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Published:

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(54) **Title**: SYSTEM FOR FORMING A CONDUCTIVE PATTERN

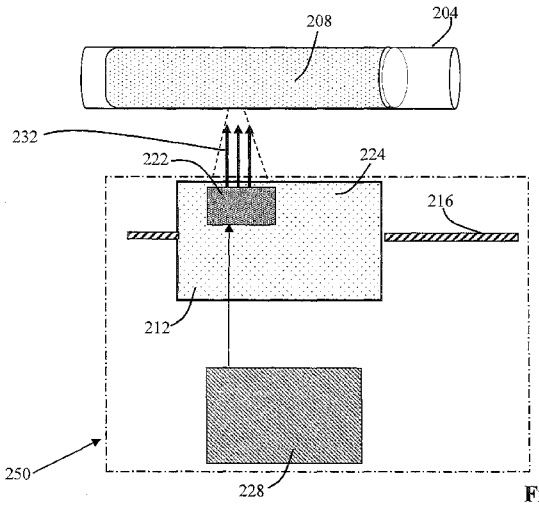

Fig. 2B

(57) **Abstract**: A system or apparatus for forming a conductive pattern on a substrate (208) includes a thermal imaging head (220) that forms an image pattern on the substrate. A functional material (240) spraying element (224) applies a functional material on the substrate which bonds with the image pattern. The spraying element is integrated in the thermal imaging head. An electro-less deposition element is applied using the electro-less deposition element on the substrate to enhance the functionality of the final product.

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SYSTEM FOR FORMING A CONDUCTIVE PATTERN

FIELD OF THE INVENTION

The present invention relates to an apparatus for functional printing using computer-to-plate imaging technology.

BACKGROUND OF THE INVENTION

Functional printing is a category of printing that uses commercial printing equipment to print circuits or electronic devices which have a function other than, or in addition to, visual display of information. An example of printed circuits is printing radio frequency identification (RFID) on a package or a product. Another example may be printing an electronic circuit on a package which is capable of producing music when the package is opened.

There are several approaches for printing functional patterns on substrates including direct printing of functional inks. Other techniques use photolithography to mask and remove a pre-deposited functional layer. There is a need however for accurate deposition for functional material.

SUMMARY OF THE INVENTION

Briefly, according to one aspect of the present invention a system or apparatus for forming a conductive pattern on a substrate includes a thermal imaging head that forms an image pattern on the substrate. A functional material spraying element applies a functional material on the substrate which bonds with the image pattern. The spraying element is integrated in the thermal imaging head. An electro-less deposition element is applied using the electro-less deposition element on the substrate to enhance the functionality of the final product.

One embodiment of the invention uses thermal writing devices, e.g. laser writing heads, or thermal transfer writing heads, to form a thermal pattern on the substrate which, combined with the chemical environment, forms a pattern of functional chemical traces on the substrate. This pattern can be used as is for various applications such as forming hydrophilic/hydrophobic regions for printing processes. Another use is to form a pattern of a catalyst material that can be used for electro-less deposition of metal such as copper, thereby forming copper traces on the substrate.

The use of laser imaging or thermal transfer to a substrate with a combination of sprayed material such as gas applied on the imaged areas is one technology for accurate deposition. The gas molecules are diffused towards the laser heated substrate to create a chemical compound between the gas and the material deposited on the surface of the substrate. The gas is referred to as functional gas and creates a compound of traces on the substrate that is used to form conductive lines for example.

The invention and its objects and advantages will become more apparent in the detailed description of the preferred embodiment presented below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 represents in diagrammatic form a prior art digital front end for driving an imaging device;

FIG. 2A represents in diagrammatic form the imaging system of FIG. 1;

FIG. 2B represents in diagrammatic form an embodiment of the imaging system having the thermal imaging element embedded functional material spraying element;

FIG. 2C represents in diagrammatic form an embodiment of the imaging system having the thermal imaging element configured to image through a chamber carrying functional material; and

FIG. 3 represents in a diagrammatic form an electro-less coating machinery applied on a patterned substrate according to this invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be directed in particular to elements forming part of, or in cooperation more directly with the apparatus in accordance with the present invention. It is to be understood that elements not specifically shown or described may take various forms well known to those skilled in the art.

