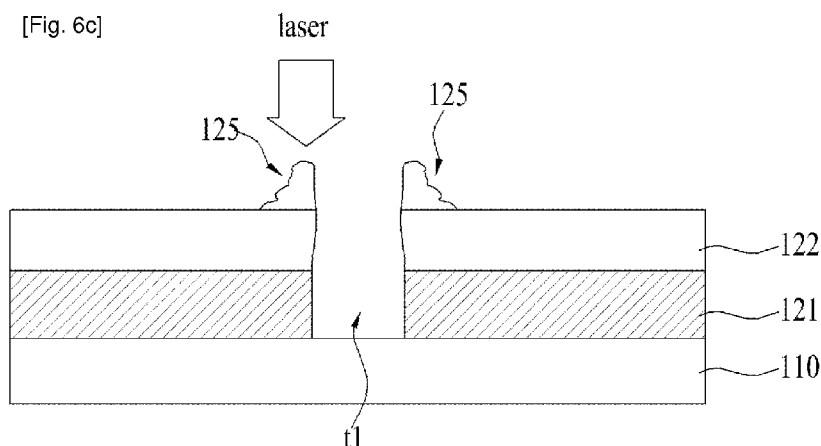




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(54) **Title:** SOLAR CELL AND METHOD FOR MANUFACTURING THE SAME



(57) **Abstract:** Disclosed are a solar cell and a method for manufacturing the same. The method includes forming a back electrode on a substrate, forming an anti-diffusion layer on the back electrode, performing primary laser scribing to divide the back electrode into a plurality of unit back electrodes, performing secondary laser scribing along one side of a first line formed by the primary laser scribing such that a process region of secondary laser scribing overlaps the first line to remove a burr produced by the primary laser scribing, and performing tertiary laser scribing along the other side of the first line such that a process region of tertiary laser scribing overlaps the first line to remove the burr.



Description

Title of Invention: SOLAR CELL AND METHOD FOR MANUFACTURING THE SAME

Technical Field

- [1] The present invention relates to a solar cell and a method for manufacturing the same.

Background Art

- [2] A solar cell is an apparatus which converts light energy into electric energy using characteristics of semiconductors.
- [3] A solar cell has a PN junction structure in which a positive (P)-type semiconductor is joined to a negative (N)-type semiconductor. When sunlight is incident upon a solar cell having this structure, energy the incident sunlight retains results in generation of holes and electrons in the semiconductor, and at this time, an electric field generated in the PN junction causes holes (+) to move toward the p-type semiconductor and electrons (-) to move toward the N-type semiconductor, thus generating an electric potential charge and thereby producing electricity.
- [4] Such a solar cell is divided into a substrate-type solar cell and a thin film-type solar cell.
- [5] The substrate-type solar cell is a solar cell manufactured using a material, such as silicon, for a substrate and the thin film-type solar cell is a solar cell manufactured by forming a semiconductor in the form of a thin film using a material, such as glass, for a substrate.
- [6] The substrate-type solar cell exhibits slightly superior efficiency, as compared to the thin film-type solar cell, but has disadvantages of limited thickness minimization in terms of processing aspects and increased manufacturing costs due to use of expensive semiconductor substrate.
- [7] The thin film-type solar cell exhibits slightly lower efficiency, as compared to the substrate-type solar cell, but can be manufactured at a small thickness, uses inexpensive materials and thus reduces manufacturing costs and is suitable for mass-production.
- [8] The thin film-type solar cell is manufactured by forming a front electrode on a substrate such as glass, forming a semiconductor layer on the front electrode and forming a back electrode on the semiconductor layer. A transparent conductive material such as ZnO is used for the front electrode, since the front electrode forms a light-receiving surface on which light is incident. As the substrate increases in size, electric power loss disadvantageously increases due to resistance of the transparent

conductive material.

