an image 80 of a copper trace formed after optional electroless plating of the copper trace illustrated in Fig. 7.

It is demonstrated that the inkjet formulation presented in Table 1 can be printed by a thermal inkjet printer with acceptable quality. Thus, following the aforementioned laser-induced decomposition process a conductive copper trace 72 was deposited on a substrate after printing of a formulation containing an organometallic compound by thermal ink jet printing.

Hence, there has been provided a formulation for printing organometallic compounds for use in forming conductive traces on substrates. Although the present invention has been described in terms of the presently preferred embodiments, it is to be understood that the disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the art after having read the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

CLAIMS

- 5 . 1. A formulation able to be printed onto a substrate for use in forming a desired conductive trace layout on the substrate, the formulation including:
at least one organometallic compound dissolved in at least one organic solvent, whereby metal from the
10 organometallic compound is deposited on the substrate when the organometallic compound is heated.
2. The formulation as claimed in claim 1, wherein the at least one organic solvent is water-miscible.
- 15 3. The formulation as claimed in claim 1, wherein the formulation includes a mixture of water-miscible organic solvents.
- 20 4. The formulation as claimed in claim 1, wherein the organometallic compound is water soluble.
5. The formulation as claimed in claim 1, wherein the organometallic compound is at least one of an
25 acetate, carboxylate or amine complex.
6. The formulation as claimed in claim 1, wherein the organometallic compound contains at least one of silver, gold, aluminium, copper or palladium.

30

7. The formulation as claimed in claim 1, wherein the at least one organic solvent is at least one of a ketone, pentandiol or triol.
- 5 8. The formulation as claimed in claim 1, wherein the organometallic compound is heated by electromagnetic radiation substantially near an interface area of the formulation and the substrate.
- 10 9. The formulation as claimed in claim 8, wherein the formulation is substantially transparent to the electromagnetic radiation.
- 15 10. The formulation as claimed in claim 1, wherein the formulation is substantially blue.
11. The formulation as claimed in claim 8, wherein the electromagnetic radiation is a laser light beam.
- 20 12. The formulation as claimed in claim 1, wherein the normal width of the deposited metal is less than about 40 μ m.
- 25 13. The formulation as claimed in claim 1, wherein the normal width of the deposited metal is less than about 20 μ m.
- 30 14. The formulation as claimed in claim 1, wherein the formulation is able to be printed by an inkjet printer.

15. The formulation as claimed in claim 1, wherein the organometallic compound is $\text{Cu}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$.

5 16. A chemical solution able to be printed onto a substrate using an inkjet printer and for use in forming a desired metallic trace layout on the substrate, the chemical solution including:
at least one organometallic compound dissolved in at
10 least one water-miscible organic solvent, whereby metal from the organometallic compound is deposited on the substrate as a result of heating of the substrate by laser light absorbed substantially near an interface between the printed chemical solution
15 and the substrate.

17. A formulation able to be printed onto a substrate for use in forming a desired conductive trace layout on the substrate, the formulation including:
20 an organometallic compound being less than 50% of the formulation by weight;
at least one organic solvent being less than 50% of the formulation by weight; and,
water being more than 50% of the formulation by
25 weight;
whereby metal from the organometallic compound is deposited on the substrate when the organometallic compound is heated.

18. The formulation as claimed in claim 17, wherein the organometallic compound is substantially 9% of the formulation by weight.
- 5 19. The formulation as claimed in claim 17, wherein the organic solvent is one or more of a triol, a diol or a nitrogen containing ketone.