While the present invention is described in connection with one of the embodiments, it will be understood that it is not intended to limit the invention to this embodiment. On the contrary, it is intended to cover alternatives, modifications, and equivalents as covered by the appended claims.

FIG. 1 shows a plate imaging device 108. The imaging device is driven by a digital front end (DFE) 104. The DFE receives imaging data in a digital form from desktop publishing (DTP) systems (not shown), and renders the digital information for imaging. The rendered information and imaging device control data are communicated between DFE 104 and imaging device 108 over interface line 112.

FIG. 2A shows an imaging system 200. The imaging system 200 includes an imaging carriage 212 on which a material spray element 224 is mounted along with a thermal imaging head 220. The sprayed material can be in a form of gas, liquid or fine powder. The thermal imaging head 220 can be based on thermal transfer means or laser imaging components. The thermal imaging head 220 is designed to operate of a wavelength matching the substrate 208 characteristics. The thermal imaging head 220 is configured to image on substrate 208 mounted on a rotating cylinder 204. The carriage 212 is adapted to move substantially in parallel to cylinder 204 guided by screw 216. Controller 228 controls patterning process of thermal imaging head 220 and material emission from material spray element 224. A computer-to-plate (CTP) device capable to image on flat surfaces, known as capstan devices, can be used as well for the same purpose (not shown). An internal drum CTP (not shown) configuration can be used in conjunction with this invention as well.

Imaging substrate 208, comprised of glass, metal or various polymeric materials, is mounted on rotating cylinder 204. Depending on the specific process, a material spray element 224 deploys a material in proximity of imaging substrate 208. The material may be applied prior, during or after laser exposure. Thermal imaging head 220 will image a pattern according to data received from DFE 104 on imaging substrate 208. The CTP imaging head 220 will elevate the temperature of imaging substrate 208, or opto-chemically modify its surface in the imaged areas to enable an efficient diffusion/bonding process of the functional sprayed material 232 molecules into substrate 208. Thus, the pattern created by thermal imaging head 220 induces a doping pattern on imaging substrate 208. For example, near IR (NIR) imaging head can be used for imaging on a specialized NIR absorbing polyethylene terephthalate (PET) substrate, while

applying catalyst material in a form of gas or liquid, such as 3-mercaptopropyltrimethoxysilane (MPTS) or palladium fine powder, to create traces of catalyst doping on imaging substrate 208. The liquid material may be Palladium Chloride (PdCl2) solution.

FIG. 2B shows another imaging system 250, similar to imaging system 200. The main difference between the systems is that system 250 contains an integrated imaging and spaying element 222.

FIG. 2C shows yet another imaging system 280. System 280 contains a chamber 236. Chamber 236 carries functional material 240. Chamber 236 is situated in proximity to rotating cylinder 204 is such a way that during rotation cylinder 204 and imaging substrate 208 immerses in functional material 240 in chamber 236. Thermal imaging head 220 images through chamber 236, causing temperature elevation on specific areas of imaging substrate 208, and thus opto-chemically modify its surface in the imaged areas to enable an efficient diffusion/bonding process of the functional material 240.

All the imaging systems presented show an external drum system, showing imaging substrate 208 attached on the external surface of rotating cylinder 204. A configuration which is not shown herein, may be constructed from a thermal imaging head 220 configured in an internal drum configuration wherein imaging substrate 208 is attached on the internal surface of rotating cylinder 204. In addition imaging head 220 will emit light internally in rotating cylinder 204. The functional material will be also supplied internally inside the drum.

Following the completion of the required patterning on imaging substrate 208, a standard electro-less coating process is performed to build material traces such as copper, silver or nickel traces on imaging substrate 208 by using electro-less coating machinery such as depicted in FIG. 3. These copper traces will form the pattern made by the CTP imaging head 220. See Yinxiang Lu, Qian Liang, Longlong Xue, Applied Surface Science, Volume 258, Issue 10, 1 March 2012, Pages 4782–4787.