- [9] Accordingly, a thin film-type solar cell is generally designed to have a structure in which a plurality of unit cells are connected in series, to minimize electric power loss caused by resistance of the transparent conductive material.
- [10] FIGS. 1a to 1f are sectional views illustrating a method for fabricating a conventional thin film solar cell having a structure in which a plurality of unit cells are connected in series.
- [11] Referring to FIG. 1a, a front electrode 20 is formed on a substrate 10.
- [12] Referring to FIG. 1b, to divide the front electrode 20 into a plurality of unit front electrodes, a predetermined region of the front electrode 20 is removed by a laser scribing process (P1) to form a first trench (t1).
- [13] Referring to FIG. 1c, a semiconductor layer 30 is formed over the entire surface of the substrate 10 including the front electrode 20.
- [14] Referring to FIG. 1d, to divide the semiconductor layer 30 into a plurality of unit semiconductor layers, a predetermined region of the semiconductor layer 30 is removed by a laser scribing process (P2) to form a second trench (t2).
- [15] Referring to FIG. 1e, a back electrode 50 is formed on the semiconductor layer 30.
- [16] Referring to FIG. 1f, predetermined regions of the back electrode 50 and the semiconductor layer 30 are removed by a laser scribing process (P3) to form a third trench (t3). As a result, a thin film-type solar cell having a structure, in which a plurality of unit cells are connected in series, can be obtained.
- [17] Such a thin film-type solar cell is classified into a superstrate-type solar cell in which sunlight is directly incident on a transparent substrate such as glass, and a substrate-type solar cell in which a low-transparency flexible substrate is used and sunlight is incident through the transparent conductive layer laminated on the substrate.
- [18] FIG. 2 is a view illustrating a method of laser scribing a conventional superstrate-type solar cell. FIG. 3 is a view illustrating a method of laser scribing a conventional substrate-type solar cell.
- [19] Referring to FIG. 2, since the superstrate-type solar cell uses a transparent glass through which a laser can pass, as the substrate 60, the laser passes through the substrate 60 and can remove the transparent conductive layer 61 present under the substrate 60. As shown in the drawing, particles of the removed transparent conductive layer 61 are scattered down the substrate 60 and do not remain on the transparent conductive layer 61.
- [20] Meanwhile, referring to FIG. 3, the substrate-type solar cell uses a flexible substrate 70 having low light transmittance, thus requiring processing of a film surface, since a laser cannot pass through the substrate 70.
- [21] In a state in which the back electrode 71 and the anti-diffusion layer 72 are laminated

on the substrate 70 in this order, a laser is irradiated to remove the back electrode 71 and the anti-diffusion layer 72. For this reason, particles produced during laser scribing are present in the form of a residue on the anti-diffusion layer 72 or are laminated on the edge of the anti-diffusion layer 72, melted and removed by high energy of the laser, forming a burr 73.

[22] FIG. 4 is a view illustrating a burr produced by laser scribing in a conventional substrate-type solar cell. FIG. 5 is a view illustrating a problem caused by a burr present in a conventional substrate-type solar cell.

[23] Referring to FIG. 4, the particles produced by P1 laser scribing in the substrate-type solar cell are laminated on the edge of the anti-diffusion layer 72, forming a burr 73. The burr 73 may have a height of several hundred nanometers (nm).

[24] Referring to FIG. 5, the back electrode 71 and the anti-diffusion layer 72 laminated on the substrate 70 are subjected to P1 laser scribing, producing a burr 73.

[25] The burr 73 produced during P1 laser scribing passes through the semiconductor layer 74 formed on the anti-diffusion layer 72 by a subsequent process and comes in contact with the front electrode 75. The burr 73 contacts the front electrode 75, which causes the front electrode 75 to come into contact with the back electrode 71, thus disturbing insulation of the solar cell and causing a deterioration in efficiency of the solar cell. In serious cases, the burr 73 disadvantageously prevents the solar cell from operating normally.

Disclosure of Invention

Technical Problem

[26] Accordingly, the present invention is directed to a solar cell and a method for manufacturing the same that substantially obviate one or more problems due to limitations and disadvantages of the related art.

[27] It is an object of the present invention is to provide a solar cell to prevent deterioration in insulation and efficiency due to burrs produced during laser scribing and a method for fabricating the solar cell.

Solution to Problem

[28] To achieve the object and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, provided is a method for manufacturing a solar cell, including: forming a back electrode on a substrate; forming an anti-diffusion layer on the back electrode; performing primary laser scribing to divide the back electrode into a plurality of unit back electrodes; performing secondary laser scribing along one side of a first line formed by the primary laser scribing such that a process region of secondary laser scribing overlaps the first line to remove a burr produced by the primary laser scribing; and performing tertiary laser scribing along the

other side of the first line such that a process region of tertiary laser scribing overlaps the first line to remove the burr.