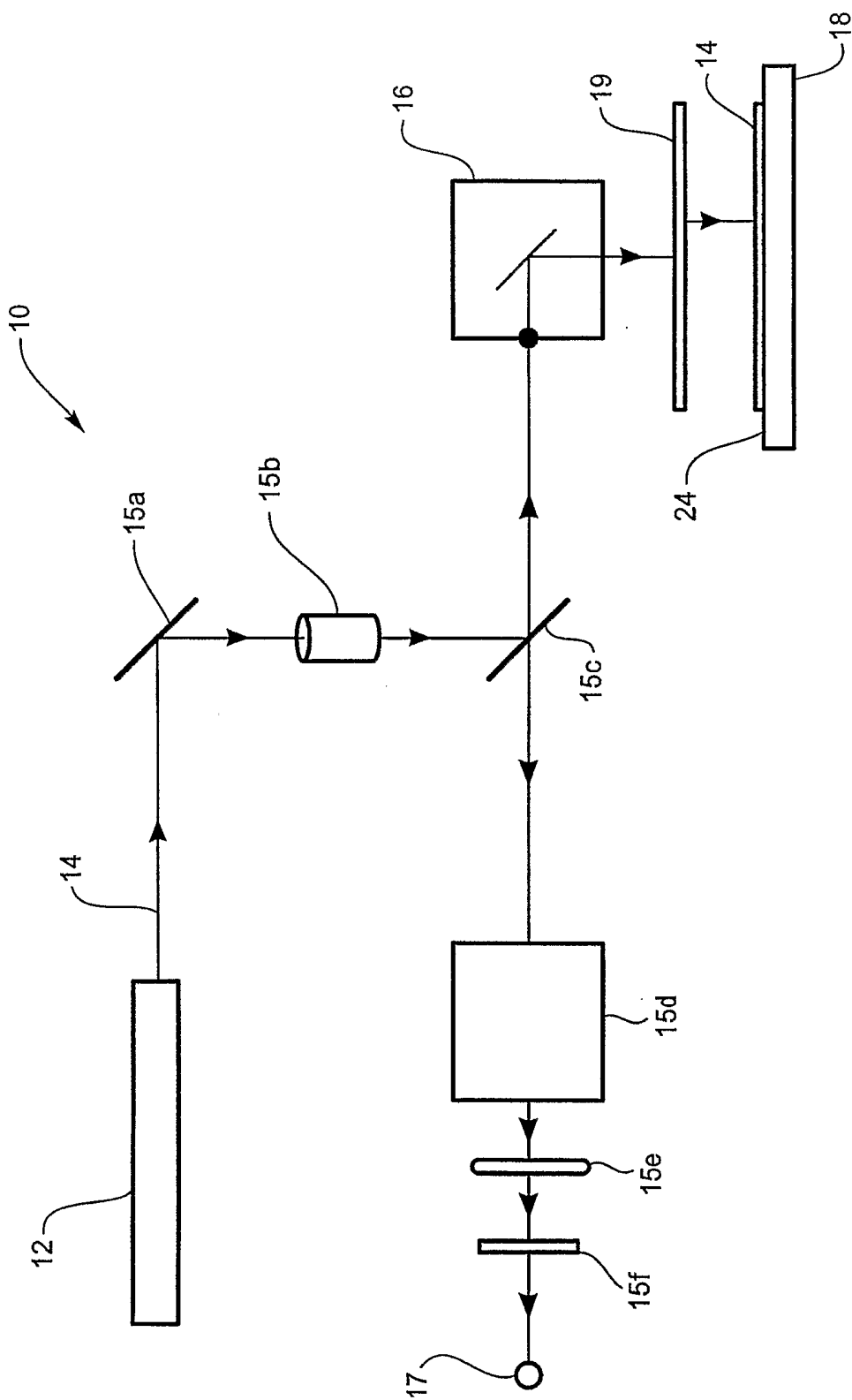


Fig. 1