Assuming the substrate heat capacity and density are ~1.2 Jg-1K-1 and 1.37gcm-3 respectively and assuming a penetration depth of 10μm is

required, energy in the vicinity of 1.644mJ/cm2 will be needed for increasing substrate 208 temperature by 1K. Thus, to achieve 100K temperature an increase of 164mJ/cm2 will be required, which within the working range of current CTP devices.

Patterning resolution is determined by the resolution of the CTP thermal imaging head 220 and by imaging substrate 208 characteristics such as thermal conductivity.

PARTS LIST

104 digital front end (DFE)
108 imaging device
112 interface line
200 imaging system
204 rotating cylinder
208 imaging substrate
212 carriage
216 screw
220 thermal imaging head
222 thermal imaging head integrated with a spaying element
224 material spray element
228 controller
232 sprayed material
236 chamber containing functional material
240 functional material
250 imaging system
280 imaging system

CLAIMS:

1. A system or apparatus for forming a conductive pattern on a substrate comprising:

a thermal imaging head that forms an image pattern on said substrate;

a functional material spraying element that applies a functional material on said substrate which bonds with said image pattern wherein said spraying element is integrated in said thermal imaging head; and

an electro-less deposition element wherein a deposition process is applied using said electro-less deposition element on said substrate to enhance the functionality of the final product.

2. The system or apparatus according to claim 1 wherein said spraying element is detached from said thermal imaging head.

3. The system or apparatus according to claim 1 wherein said thermal imaging head is a laser imaging component.

4. The system or apparatus according to claim 1 wherein said thermal imaging head is comprised of a plurality of heating elements such as in thermal transfer head.

5. The system or apparatus according to claim 1 wherein said substrate is polyethylene terephthalate (PET) treated to absorb near intra-red (NIR) radiation.

6. The system or apparatus according to claim 3 wherein:

said laser imaging component is configured to image on said substrate; and

wherein said substrate is mounted on a capstan imaging device.

7. The system or apparatus according to claim 3 wherein:

said laser imaging component is configured to image on said substrate; and

wherein said substrate is mounted on an external drum.

8. The system or apparatus according to claim 3 wherein:

said laser imaging component is configured to image on said substrate; and

wherein said substrate is mounted on an internal drum.

9. The system or apparatus according to claim 3 wherein said laser imaging component is configured to image ultra violet.

10. The system or apparatus according to claim 3 wherein said laser imaging component is configured to image near infra-red (NIR).

11. The system or apparatus according to claim 1 wherein said functional material is 3-mercaptopropyltrimethoxysilane (MPTS).

12. The system or apparatus according to claim 1 wherein said functional material is palladium fine powder.

13. The system or apparatus according to claim 1 wherein said electro-less deposition element deposits a metal such as copper, nickel, or silver.

14. The system or apparatus according to claim 1 wherein said functional material is in a form of gas.

15. The system or apparatus according to claim 1 wherein said functional material is in a form of liquid.

16. A system or apparatus for forming a conductive pattern on a substrate comprising:

a thermal imaging head that forms an image pattern on said substrate;

functional material chamber situated in proximity to said substrate wherein said functional material bonds with said image pattern; and

an electro-less deposition element wherein a deposition process is applied using said electro-less deposition element on said substrate to enhance the functionality of the final product.

17. The system or apparatus according to claim 15 wherein said functional material in a form of liquid such as Palladium Chloride (PdCl2) solution.

