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(54) **Title:** METHOD FOR DEPOSITING METAL ON A SUBSTRATE, IN PARTICULAR FOR METALLIZATION OF SOLAR CELLS AND MODULES

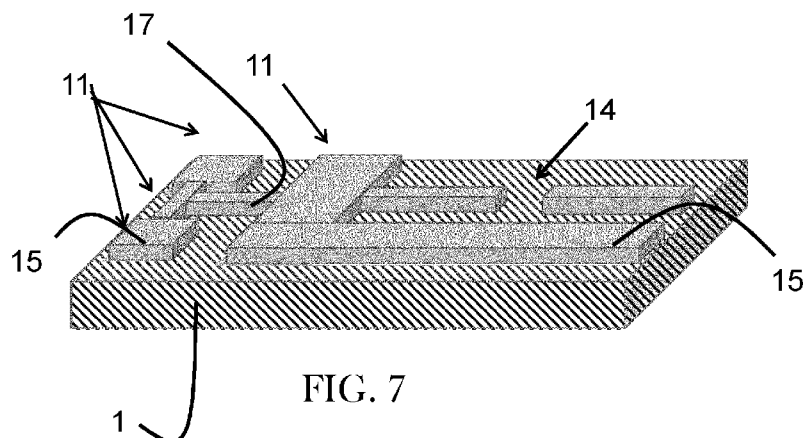


FIG. 7

(57) **Abstract:** The invention relates to a method for depositing metal on a substrate (1) comprising the following steps: - deposition of a sensitizer (9) comprising laser activable metal based molecules in a neutral state on the substrate (1), - activation of said laser activable metal based molecules of the sensitizer (9) through laser activation (103) so as to create metal ions from said laser activable metal based molecules which catalyze areas (11) on the substrate, - chemical deposition of metal on said catalyzed areas (11) of the substrate (1).



**Method for depositing metal on a substrate, in particular for
metallization of solar cells and modules**

5 FIELD OF THE INVENTION

The present invention relates to a method for depositing metal on a substrate, in particular for metallization of solar cells and modules.

10 BACKGROUND AND PRIOR ART

As is known per se, a photovoltaic module comprises a plurality of photovoltaic cells (or solar cells) connected in series and/or in parallel. A photovoltaic cell is a semiconductor diode designed to absorb light energy and convert it into electrical energy. This semiconductor diode comprises a
15 p-n junction between two layers of respectively p-doped and n-doped silicon. During the formation of the junction, a potential difference (and therefore a local electric field) appears, due to the excess of free electrons in the n layer and due to the shortage of free electrons in the p layer.

20

When photons are absorbed by the semiconductor, they give up their energy in order to produce free electrons and holes. Given the potential difference that exists at the junction, the free electrons have a tendency to accumulate in the n zone and the holes to accumulate in the p zone.
25 Collecting electrodes in contact respectively with the n zone and the p zone make it possible to recover the current emitted by the photovoltaic cell.

Solar cells based on monocrystalline or polycrystalline silicon are conventionally developed by putting the positive and negative contacts on
30 each of the faces of the cell. The back face is generally completely covered with metal since only the conductivity counts (no light having to pass

through the back face), whereas the front face, that is to say the one which is illuminated, is contacted by a metal grid which allows most of the incident light to pass through.

Recently, it has been proposed to place the electrical contacts only on the back face (rear-contacted cells). This implies producing selective contacts on a single face. The advantage of this technique is not having any shading on the front face while making it possible to reduce the ohmic losses due to the metal contacts since they cover a much larger surface of the cell. Added to this is the fact that it is not necessary to use a transparent conductive oxide on the front face (no electrical conduction is necessary) but rather amorphous silicon and/or a dielectric which has the property of not absorbing light as much as a transparent conductive oxide (which furthermore is often composed of expensive and/or rare products). It is therefore possible, a priori, to produce cells having a higher short-circuit current and therefore a higher efficiency.

However, the manufacture of the metal contacts and the interconnections remains relatively critical to implement for certain aspects.

Indeed, one known method comprises screen printing at module level, in particular with mini-modules of only several PV cells. One problem of this known process is that the paste deposition is not homogenous enough and that cracks appear after a firing step on the wafer. The consequence of this is that the performance of the PV-cell and/ or module reduces because of a non-uniform topography of the metallic contacts and interconnections.

Another known method comprises Cu plating. In this method, a seed layer is deposited by a vapour deposition (PVD) or a sputtering process (TiCu). Then a plating resist layer is deposited and patterned. After then, a seed layer is etched and the plating resist layer is removed before the final Cu plating.

Because of patterning and the use of lithography and PVD, this method is quite very expensive. In addition, cracks have also been observed

on the seed layer that are probably due to mechanical stress, in particular if the substrate is very thin.

Furthermore, the thickness of solar cells tends to be reduced for cost reduction of the wafer. However, wafer of thickness of only about 100µm are not easy to be handled mechanically without a growing risk of breach. Conventional methods of metallization like screen printing methods show an important mechanical impact on the wafers that are no more acceptable with very thin wafers.

For depositing metal on a substrate, it is well known to deposit a sensitizer on a substrate to catalyze the surface of the substrate, thus allowing subsequent deposition of metal on the catalyzed surface. As known in the art, the sensitizers are deposited on the substrate in ionized form (for example in an aqueous solution) and they catalyze the surface of the substrate when deposited thereon. Those sensitizing solutions are for example described in the handbook « Modern Electroplating » edited by Mordechay Schlesinger and Milan Paunovic, The Electrochemical Series (ECS), 5th Edition, 2010, in particular pages 447 to 459. However, since those sensitizing solutions are in ionized form, it is difficult to control the areas where the surface of the substrate is catalyzed for subsequent metal deposition. An object of the invention is to provide a method for depositing metal on a substrate with an improved preciseness on the locations where the metal is deposited, thereby allowing precise formation of conductive tracks and / or electrical contacts.

US 4 440 801 describes a method for selective electro-less deposition of a metal on a polyester substrate.

In this document, the polyester substrate is submitted to UV radiation that may be emitted by a laser.

However, for the method described in this document, use of a mask is mandatory which leads to several drawbacks among the following:

The use of a mask may result in a loss of resolution. Indeed, it is very difficult to find large (module level) mask with resolution down to a couple of microns (<10 μm).

5 The process costs are increased because of a step of the mask mounting on the module prior to the illumination.

In case, the mask will be in contact with the solar cells, thin cells may not be compatible because of the mechanical impact induced by this mask and, a mask may be not compatible with surfaces with different structures and height (e.g. space between cells in the module).

10 In addition, the effect of UV exposure of the polyester causes the polyester surface to become acidic and then strongly hydrophilic.

In order to proceed to electro-less plating, a pre-plating treatment bath has to be applied, like a dilute ammonia bath. As said in this document, "If there is only UV radiation and no pre-treatment, substantial electro-less
15 deposition will occur in those areas which have not been exposed to UV light."

Thus, in summary, the method described in this document needs use of a mask, the polyester is directly exposed to UV light, and a pre-treatment bath is necessary to get electro-less plating only in the areas exposed to UV
20 light.

US 4 268 536 describes also a method for depositing a metal on a surface. In this document, the substrate is first etched and then immersed in a sensitizer solution. After then, the sensitizer solution was removed and the substrate dried and stored.

25 Then, the dried substrate was exposed to UV-light through an imaging mask.

As one can understand, the method here described shows similar drawbacks as US 4 440 801 discussed above.

US2010009094 relates to a method for producing structured
30 electrically conductive surfaces on a substrate.

In this document, a base layer, which contains electrolessly and/or electrolytically coatable particles, is applied onto the substrate.

The base layer is then structured by ablation according to a predetermined structure with a laser.