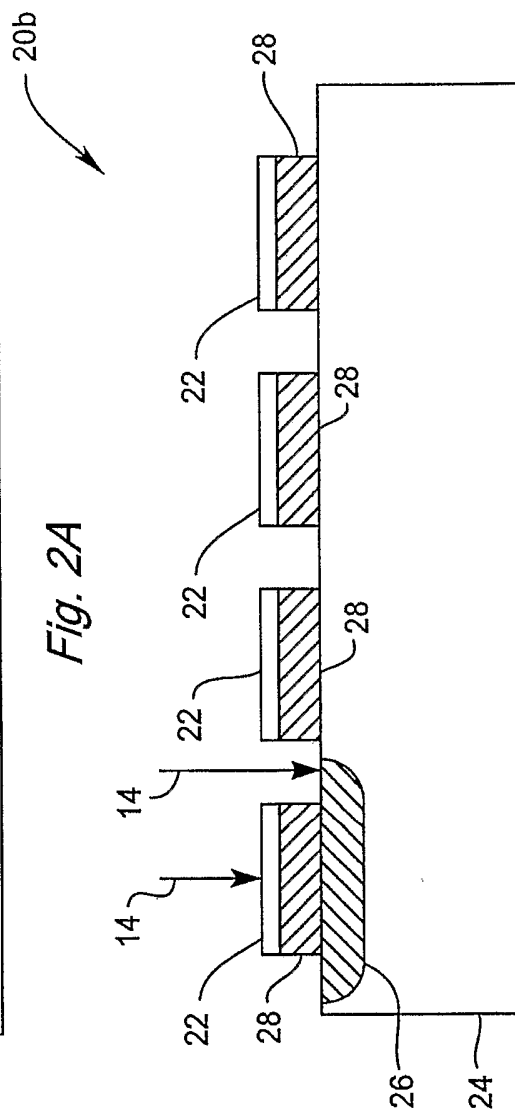
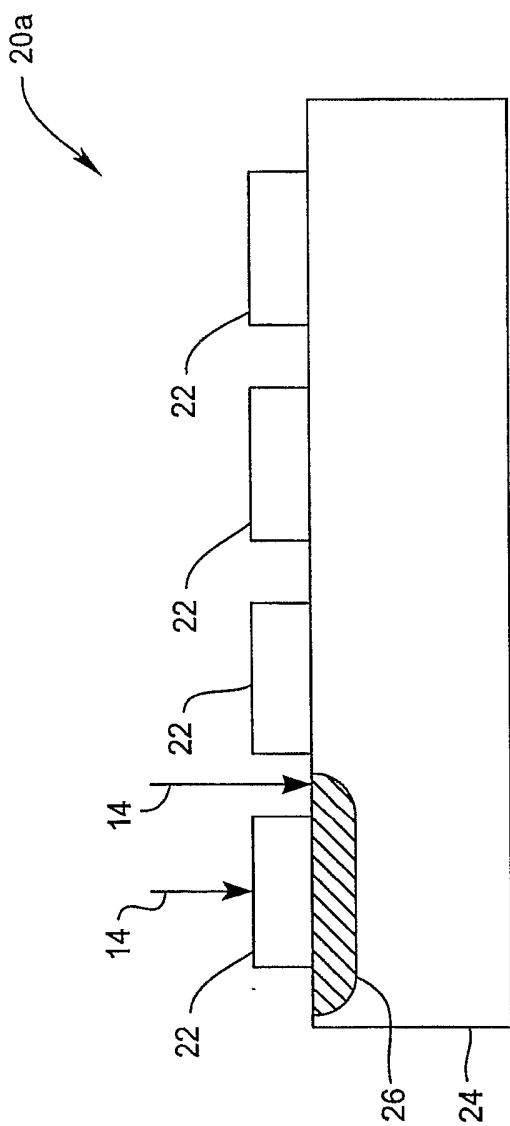