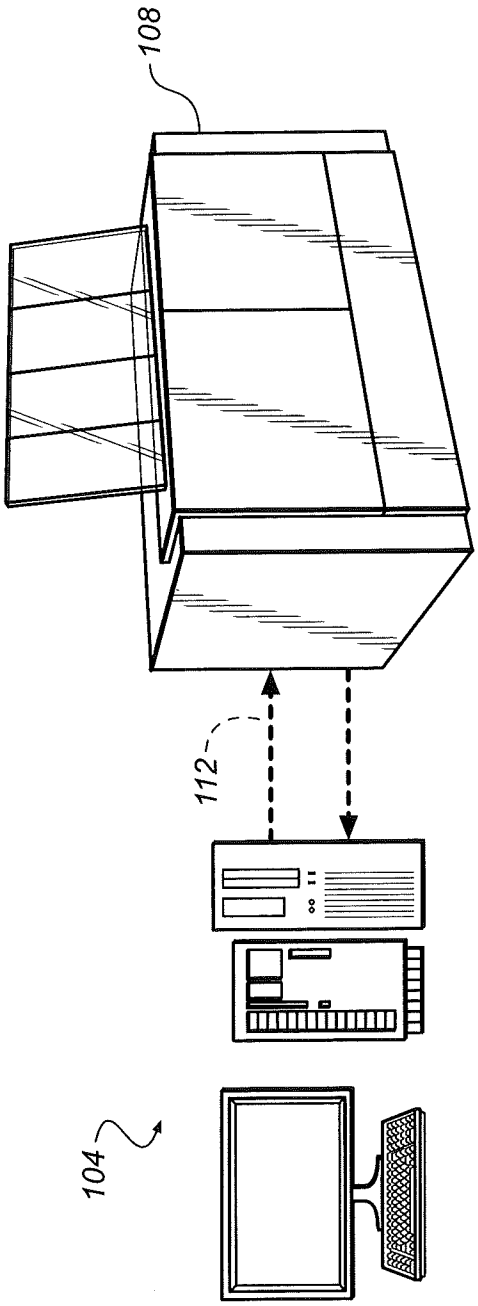


FIG. 1
(PRIOR ART)