5 The particles in the base layer of this document are ready to be plated or to accept a metal deposition and the laser action is only to reveal these particles to make them accessible for plating afterwards. In fact, the plating takes place on the base layer with its revealed particles, but not on the substrate itself. The base layer has therefore the function to fix the particles
10 to be plated on the substrate.

WO2011072506 relates to a method for metallizing a plastic surface. In this document, the plastic comprises a supporting material and an electroless plating promoter.

15 For plating, the method described in this document comprises the steps of gasifying the plastic surface to expose the electroless plating promoter and to realize then electroless plating step of a layer of copper or nickel on the plastic surface, followed by electroplating or a second electroless plating to form a metallized layer on the plastic surface.

20 However, in this case the plastic must already contain an electroless plating promoter which alters the characteristics of the plastic (for example aging, or mechanical characteristics).

The laser-gasifying is achieved on the surface of the plastic article where the part is made of plastic to expose the electroless plating promoter.

25 However, this alters the surface characteristics like roughness for example. The energy demand of the method in this document is low, it just needs to gasify the surface of the support to expose the electroless plating promoter, without reducing the support to the metal core. Thus the laser has no action on the electroless plating promoter for example to create ions. During metal deposition, the metal attaches itself directly to the electroless
30 plating promoter.

EP 1 367 872 describes a laser activated dielectrical material and method for using the same in an electro-less deposition process.

In this document, a dielectric coating containing a latent inert additive,
5 like inorganic fillers as for example titanium dioxide (TiO₂), aluminium nitride (AlN) or Zirconium dioxide (ZrO₂), that becomes catalytic to electro-less deposition after exposure to a laser beam is applied to a substrate.

In this document, "activating" means only to reveal for example the TiO₂ molecules and to separate the Ti atom from the O₂ molecule allowing
10 therefore plating directly on the Ti atoms. In this case no charged ions are created.

Moreover, after that specific coating and exposure to laser light of the dielectric coating which becomes catalytic; a sensitizer solution needs to be applied before copper deposition by electro-less plating. Thus, it is
15 understood that a specific preparation step of the substrate is necessary before application of a sensitizer solution which is done every time which make the process described in this documents complex and expensive.

In addition, the dielectric coating is not removed from the substrate so that after exposure to laser light, the surface is roughened by channels.
20

US 4 042 730 describes a classical process for electro-less plating that uses separate sensitization and activation process. However, this process is not selective enough and needs various mechanical manipulations that should be avoided because of the low thickness of the substrates in particular when used with solar modules and/or solar cells.
25

Consequently, there is a real need to develop a method for metal deposition on a substrate, in particular for metallization of solar cells and modules, which is less expensive and reliable.

For this purpose, the invention proposes a method for depositing metal
30 on a substrate comprising the following steps:

- deposition of a sensitizer comprising laser activable metal based molecules in a neutral state on the substrate,
- activation of said laser activable metal based molecules of the sensitizer through laser activation so as to create metal ions from said laser activable metal based molecules which catalyze areas on the substrate,
- chemical deposition of metal on said catalyzed areas of the substrate.

As said laser activable metal based molecules of the sensitizer are deposited in a neutral state, they are inert and have no catalyzing properties in this state. This is quite different from the known solutions where a metal salt is contained in an aqueous solution and therefore already in an ionized, non-neutral state. The present invention allows therefore to be more selective and precise thanks to the fact that the sensitizer is ionized (i.e. activated) only after it is exposed to the laser and only in the areas where it is exposed to such laser.

Thanks to the laser activation, conductive patterns comprising for example conductive tracks and/or electrical contacts can be defined with a high resolution (for example with a width of 5-10 μ m) and without submission of the wafers to mechanical stress. Furthermore, the patterns for metallization can be formed without the use of masks.

Due to direct exposure to laser light of the sensitizer coating the substrate (which is in neutral form before being exposed to the laser), specific and expensive pre-treatment steps as known in prior art are no longer necessary.

The whole method is a low temperature process, which does not impact the performance of the solar cells.

According to other characteristics taken alone or in combination:

Said laser activable metal based molecules may comprise a metal salt or a metal oxide.

According to one aspect the sensitizer is a gel solution.

5

As a gel, the sensitizer can be applied easily by spin coating as a thin film. Such a gel can be dried and solidified which allows a more easy manipulation of the substrate.

10 According to another aspect, the sensitizer comprises a support material for the metal based molecules conserving these metal based molecules in a neutral state.

15 Such a support material, like a solvent or a polymer is non-aqueous and therefore may conserve the metal salts or metal oxide in a neutral state, meaning electrically non-charged or not ionized. As solvent, toluene or a polymer may be used.

20 Furthermore, the metal atoms of said laser activable metal based molecules may be noble metal atoms, in particular palladium atoms or platinum atoms, or are metal atoms to be deposited on the substrate.

25 Salts or oxides with noble metal atoms show once laser activated a good performance to catalyze the substrate. Use of a metal atom that shall be deposited after then may be cheaper.

According to another aspect, the chemical metal deposition step is realized by electro-less plating, which is quite cheap and simple to realize.

30 Furthermore, the deposited metal may have a thickness comprised between 0,1 - 10 μ m. This range is quite a good compromise to create a

first metal layer that has sufficient conductivity for subsequent electroplating.

5 The sensitizer is removed from the substrate after laser activation that may avoid any potential negative effect on the chemical metal deposition.

10 According to further development a step of deposition of a subsequent metal on the deposited metal through an electroplating process may be foreseen. This allows creating electrical contacts and / or conductor tracks which have an enough low resistivity.

15 The substrate is for example part of a solar cell or a solar module component. The method according the invention allows creating conductive tracks and / or electrical contacts cheaper and easier.

20 In one embodiment two different substrates are placed adjacent to each other and where said metal deposition method is applied to form a conductor track on both substrates. The method may be applied although the substrate underneath changes which is easier in a manufacturing process.

25 One of said two different substrates may belong to the module level components, in particular an insulator, an encapsulant, a plastic, or a glass and the other one of said two different substrates belongs to the solar cell level components, in particular an Si layer, a dielectrics layer, an oxide layer.

30 The invention also relates to a solar cell comprising electrical tracks and/ or electrical contacts realized by a method as defined above.

The invention also relates to a solar module comprising a plurality of solar cells as defined above.

5 Due to the electro-less plating, or the combination of electro-less plating for the seed and then electroplating, for the conductive metal, an important cost reduction can be achieved.

BRIEF DESCRIPTIONS OF THE DRAWINGS

10 Other advantages and characteristics will appear with the reading of the description of the following figures, among which:

- FIG. 1 shows a schematic view of a substrate for applying the method of the invention,

15

- FIG. 2 shows a flowchart for illustrating the different steps of the method of the invention according a first embodiment,

- FIG. 3 to 7 show a schematic view of the substrate of figure 1 for illustrating different steps of the method of the invention,

20

- FIG. 8 shows a schematic view of two adjacent substrates for applying the method of the invention,

- FIG. 9 to 13 show a schematic view of two adjacent a substrates of figure 8 for illustrating different steps of the method of the invention according to another embodiment,

25 DETAILED DESCRIPTION

On all the figures the same references refer to the same elements.

FIG.1 schematically illustrates a substrate 1 to which a metal deposition
30 method as described below shall be applied to form for example

continuous conductor tracks or to form electrical contacts, in particular back contacts for a solar cell.

The substrate may be made of any non-conducting material, like an insulator, an encapsulant, a plastic, a glass, a dielectric layer, an oxide layer of a solar cell or a silicon based material.

As shown in figure 1, the substrate 1 is conformed for example as a layer. Preferentially, the substrate 1 may be the top or bottom layer of a stack of different layers of a PV module (photovoltaic module) or a solar cell.