- [29] The secondary laser scribing and the tertiary laser scribing may be performed simultaneously or sequentially.
- [30] Assuming that the line formed by secondary laser scribing is defined as a second line and a line formed by tertiary laser scribing is defined as a third line, the width of the second line and the third line may be 1/2 or less of the width of the first line.
- [31] The width of the second line and the third line may overlap the width of the first line by 10 μ m or more.
- [32] The first line may have a width of 50 to 60 μ m and the width of the second line and the third line may have a width of 20 to 30 μ m.
- [33] The secondary laser scribing and the tertiary laser scribing may be carried out at a low frequency lower and at a low power, as compared to the secondary laser scribing.
- [34] The substrate may be a flexible substrate selected from an aluminum foil, a SUS foil and a semitransparent film.
- [35] The back electrode may be selected from the group consisting of Ag, Al, Ag+Al, Ag+Mg, Ag+Mn, Ag+Sb, Ag+Zn, Ag+Mo, Ag+Ni, Ag+Cu and Ag+Al+Zn.
- [36] The anti-diffusion layer may contain any one of ZnO, ZnO:B, ZnO:Al, Ge, Al₂O₃ and SiO₂.
- [37] In accordance with another aspect, provided is a method for manufacturing a solar cell, including: forming a back electrode on a substrate; performing primary laser scribing to divide the back electrode into a plurality of unit back electrodes; performing secondary laser scribing along one side of a first line formed by the primary laser scribing such that a process region of secondary laser scribing overlaps the first line, to remove a burr produced by primary laser scribing; and performing tertiary laser scribing along the other side of the first line such that a process region of tertiary laser scribing overlaps the first line to remove the burr.
- [38] In accordance with another aspect, provided is a method for manufacturing a solar cell, including: forming a back electrode on a substrate; forming an anti-diffusion layer on the back electrode; performing primary laser scribing to divide the back electrode into a plurality of unit back electrodes; and performing secondary laser scribing along both sides of a first line formed by the primary laser scribing such that a process region of secondary laser scribing overlaps the first line, to remove a burr produced by primary laser scribing.
- [39] The area of region where the secondary laser scribing is performed may be larger than the area of region where the primary laser scribing is performed.
- [40] In accordance with yet another aspect, provided is a solar cell including: a substrate; a back electrode and an anti-diffusion layer spaced by a first trench on the substrate; a

semiconductor layer spaced by a second trench (t2) on the anti-diffusion layer; and a front electrode spaced by a third trench on the semiconductor layer, wherein the edge of the anti-diffusion layer adjacent to the first trench has a step lower than the top of the anti-diffusion layer.

[41] The width of the step may be 1/4 or less of the width of the first trench.

[42] It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

Brief Description of Drawings

[43] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and along with the description serve to explain the principle of the invention. In the drawings:

[44] FIGS. 1a to 1f are sectional views illustrating a method for fabricating a conventional thin film-type solar cell having a structure in which a plurality of unit cells are connected in series;

[45] FIG. 2 is a view illustrating a method of laser scribing a conventional superstrate-type solar cell;

[46] FIG. 3 is a view illustrating a method of laser scribing a conventional substrate-type solar cell;

[47] FIG. 4 is a view illustrating burrs produced by laser scribing a conventional superstrate-type solar cell;

[48] FIG. 5 is a view illustrating a problem caused by burrs in a conventional superstrate-type solar cell;

[49] FIGS. 6a to 6j are views illustrating a process for manufacturing a solar cell according to one embodiment of the present invention;

[50] FIG. 7 is a view illustrating a process for laser scribing in the method for manufacturing the solar cell according to one embodiment of the present invention;

[51] FIG. 8 is a view illustrating a state in which burrs are removed by laser scribing according to one embodiment illustrated in FIG. 7;

[52] FIG. 9 is a sectional view illustrating a solar cell according to one embodiment of the present invention;

[53] FIGS. 10a to 10f are views illustrating a process for manufacturing a solar cell according to one embodiment of the present invention;

[54] FIGS. 11a to 11d are views illustrating a process for manufacturing a solar cell according to another embodiment of the present invention; and

[55] FIG. 12 is a view comparing a conventional apparatus and an apparatus of the

present invention, used for manufacturing a solar cell.