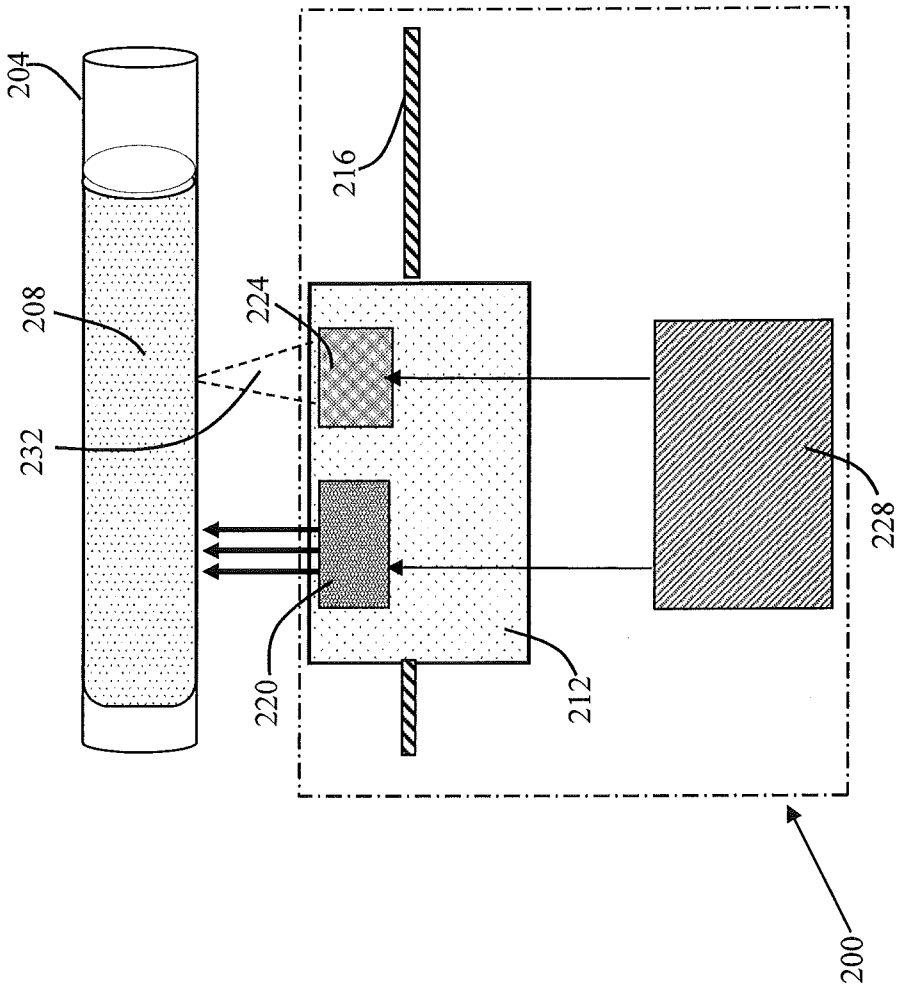


Fig. 2A

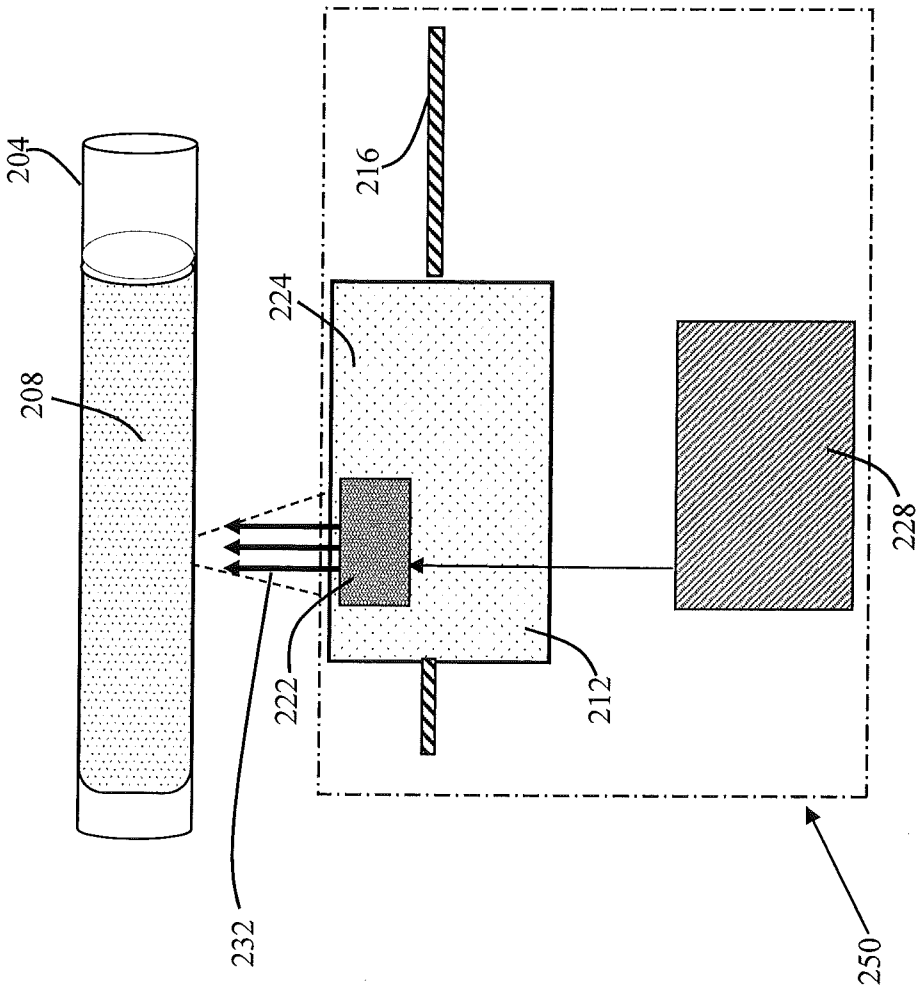