In figure 1, the surface is plane, but might be also convex, concave or show some protrudes or relief / three dimensional shapes.

The substrate 1 belongs for instance to a solar / PV module and/or a solar cell where electrical tracks and/ or electrical contacts shall be realized by a method as described below. Concerning solar cells, the here described method may advantageously applied to solar cells with back contacts also known as rear contacted cells.

The following description focuses more specifically on PV cells and PV modules, but does not exclude other devices where electrical circuits or contacts have to be realized on, like a printed circuit board (PCB).

In a flowchart in figure 2 are represented different steps of an embodiment of a method for deposition of a metal on a substrate as shown for example in figure 1.

Other different steps of the method are then also shown in more detail in figures 3 to 7. Not all described steps are essential and in some other embodiments, some steps might be omitted.

In a first step 101 (figure 3), a sensitizer 9 comprising laser activable metal based molecules in a neutral state, like for example a metal salt or a metal oxide, is disposed on the substrate 1.

As the laser activable metal based molecules are in a neutral state when the sensitizer is deposited, they are inert and have no catalyzing properties in this state. As such, in a neutral state, they are inactive at a stable state and therefore do not have a catalytic effect on the substrate when simply deposited on the substrate.

The metal atom of the metal salt or oxide may be noble metal atom, in particular palladium atom (the metal salt would be PdCl_2) or platinum atom (the metal salt would be PtCl_2), or with metal atom to be deposited on the substrate (Cu chloride, Ni chloride or other salts). Also SnCl_2 can be envisaged.

Once laser activated, meaning broken down to charged ions, salts and/or oxides with noble metal atoms show a good performance to catalyze the substrate, in particular its surface. The use of a metal atom that shall be deposited after then may be cheaper.

The sensitizer 9 composition comprises a support material for the metal based molecules that conserves these molecules in a neutral state as for example a solvent or a polymer.

The solvent is non-aqueous and therefore may conserve the metal salts and/or oxide in a neutral state, meaning electrically non-charged or not ionized. As solvent, toluene or a polymer like PPSQ (PolyPhenylSilsesquioxane.) dissolved in actone or toluene can be used.

The sensitizer 9 might be a gel based solution.

When deposited, the sensitizer is thus inert and inactive, which would mean that areas covered by the sensitizer, but that are not exposed to laser activation would not be catalyzed and thus would not be subject to chemical metal deposition.

Due to exposure to the laser light, photons are absorbed in the laser activable metal based molecules in a neutral state such as metal salt and/or metal oxide. This has the effect that the molecules are broken and the metal ions are created at the surface underneath of the substrate 1, catalyzing this area of the substrate 1.

The catalyzing process consist for the metal ion to interact with the atoms of the substrate surface by being reduced at the surface or by making this surface sensitive to further metal ions reduction during the metal chemical deposition.

These catalyzed areas therefore show at the surface of the substrate 1 open bindings where the metal atoms may be deposited via electro-less plating, allowing therefore direct metal deposition on the surface of the substrate 1.

According to one aspect, the deposition of the sensitizer is done by spin-coating or simple immersion. In particular as a gel, the sensitizer can be applied easily by spin coating as a thin film or layer.

Optionally, after deposition of the sensitizer 9, the sensitizer based material might solidified, for example during a curing step.

Then, in step 103 (figure 4), the sensitizer 9 is laser activated by a laser beam 10 so as to form catalyzed areas 11. Arrows 13 illustrate the movement of the laser beam 10 that may scan all the surface coated with the sensitizer 9, but impact the surface only at predetermined locations so as to form the catalyzed areas 11. The laser activates the sensitizer at the surface but also in the depth near the surface of the substrate.

In one example, the laser or laser head might move above the substrate 1. However, it is also envisaged that the laser beam 10 moves across the substrate due to moving mirrors that deflect the outgoing laser beam to the areas to be activated. In quite another solution, the laser does not move and the substrate moves beneath the laser beam 10. A combination where the substrate 1 moves as well as the laser beam 10 is also possible which enhances the throughput in the manufacturing process.

These catalyzed 11 areas correspond to a specific pattern where electrical contacts and/or conductor tracks shall be created afterwards.

In particular, one can also see a gap 14 where said metal based molecules in a neutral state are not activated and therefore no metal deposition will take place at these locations.

Such gaps 14 might be interesting for solar cell / modules manufacturing, in particular for example to implement later on other electrical / electronic components, like diodes, that may be used as by-pass diodes for avoiding shadowing effects.

As an alternative to the above described optional curing step before the laser activation step 103, the laser power may be adjusted in a way that the sensitizer 9 is solidified through the laser activation step.

As already stated above, during laser activation, the surface underneath of the substrate 1 is catalyzed.

Thanks to the laser activation, a very precise pattern of catalyzed areas 11 that will be subject to metal deposition, may be created with high resolution.

After laser activation 103, the sensitizer is removed from the substrate 1 in step 105, for example in a cleaning step (figure 5).

Thus, the sensitizer 9 with its support material and the metal based molecules is removed so that only the substrate 1 remains with its activated catalyzed areas 11.

Then, in step 107 (figure 6), a platable metal 19 is disposed by chemical metal deposition, for example an electro-less plating process, at said catalyzed areas 11 where the sensitizer has been activated by the laser, meaning directly on the catalyzed areas 11 of the surface of the substrate 1.

The deposited metal defines for example electrical contacts 15 and/or conductor tracks 17.

Indeed, thanks to the laser activation, metal deposition will only take place at the catalyzed areas 11, on the surface of the substrate 1.

The metal 19 that is deposited may be chosen to present a conductivity sufficient to allow an optional subsequent electro-plating process step and may be comprised in the group of a noble metal, Cu, Ti, W, Co, Ni, Zn, Sn, Ag. Among these metals, nickel is preferred for its price and good adherence and conduction properties.

The deposited metal 19 has a thickness comprised between 0,1 - 10µm.

5 In a more developed alternative, after step 107, a second, subsequent metal may optionally be disposed through an electro-less or electroplating process on the first metal that has been deposited by electro-less plating before.

10 The second metal may be comprised in the group of a Cu, Ni, Zn, Sn, Ag. Among these metals, copper is preferred because of its price and good adherence, in particular on nickel, and conduction properties.

The thickness of the second metal layer is comprised between 10 to 50-60 microns.

15 In a specific embodiment, where Ni is used as a first deposited metal 19 for a seed layer, and Cu is used as the second subsequent metal for electroplating, it is observed that the Ni seed layer is cheap and a good barrier to Cu diffusion.

20 It has to be noted that the first and second metal may be different or the same.

25 Finally, depending on the application and the deposed metals used, after the electro-plating process step 109, a protection layer, in particular against corrosion, may be applied in a step 111. The protection layer may be a Sn/OSP finishing (OSP = organic surface protection or Organic solderability preservatives), in particular for the conductive tracks. For the electrical contacts, a protection layer of Sn or Ag is preferred. The method
30 of deposition includes electro-less, electroplating, metal immersion and others ways of coatings

For module manufacturing, an encapsulation step may be foreseen after step 111.

5 FIG.8 schematically illustrates two different substrates 1 and 3 to which a metal deposition method as described below shall be applied to form for example continuous conductor tracks at the interface of said two different a substrates 1 and 3 or to form electrical contacts, in particular back contacts.

10

The two different substrates 1 and 3 are placed adjacent to each other to form a surface 5. Thus both substrates 1 and 3 have a common interface 7, where they touch each other.

15 “Different” means here, that the nature of the materials are different, like for example an Si-layer on the one hand and plastic on the other hand (other examples are possible and detailed below).