Best Mode for Carrying out the Invention

- [56] Hereinafter, the configurations and actions of preferred embodiments of the present invention will be described with reference to the annexed drawings. When elements are represented by reference numerals in respective drawings, it should be noted that identical elements are represented by the same or similar reference numerals, although they are represented in different drawings.
- [57] FIGS. 6a to 6j are views illustrating a process for manufacturing a solar cell according to one embodiment of the present invention.
- [58] A flexible solar cell is formed by laminating an electrode layer and a semiconductor layer on a flexible substrate having low light transmittance, which is light, foldable and portable and may thus be equipped in sunroofs, sun visors, curtains and the like. In the flexible solar cell, sunlight is not incident upon the flexible substrate, instead is incident upon the transparent conductive layer laminated on the flexible substrate. Such a solar cell is also referred to a "substrate-type solar cell".
- [59] A patterning process using laser is a considerably important factor in manufacturing flexible solar cells. The flexible solar cell uses a flexible substrate having low light transmittance, thus requiring film surface processing, since a laser cannot pass through the flexible substrate. The particles produced during laser scribing may be present in the form of residues, or be laminated on the edge of the electrode layer melted and removed by high energy of the laser, producing a burr. The burr blocks insulation of the solar cell, thus causing deterioration in efficiency of the solar cell and preventing the solar cell from operating normally. Accordingly, the present invention provides a method for manufacturing a solar cell to efficiently remove the burrs.
- [60] Referring to FIG. 6a, a back electrode 121 and an anti-diffusion layer 122 are formed on a flexible substrate 110 (or substrate). The flexible substrate 110 refers to a substrate which is made of a material having flexibility and low light transmittance and thus does not transmit laser. The flexible substrate 110 may be made of a material such as metals or plastics, for example, aluminum foils, SUS foils, semi-transparent films and the like.
- [61] The back electrode 121 is formed on the flexible substrate 110 using a metal such as Ag, Al, Ag+Al, Ag+Mg, Ag+Mn, Ag+Sb, Ag+Zn, Ag+Mo, Ag+Ni, Ag+Cu, or Ag+Al+Zn, or a transparent conductive material (TCO) such as indium tin oxide (ITO), fluorine doped tin oxide (FTO), ZnO, ZnO:B, ZnO:Al, Ag, SnO₂, SnO₂:F, ZnO:Ga₂O₃, ZnO:Al₂O₃ or SnO₂:Sb₂O₃.
- [62] The anti-diffusion layer 122 prevents the material of the back electrode 121 from being diffused into the semiconductor layer 150 arranged on the back electrode 121

and contributes to an improvement in efficiency of the solar cell. The anti-diffusion layer 122 may be made of a conductive material such as ZnO, ZnO:B, ZnO:Al, Ge, Al₂O₃ or SiO₂. The anti-diffusion layer 122 may be omitted.

- [63] Next, primary laser scribing is performed to divide the back electrode 121 into a plurality of unit back electrodes. Laser scribing requires no mask to divide the back electrode 121 into unit back electrodes, thus having economic advantages in the process of manufacturing thin film-type solar cells.
- [64] The flexible substrate 110 is made of a material which does not transmit laser light. For this reason, the primary laser scribing is carried out by directly irradiating laser to the back electrode 121 and the anti-diffusion layer 122.
- [65] Referring to FIG. 6b, a first trench t1 is formed in a region removed by primary laser scribing. Particles of the back electrode 121 and the anti-diffusion layer 122 removed by primary laser scribing are present in the form of residues on the anti-diffusion layer 122, or are melted by the high energy of laser and laminated on the edges of the anti-diffusion layer 122 present on both sides of the first trench t1, producing a burr 125.
- [66] The burr 125 may have a height of several hundred nanometers (nm). Referring to FIG. 5, the burr 73 passes through the semiconductor layer 74 and comes into contact with the front electrode 75, thus disturbing insulation of the solar cell and causing a decrease in efficiency of the solar cell.
- [67] Referring to FIG. 6c, secondary laser scribing is performed to remove the burr 125 arranged on one side of the first trench t1. The secondary laser scribing may be carried out using the same laser apparatus as the primary laser scribing.
- [68] Referring to FIG. 6d, the burr 125 present on one side of the first trench t1 is removed by secondary laser scribing. At this time, a part of the edge of the anti-diffusion layer 122 is removed and the removed region may form a step 126.
- [69] Referring to FIG. 6e, tertiary laser scribing is performed to remove the burr 125 present on the other side of the first trench t1. The tertiary laser scribing may be concurrently performed with the secondary laser scribing. The tertiary laser scribing may be carried out using the same laser apparatus as the primary laser scribing.
- [70] Referring to FIG. 6f, the burr 125 arranged on the other side of the first trench t1 is removed by tertiary laser scribing. At this time, a part of the edge of the anti-diffusion layer 122 is removed and the removed region may form a step 126.
- [71] Referring to FIG. 6g, a semiconductor layer 130 is formed on the anti-diffusion layer 122. The semiconductor layer 130 is formed such that it has an NIP structure in which an n-type semiconductor layer, an i-type semiconductor layer and a p-type semiconductor layer are laminated in this order.
- [72] Referring to FIG. 6h, P2 laser scribing is performed to divide the semiconductor layer 130 into a plurality of unit semiconductor layers. The second trench (t2) is