Fig. 2B

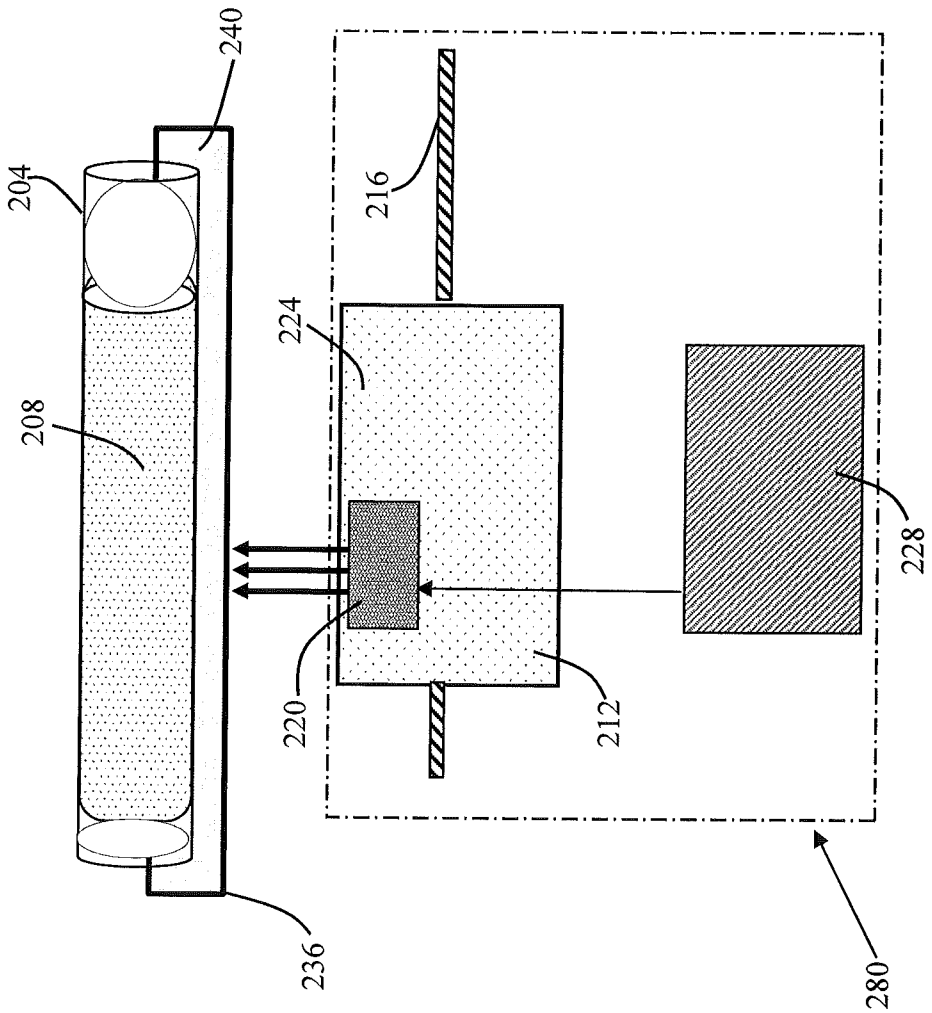
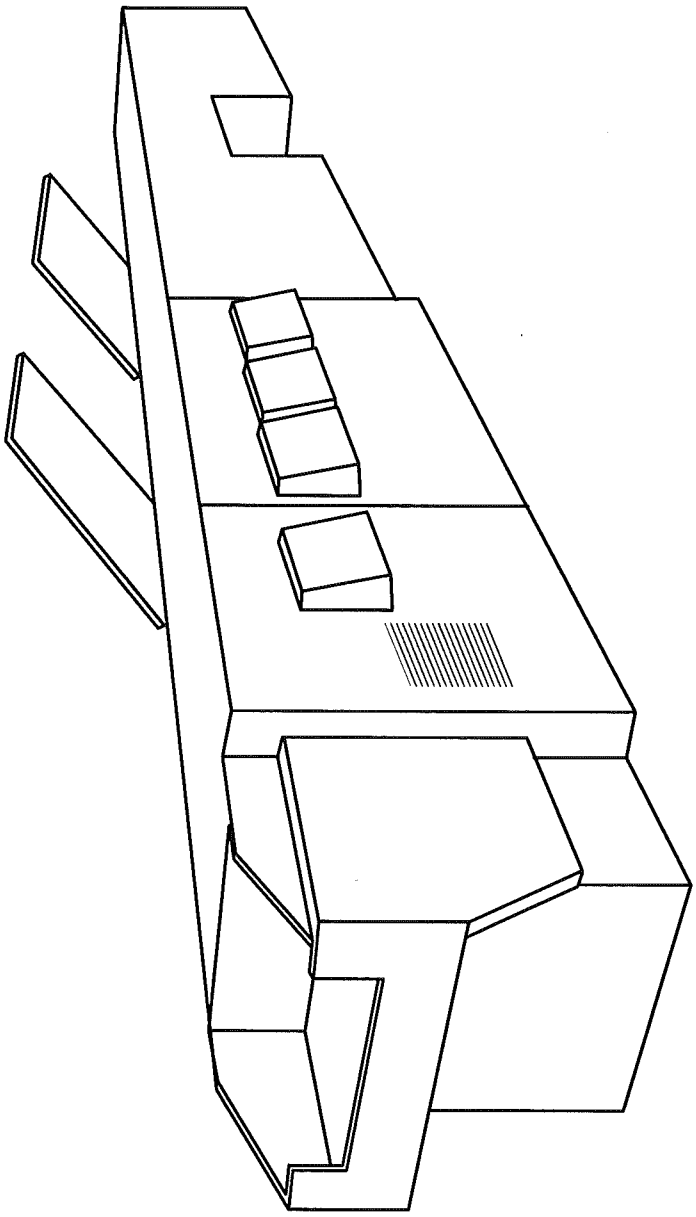