20 As shown in figure 8, substrates 1 and 3 are conformed for example as a layer. Preferentially, these a substrates 1 and 3 are the top or bottom layer of a stack of different layers of a module or a solar cell, each stack may be different.

25 As can be seen in figures 9-13, the process steps applied to these adjacent substrates 1 and 3 may be quite identical to those describes in figures 1 to 7 for only one substrate. This is quite an advantage as continuous conductive tracks can be created irrespective a change of substrate underneath and without change of the metal deposition method.

30

The method according to the invention has the advantage that nearly no mechanical stress is applied to the wafer / cells, the conductive tracks and electrical contacts might be defined with high precision and the method allows a good cost compromise in using electro-less plating only for creating seed locations that are enforced then through conventional cheaper electroplating process. Therefore the overall cost of the metallization process can be optimized.

In addition, a self-aligned metallization for cell contacts and module interconnections (the conductive tracks) can be achieved.

The above method is in particular well adapted for thin wafers (about 100µm).

The above method is also a low temperature process which is suitable for module level processing with glass, encapsulants, backsheet and insulators. Thanks to laser activation, there is a great flexibility for the metal pattern definition.

CLAIMS

1. Method for depositing metal on a substrate (1,3) comprising the
5 following steps:
- deposition (101) of a sensitizer (9) comprising laser activable metal based molecules in a neutral state on the substrate (1,3),
 - activation of said laser activable metal based molecules of the sensitizer (9) through laser activation (103) so as to create metal ions
10 from said laser activable metal based molecules which catalyze areas (11) on the substrate,
 - after laser activation (103), the sensitizer (9) is removed from the substrate (1),
 - chemical deposition of metal (107) on said catalyzed areas (11) of the
15 substrate (1, 3).
2. Method according to claim 1, where said laser activable metal based molecules comprise a metal salt.
- 20 3. Method according to claim 1, where said laser activable metal based molecules comprise a metal oxide.
4. Method according to any of claims 1 to 3, where the sensitizer (9) is a gel solution.
- 25 5. Method according any of claims 1 to 4, where the sensitizer (9) composition comprises a support material for the metal based molecules conserving these metal based molecules in a neutral state.
- 30 6. Method according to any of claims 1 to 5, where the metal atoms of said laser activable metal based molecules are noble metal atoms, in

particular palladium atoms or platinum atoms, or are metal atoms to be deposited on the substrate.

7. Method according any of claims 1 to 6, where the chemical metal deposition step is realized by electro-less plating.

8. Method according to any of claims 1 to 7, where the deposited metal has a thickness comprised between 0,1 - 10µm.

9. Method according any of claims 1 to 8, further comprising a step of deposition of a subsequent metal on the deposited metal through an electroplating process.

10. Method according to any of claims 1 to 9, where said substrate (1, 3) is part of a solar cell or a solar module component.

11. Method according to claim 10, where two different substrates (1,3) are placed adjacent to each other and where said metal deposition method is applied to form a conductor track (15) on both substrates (1, 3).

12. Method according to claim 11, where one (1) of said two different substrates belongs to the module level components, in particular an insulator, an encapsulant, a backsheet, a plastic, or a glass and where the other one (3) of said two different substrates belongs to the solar cell level components, in particular an Si layer, a dielectrics layer, an oxide layer.

13. Solar cell comprising electrical tracks (15) and/ or electrical contacts (17) realized by a method according to any of claims 1 to 12.

14. Solar module comprising a plurality of solar cells according to claim 13.

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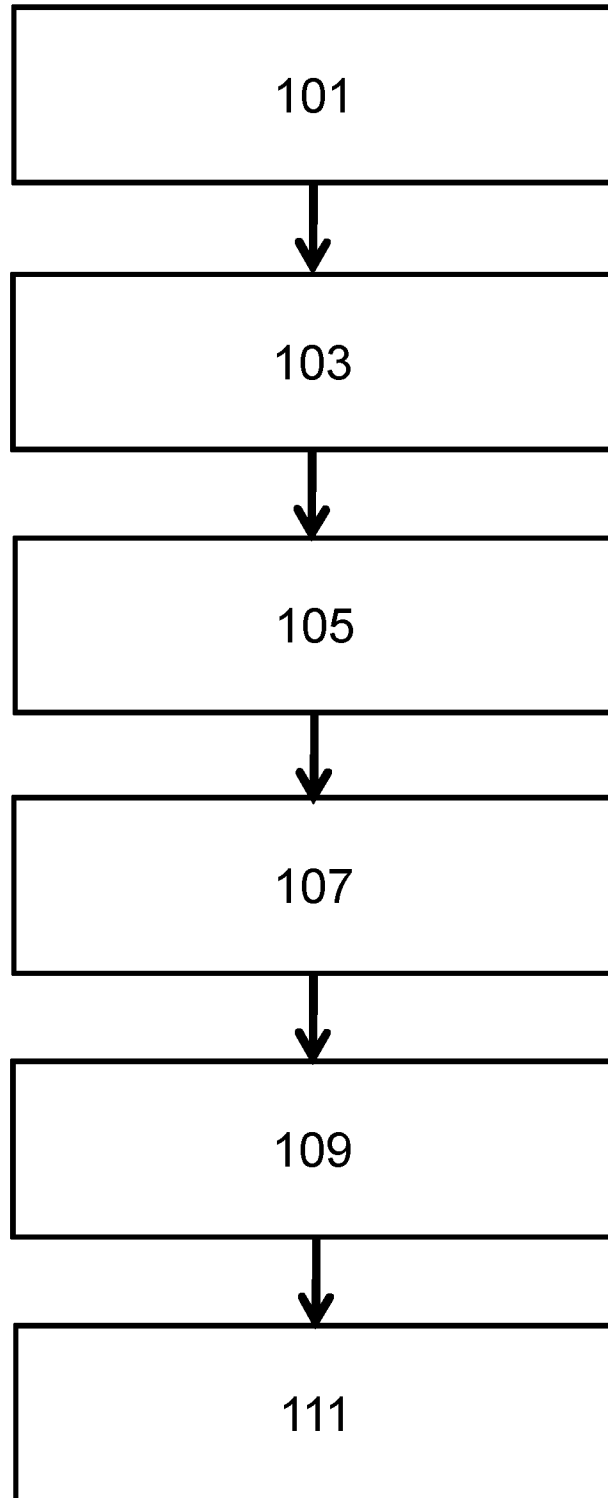


FIG. 2

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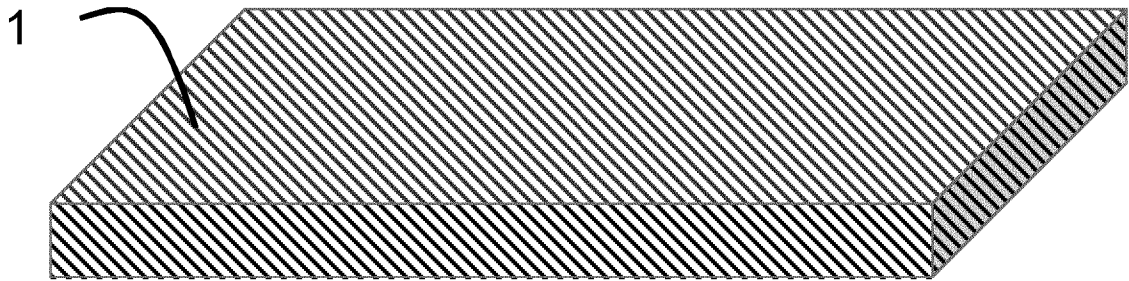