formed by P2 laser scribing.

- [73] Referring to FIG. 6i, a front electrode 140 is formed on the semiconductor layer 130 including the second trench t2. The front electrode 140 has a surface upon which sunlight is incident and is made of a transparent conductive material such as ZnO, ZnO:B, ZnO:Al, SnO₂, SnO₂:F or indium tin oxide (ITO).
- [74] Referring to FIG. 6j, laser scribing is performed to divide the front electrode 140 into a plurality of unit front electrodes. A third trench t3 is formed by P3 laser scribing. As a result, the solar cell has a structure in which a plurality of unit cells are connected in series.
- [75] As mentioned above, in the process of forming the first trench t1 by removing the back electrode 121 and the anti-diffusion layer 122 arranged on the flexible substrate 110 by laser scribing (this process is referred to as "P1 laser scribing"), particles melted by high energy of laser are laminated on the edge of the anti-diffusion layer 122, producing a burr 125. The burr 125 P1 is serious in the process of laser scribing in which a material having a high specific gravity is processed. The burr 125 should be removed in order to insulate the solar cell. In conventional cases, the burr 125 is removed by an additional cleaning process.
- [76] In accordance with the preparation method of the solar cell, the burr 125 produced during P1 laser scribing can be removed by additional secondary and tertiary laser scribing processes using the laser used in the primary laser scribing process without using any additional apparatus. Accordingly, deterioration in insulation and efficiency, problems of the solar cell caused by the burr 125 can be easily solved.
- [77] The method of the present invention requires no additional wet cleaning process to remove burrs (by-products), thus reducing time and cost involved therein. In addition, the flexible substrate, which is vulnerable to water, requires a separate drying process after the wet cleaning process, but the method of the present invention omits the drying process, thus reducing time and cost involved in manufacture of the solar cell.
- [78] The embodiment in which the burr 125 produced during P1 laser scribing is removed by a series of laser processing may be applied to remove burrs produced during P1 laser scribing as well as burrs produced during P2 laser scribing performed to divide the semiconductor layer 130 into a plurality of unit semiconductor layers, and burrs produced during P3 laser scribing performed to divide the front electrode 140 into a plurality of unit front electrode 140.
- [79] FIG. 7 is a view illustrating a process for performing laser scribing in the method for manufacturing a solar cell according to one embodiment of the present invention.
- [80] Referring to FIGS. 6a to 6j and 7, first, the back electrode 121 is removed by primary laser scribing to divide the back electrode 121 into a plurality of unit back electrodes. The back electrode 121 on which the anti-diffusion layer 122 is formed is intended to

include the anti-diffusion layer 122 (see FIG. 6a).

[81] A first line L1 is formed along the back electrode 121 removed by the primary laser scribing. Primary laser scribing is carried out at a high frequency and at a high power with a large width. The first line L1 may have a width (W1) of 50 to 60 μm .

[82] Then, secondary laser scribing is performed to remove burrs produced at one of both sides of the first line L1 by primary laser scribing such that a process region of secondary laser scribing overlaps the first line L1. Secondary laser scribing may be carried out by setting the center of the laser as one side of the first line L1. The secondary laser scribing is carried out at a low frequency, and at a low power with a small width, as compared to primary laser scribing.

[83] A second line L2 is formed by secondary laser scribing. The second line L2 may have a width W2 of 20 to 30 μm . At this time, the width of a region where the first line L1 overlaps the second line L2 may be 10 to 15 μm , which is 1/2 of the width W2 of the second line L2 and is 1/4 or less of the width W1 of the first line L1.