Fig. 2C



ELECTROLESS PLATING PROCESS LINE

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/040439

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05K3/18 C23C18/20 C23C18/18 C23C18/16
ADD.

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)
C23C H05K

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 822 633 A (INOUE KIYOSHI [JP]) 18 April 1989 (1989-04-18) claims 1,2 column 4, lines 10-12 column 5, lines 58-60 column 6, lines 24,25,35,49-53 column 7, lines 27-31 figures 7,10,11 -----	1-17
A	WO 2012/046651 A1 (MEIKO ELECTRONICS CO LTD) 12 April 2012 (2012-04-12) abstract & US 2013/183534 A1 (MORI KUNIO [JP] ET AL) 18 July 2013 (2013-07-18) claims 1-3 paragraphs [0092] - [0093] ----- -/--	1-17

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* 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
19 September 2014	30/09/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dardel, Blaise

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/040439

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 389 496 A (CALVERT JEFFREY M [US] ET AL) 14 February 1995 (1995-02-14) claims 1,13 column 8, lines 66-68 example 20	1-17
A	US 5 580 616 A (NIINO HIROYUKI [JP] ET AL) 3 December 1996 (1996-12-03) claim 6	1-17
A	SUSUMU SAWADA ET AL: "Micropatterning of Copper on a Poly(ethylene terephthalate) Substrate Modified with a Self-Assembled Monolayer", LANGMUIR, vol. 22, no. 1, 3 December 2005 (2005-12-03), pages 332-337, XP055114457, ISSN: 0743-7463, DOI: 10.1021/la051538r Experiment section; page 333 - page 334 figure 1	1-17
X,P	US 2014/134326 A1 (SCHUSTER ISRAEL [IL]) 15 May 2014 (2014-05-15) page 2, lines 27-31 figure 2	2

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2014/040439

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4822633 A	18-04-1989	EP 0151413 A2	14-08-1985
		US 4639378 A	27-01-1987
		US 4822633 A	18-04-1989
WO 2012046651 A1	12-04-2012	CN 103038390 A	10-04-2013
		EP 2626448 A1	14-08-2013
		JP 4936344 B1	23-05-2012
		KR 20130018380 A	20-02-2013
		TW 201226399 A	01-07-2012
		US 2013183534 A1	18-07-2013
		US 2014227539 A1	14-08-2014
		WO 2012046651 A1	12-04-2012
US 5389496 A	14-02-1995	US 5389496 A	14-02-1995
		US 5500315 A	19-03-1996
US 5580616 A	03-12-1996	DE 4343753 A1	23-06-1994
		FR 2699543 A1	24-06-1994
		JP H075773 B2	25-01-1995
		JP H06192452 A	12-07-1994
		US 5580616 A	03-12-1996
US 2014134326 A1	15-05-2014	US 2014134326 A1	15-05-2014
		WO 2014078361 A1	22-05-2014