FIG. 1

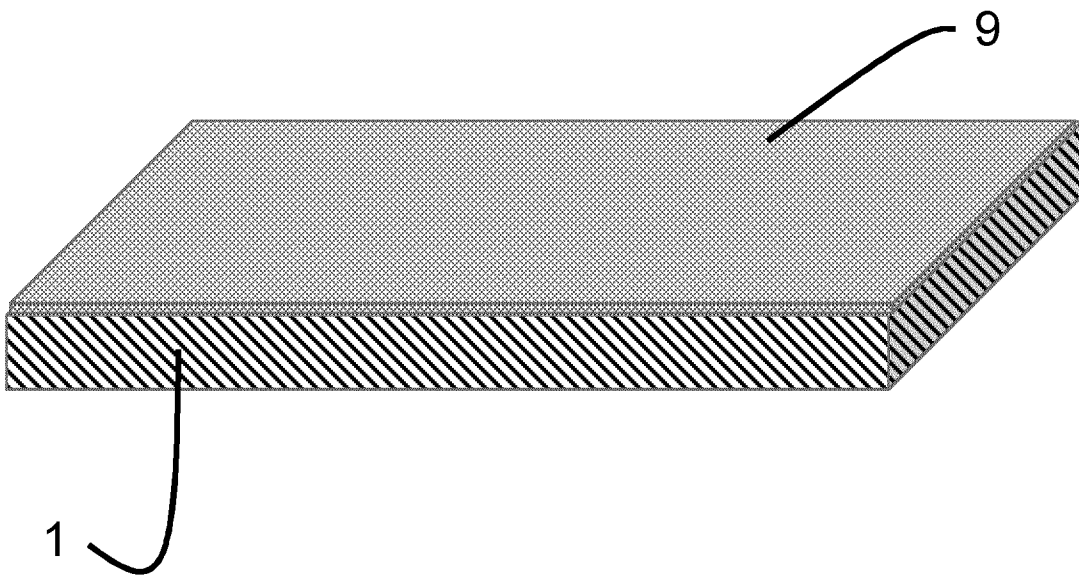
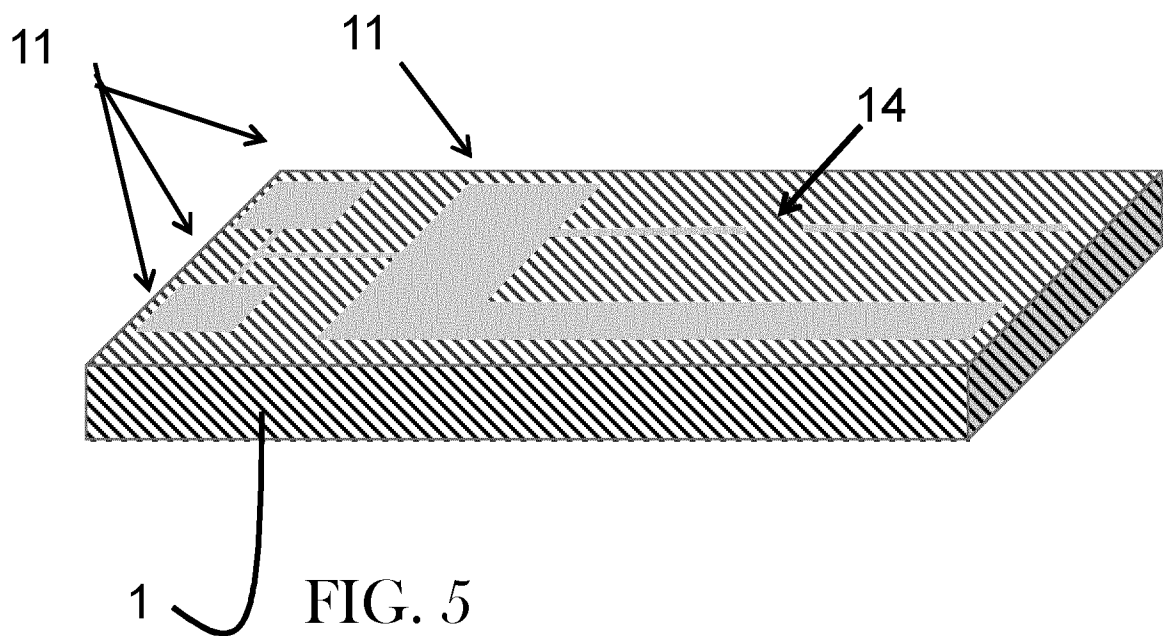
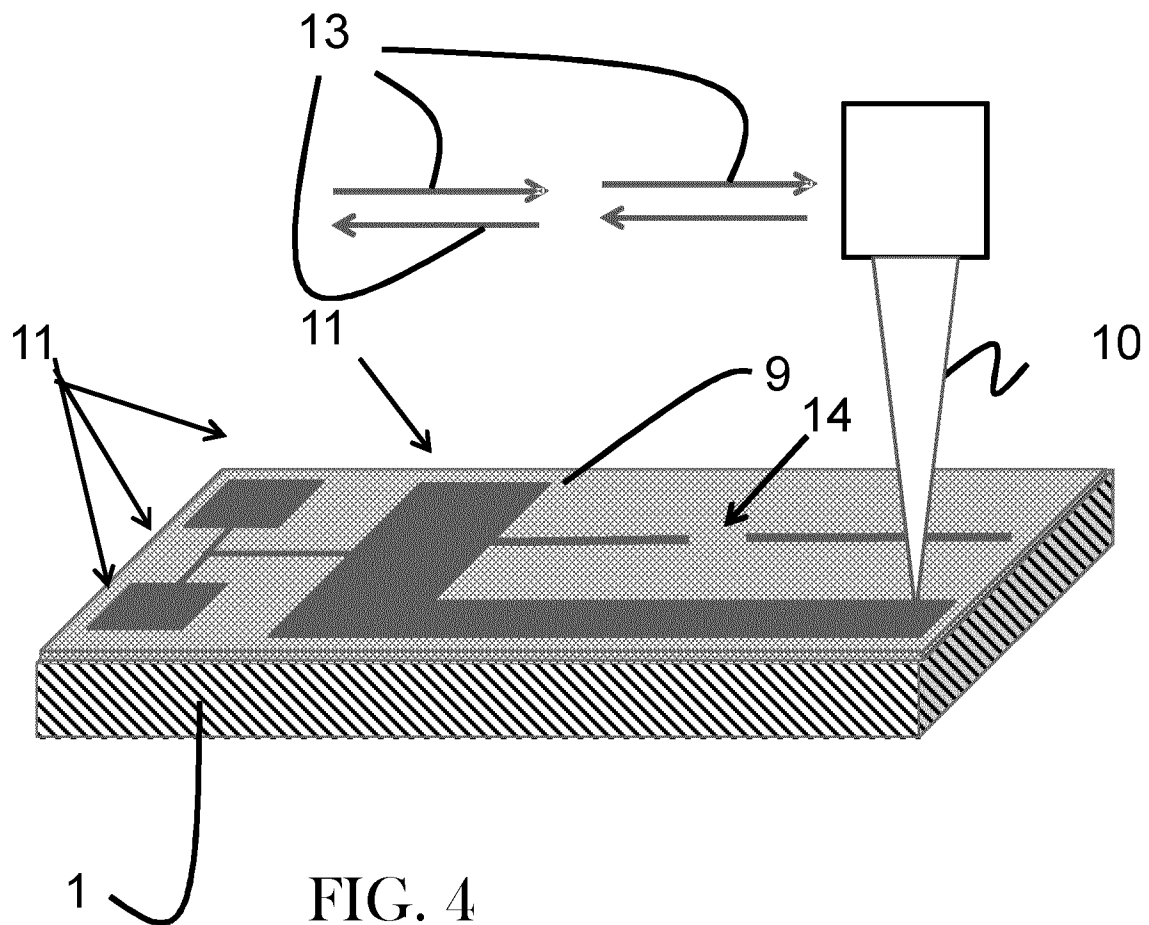
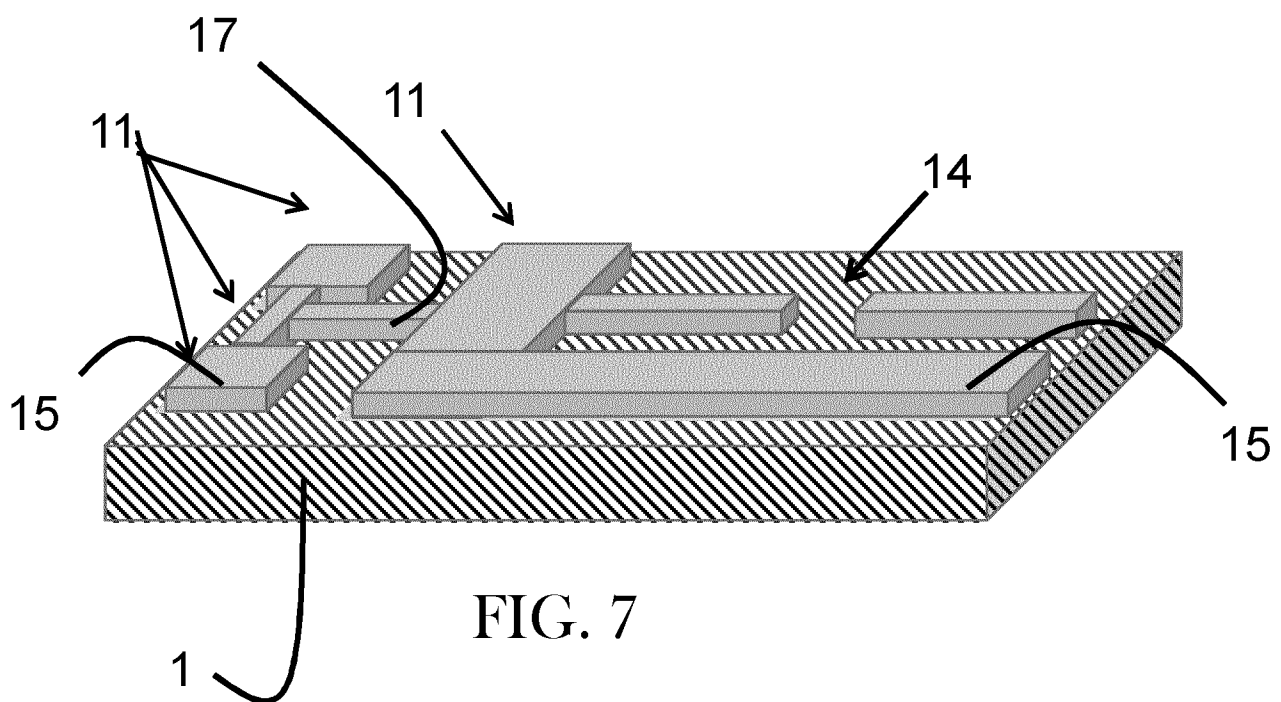
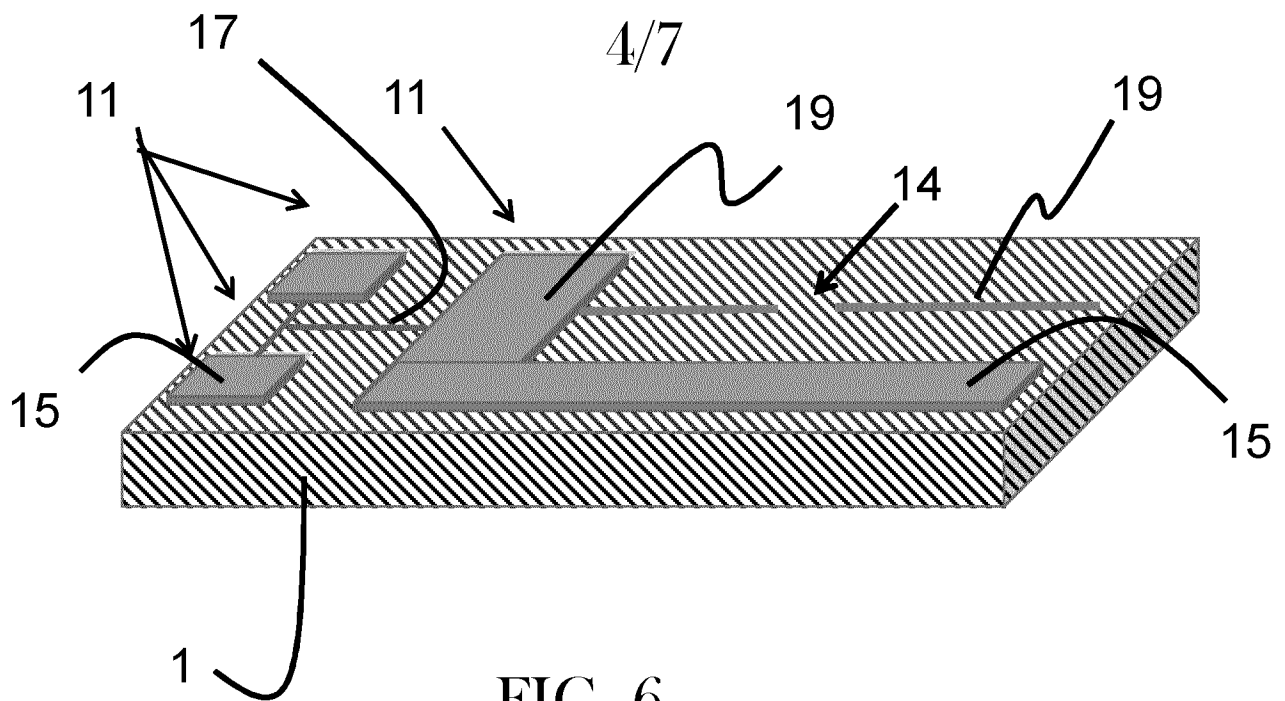