[84] Then, tertiary laser scribing is performed to remove burrs produced at the other of both sides of the first line L1 by primary laser scribing such that a process region of tertiary laser scribing overlaps the first line L1. The tertiary laser scribing may be carried out by setting the center of the laser as the other side of the first line L1. The tertiary laser scribing is carried out at a low frequency, and at a low power with a small width, as compared to primary laser scribing.

[85] A third line L3 is formed by tertiary laser scribing. The third line L3 may have a width W3 of 20 to 30 μm . At this time, the width of a region where the first line L1 overlaps the second line L2 may be 10 to 15 μm , which is 1/2 of the width W3 of the third line L3.

[86] As such, the burr can be efficiently removed by performing tertiary laser scribing such that the process region of tertiary laser scribing partially overlaps the formed first line L1. As the secondary and tertiary laser scribing processes are performed at a low frequency and at a low power with a small width, as compared to primary laser scribing, only the burr can be efficiently removed without having any effect on the back electrode 121.

[87] FIG. 8 is a view illustrating a state in which a burr is removed by laser scribing according to one embodiment illustrated in FIG. 7.

[88] Referring to FIG. 4, the burr 73 is formed on the anti-diffusion layer 72. On the other hand, referring to FIG. 8, the anti-diffusion layer 122 is completely removed, while the edge thereof forms a slight step.

[89] FIG. 9 is a sectional view illustrating a solar cell according to one embodiment of the present invention.

[90] The substrate 110 is made of a material which is flexible and has low light trans-

mittance. The substrate 110 may be made of a metal or plastic, for example, aluminum foils, SUS foils, semi-transparent films or the like.

[91] A back electrode 121 is formed on the substrate 110. The back electrode 121 may be made of a metal such as Ag, Al, Ag+Al, Ag+Mg, Ag+Mn, Ag+Sb, Ag+Zn, Ag+Mo, Ag+Ni, Ag+Cu, or Ag+Al+Zn, or a transparent conductive material (TCO) such as indium tin oxide (ITO), fluorine doped tin oxide (FTO), ZnO, ZnO:B, ZnO:Al, Ag, SnO₂, SnO₂:F, ZnO:Ga₂O₃, ZnO:Al₂O₃, SnO₂:Sb₂O₃.

[92] An anti-diffusion layer 122 may be formed on the back electrode 121. The anti-diffusion layer 122 prevents the material of the back electrode 121 from being diffused into the semiconductor layer and thus improves efficiency of the solar cell. The anti-diffusion layer 122 may be made of a conductive material such as ZnO, ZnO:B, ZnO:Al, Ge, Al₂O₃ or SiO₂. The anti-diffusion layer 122 may be omitted.

[93] The back electrode 121 and the anti-diffusion layer 122 are spaced by the first trench t1. The first trench t1 is formed by P1 laser scribing.

[94] The edge of the anti-diffusion layer 122 adjacent to the first trench t1 has a step 126 which is lower than the anti-diffusion layer 122. The step 126 may be formed by the series of laser processing to remove burrs produced during P1 laser scribing. The step 126 may have a width which is 1/4 or less of the width W1 of the first trench t1.

[95] In the case where the anti-diffusion layer 122 is not formed, the edge of the back electrode 121 adjacent to the first trench t1 has a step.

[96] The semiconductor layer 130 is formed over the anti-diffusion layer 122 including the first trench t1. The semiconductor layer 130 has an NIP structure in which an n-type semiconductor layer, an i-type semiconductor layer and a p-type semiconductor layer are laminated in this order.

[97] The semiconductor layer 130 is spaced by the second trench (t2). The second trench (t2) is formed by P2 laser scribing.

[98] A front electrode 140 is formed over the semiconductor layer 130. The front electrode 140 has a surface upon which sunlight is incident, which is made of a transparent conductive material such as ZnO, ZnO:B, ZnO:Al, SnO₂, SnO₂:F or indium tin oxide (ITO).

[99] The front electrode 140 is spaced by the third trench t3. The third trench t3 is formed by P3 laser scribing.

[100] FIGS. 10a to 10f are views illustrating a process for manufacturing a solar cell according to one embodiment of the present invention. The same elements as in the embodiment illustrated in FIGS. 6a to 6f are represented by identical reference numerals and a detailed explanation thereof is omitted.