Fig. 2A

Fig. 2B

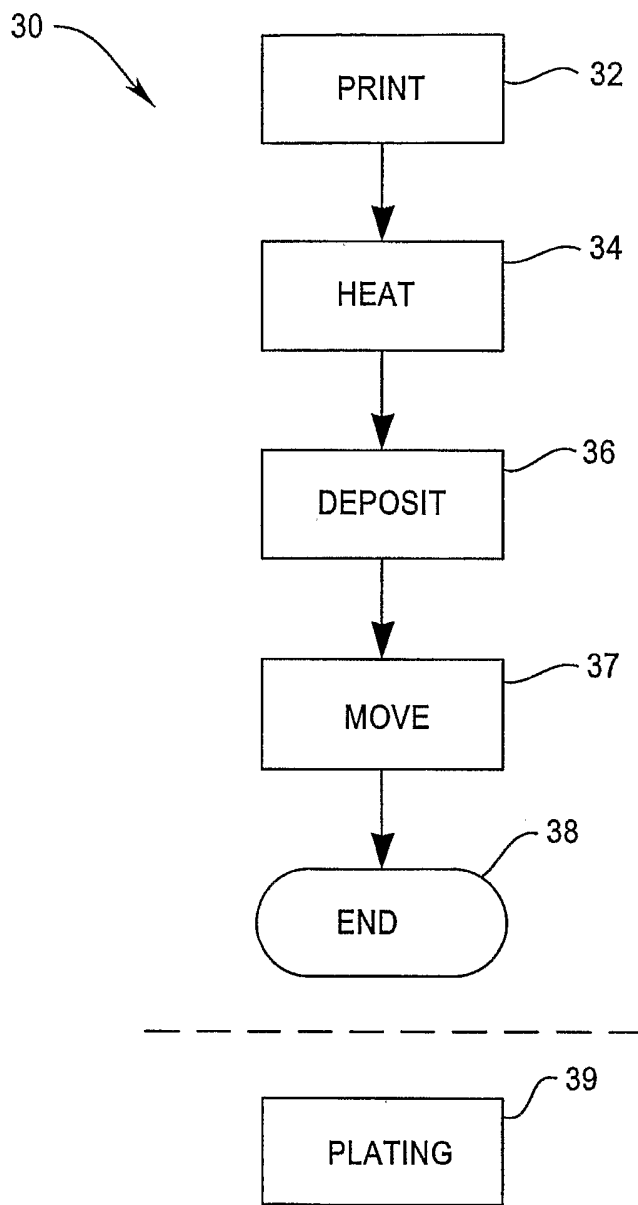


Fig. 3

4/5

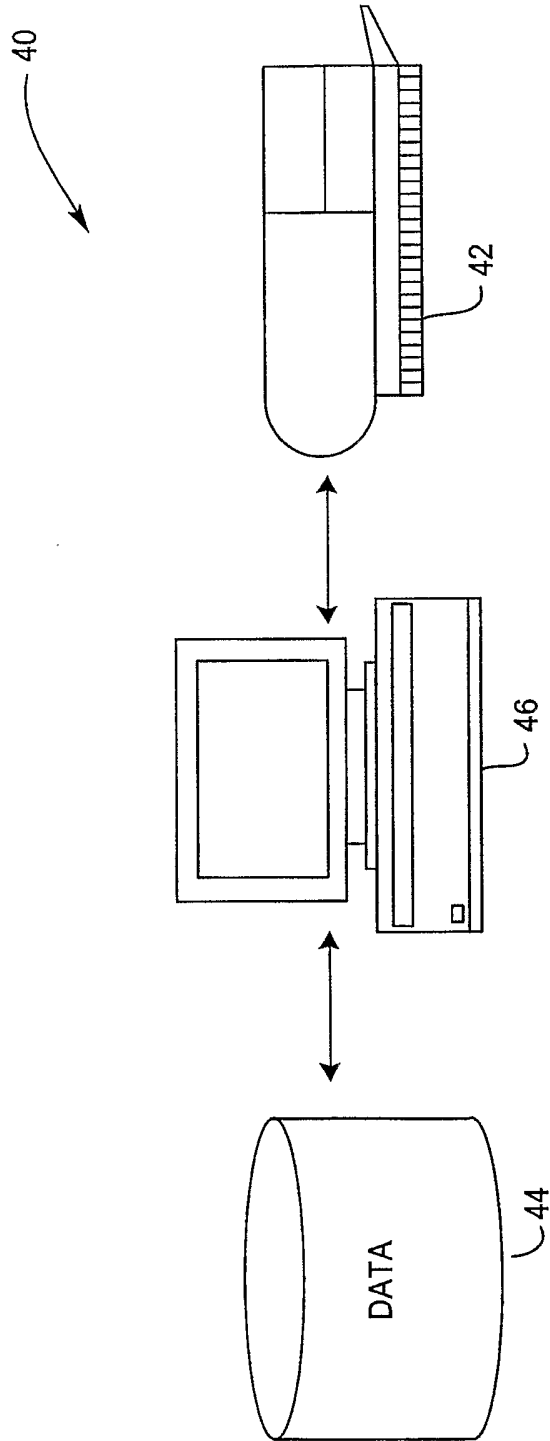


Fig. 4

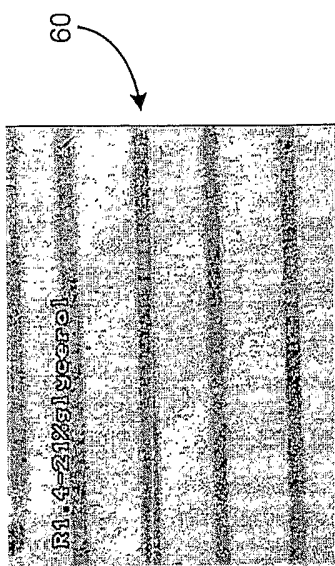


Fig. 6

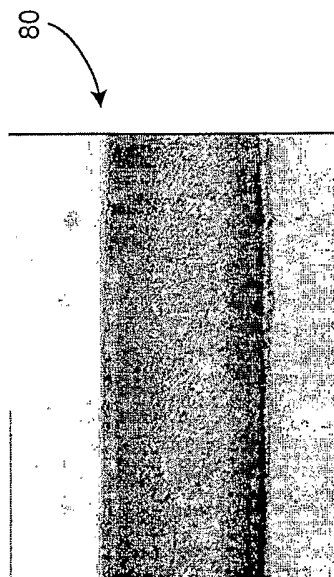


Fig. 8

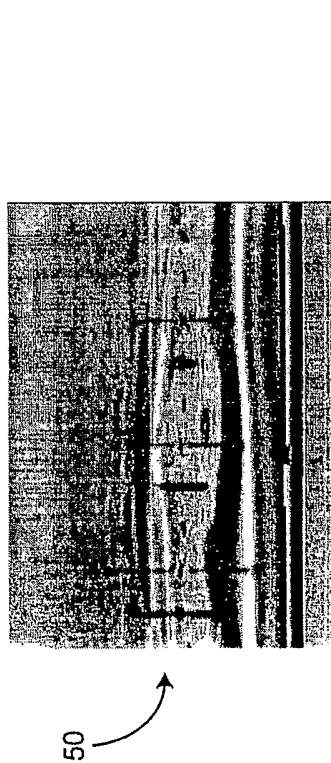


Fig. 5

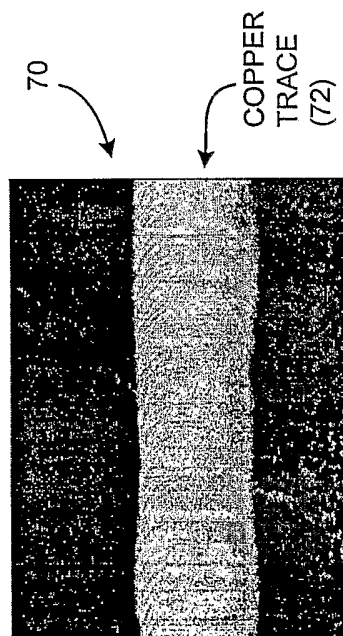


Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SG2005/000162A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B41M5/26 B41M5/28

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 7 B41M H05K C23C G03C

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

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

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 489 411 A (XEROX CORPORATION) 10 June 1992 (1992-06-10) claims example 1	1,2,4-9, 11,14,16
X	US 2004/026258 A1 (NO CHANG HO ET AL) 12 February 2004 (2004-02-12) example 3 claims 6,7	1,2,4-9, 14,16
X	US 6 319 564 B1 (NAUNDORF GERHARD ET AL) 20 November 2001 (2001-11-20) claims column 2, line 5	1,5,6,8, 11-14,16

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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Date of the actual completion of the international search

30 August 2005

Date of mailing of the international search report

30/09/2005

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/SG2005/000162

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