FIG. 3

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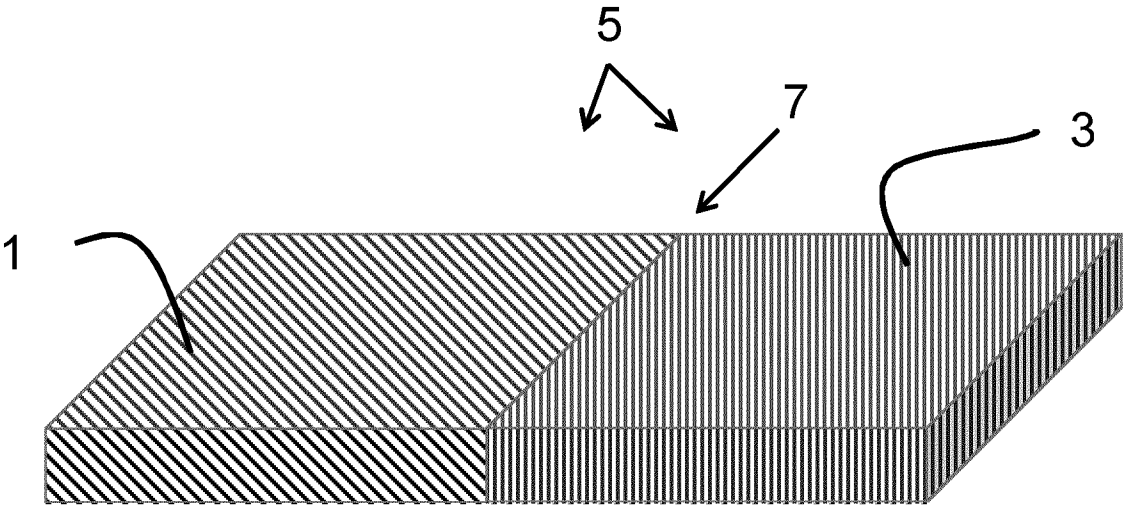


FIG. 8

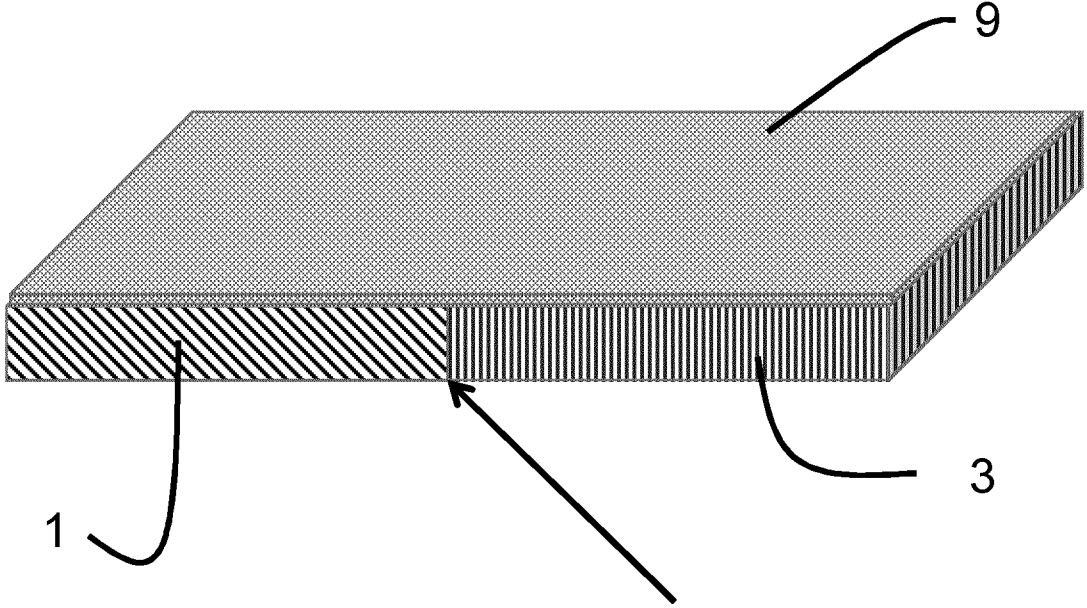
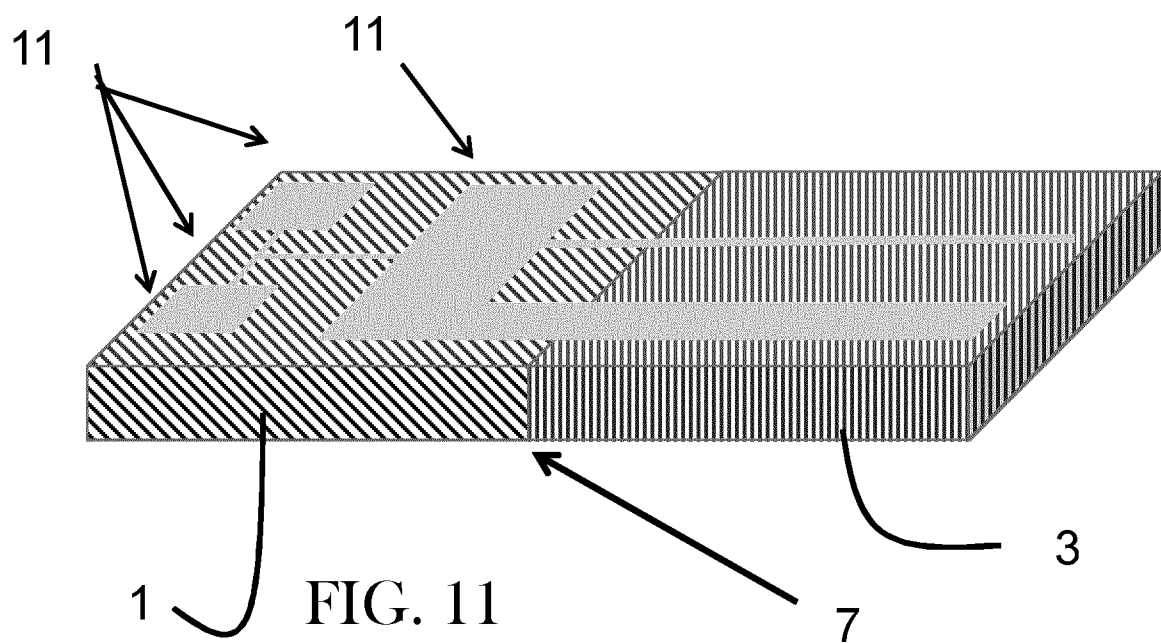
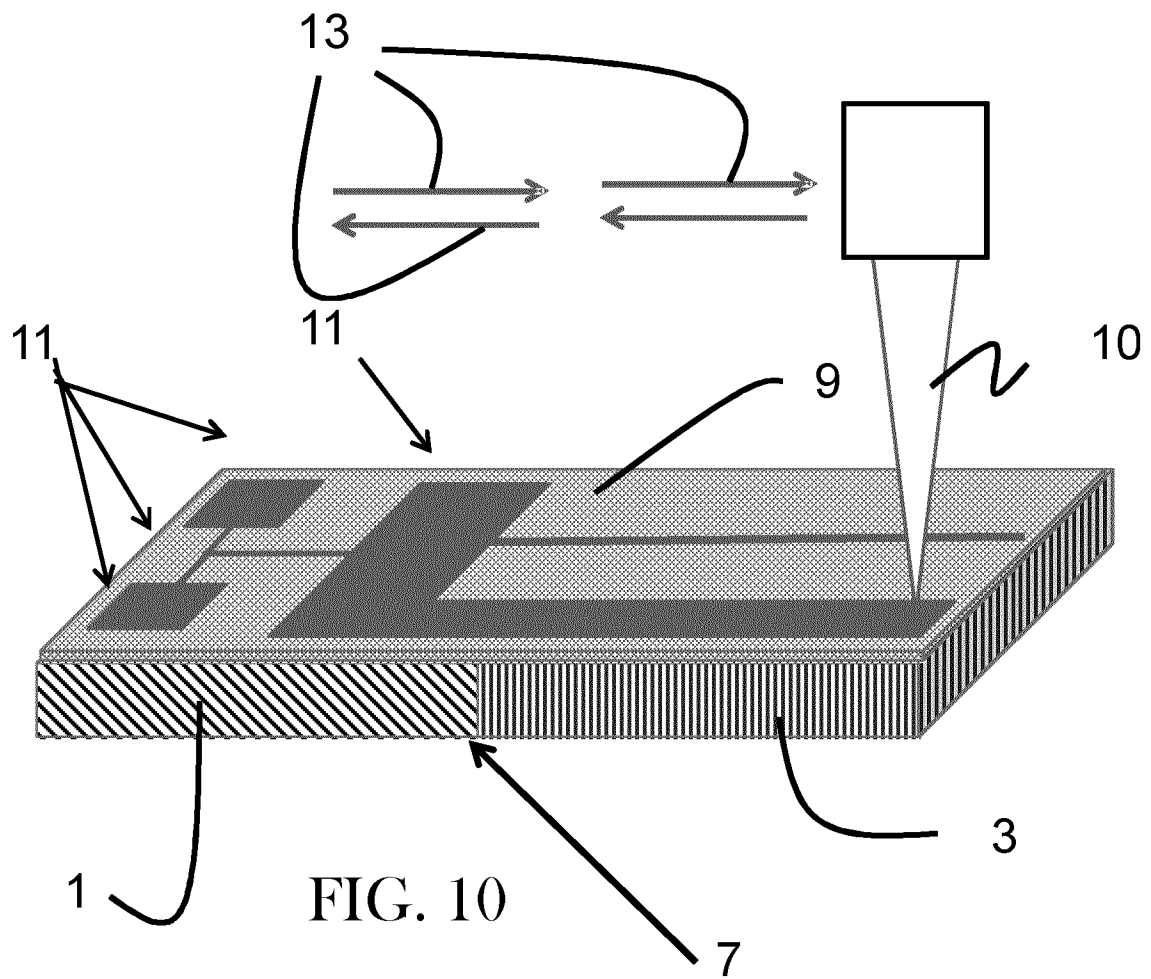
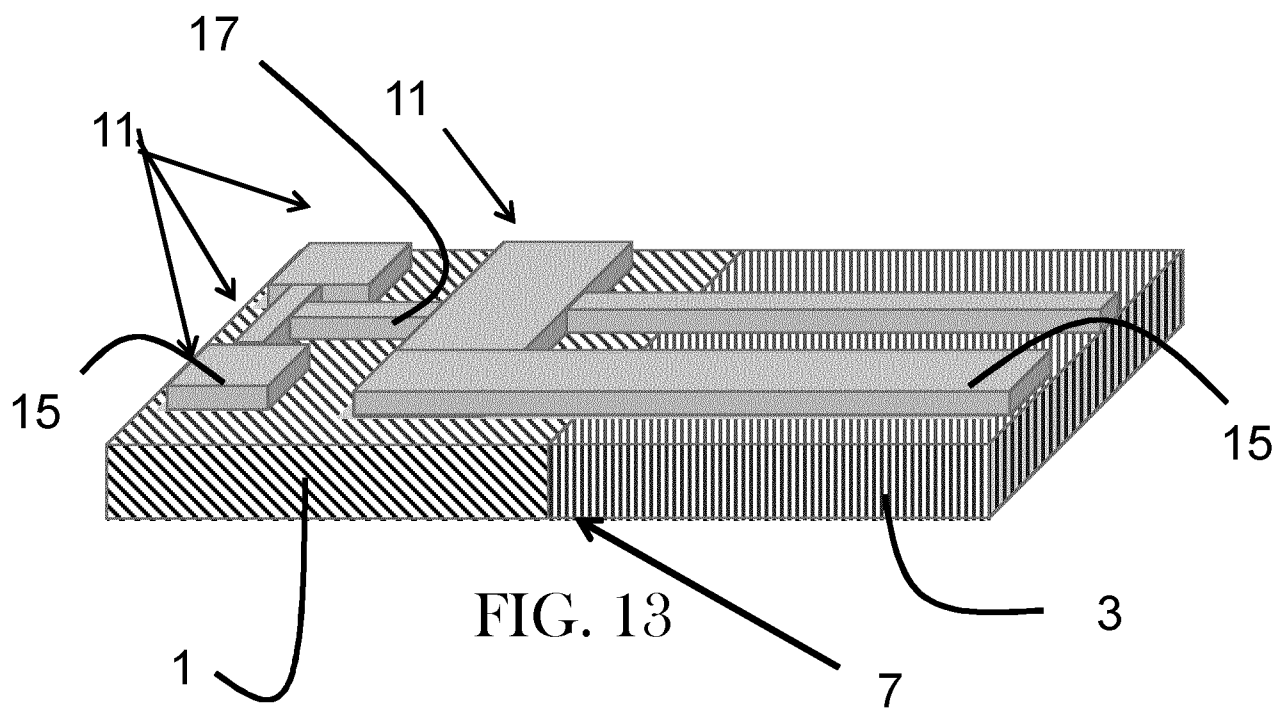
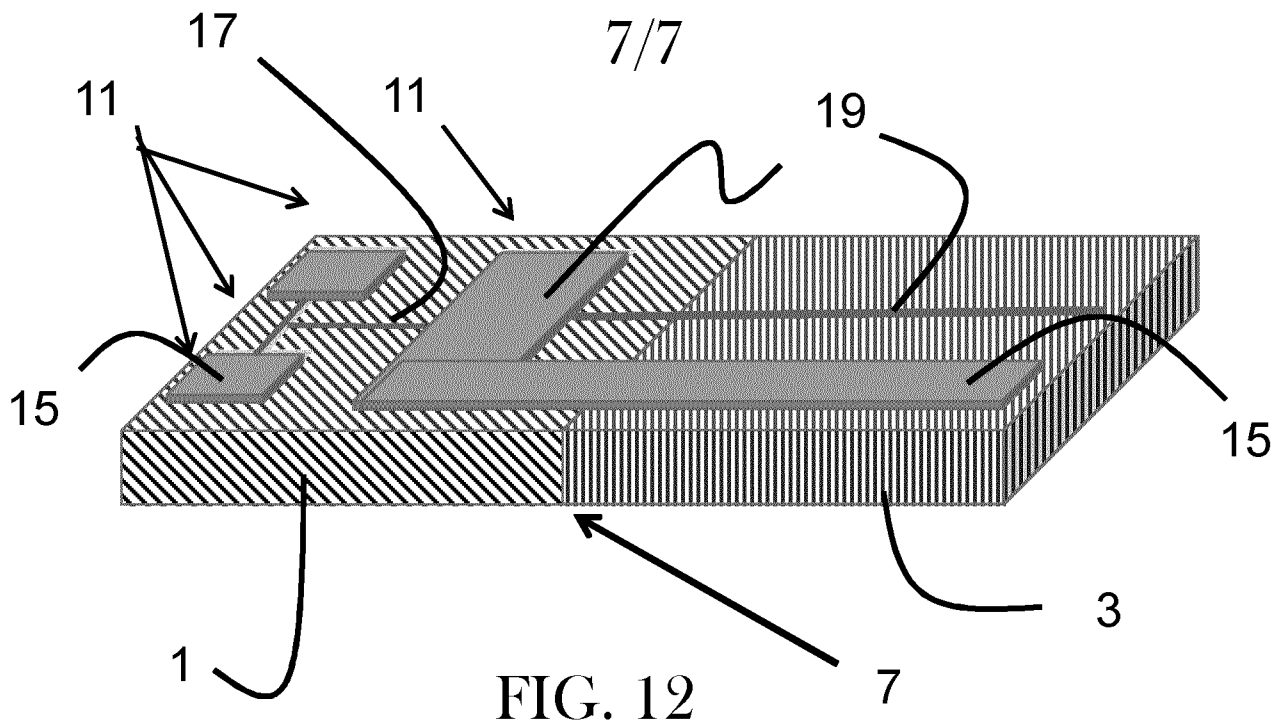


FIG. 9

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2014/066847

A. CLASSIFICATION OF SUBJECT MATTER

INV. C23C18/06 C23C18/28 C23C18/31
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

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

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X	WO 2008/087172 A1 (BASF SE [DE]; LOCHTMAN RENE [DE]; KACZUN JUERGEN [DE]; WAGNER NORBERT) 24 July 2008 (2008-07-24) cited in the application the whole document	1-14
X	WO 2011/072506 A1 (BYD CO LTD [CN]; GONG QING [CN]; ZHOU LIANG [CN]; MIAO WEIFENG [CN]; Z) 23 June 2011 (2011-06-23) cited in the application the whole document	1-14
X	EP 1 367 872 A2 (SHIPLEY CO LLC [US]) 3 December 2003 (2003-12-03) cited in the application the whole document	1-14



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

4 November 2014

Date of mailing of the international search report

11/11/2014

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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