[101] Referring to FIG. 10a, a back electrode 121 and an anti-diffusion layer 122 are formed on a substrate 110. Then, primary laser scribing is performed to divide the back

electrode 121 into a plurality of unit back electrodes.

- [102] Referring to FIG. 10b, a first trench t1 is formed in a region removed by primary laser scribing. Particles of the back electrode 121 and the anti-diffusion layer 122 removed by primary laser scribing are present in the form of residues on the anti-diffusion layer 122, or are melted by the high energy of laser and laminated on the edges of the anti-diffusion layer 122 present on both sides of the first trench t1, producing a burr 125.
- [103] Referring to FIG. 10c, secondary laser scribing is performed to remove the burr 125 arranged on one side of the first trench t1. At this time, the back electrode 121 and the anti-diffusion layer 122 present under the burr 125 may be removed. The secondary laser scribing may be carried out using the same laser apparatus as the primary laser scribing.
- [104] Referring to FIG. 10d, the burr 125 arranged at one side of the first trench t1 by secondary laser scribing, and the back electrode 121 and the anti-diffusion layer 122 arranged thereunder are removed.
- [105] Referring to FIG. 10e, tertiary laser scribing is performed to remove the burr 125 present on the other side of the first trench t1. At this time, the back electrode 121 and the anti-diffusion layer 122 present under the burr 125 may be removed. The tertiary laser scribing may be concurrently performed with the secondary laser scribing. The tertiary laser scribing may be carried out using the same laser apparatus as the primary laser scribing.
- [106] Referring to FIG. 10f, the burr 125 arranged at the other side of the first trench t1 by tertiary laser scribing and the back electrode 121 and the anti-diffusion layer 122 arranged under the burr 125 are removed.
- [107] This embodiment is different from the embodiment illustrated in FIGS. 6a to 6f in that the burr 125 is removed together with the back electrode 121 and the anti-diffusion layer 122 arranged under the burr 125 by secondary and tertiary laser scribing.
- [108] FIGS. 11a to 11d are views illustrating a process for manufacturing a solar cell according to another embodiment of the present invention. The same elements as in the embodiment illustrated in FIGS. 6a to 6f are represented by identical reference numerals and a detailed explanation thereof is omitted.
- [109] Referring to FIG. 11a, a back electrode 121 and an anti-diffusion layer 122 are formed on a substrate 110. Then, primary laser scribing is performed to divide the back electrode 121 into a plurality of unit back electrodes.
- [110] Referring to FIG. 11b, a first trench t1 (or first line) is formed in a region removed by primary laser scribing. Particles of the back electrode 121 and the anti-diffusion layer 122 removed by primary laser scribing are present in the form of residues on the anti-diffusion layer 122, or are melted by the high energy of laser and laminated on the

edges of the anti-diffusion layer 122 present on both sides of the first trench t1, producing a burr 125.

[111] Referring to FIG. 11c, secondary laser scribing is performed to remove the burr 125 arranged on both sides of the first trench t1. At this time, only the burr 125 may be removed, and the back electrode 121 and the anti-diffusion layer 122 arranged under the burr 125 may also be removed.

[112] The secondary laser scribing is continuously performed along a first line formed by primary laser scribing such that the process region of secondary laser scribing overlaps the first line. Accordingly, the area of region where secondary laser scribing is performed is larger than the area of region where primary laser scribing is performed. The secondary laser scribing may be carried out using the same or different apparatus as primary laser scribing.

[113] Referring to FIG. 11d, the burr 125 arranged at both sides of the first line, and the back electrode 121 and the anti-diffusion layer 122 arranged under the burr 125 are removed by secondary laser scribing.

[114] In this embodiment, the burr 125 present at both sides of the first line formed by primary laser scribing can be removed by secondary laser scribing, thus having advantages of simplified process and shortened process time.

[115] FIG. 12 is a view comparing a conventional apparatus and an apparatus of the present invention, used for manufacturing a solar cell.

[116] Referring to FIGS. 9 and 12, in a view illustrating the configuration of a conventional apparatus, a first sputter or CVD apparatus to form a back electrode 121 is arranged on the substrate 110.

[117] A second sputter or CVD apparatus to form an anti-diffusion layer 122 on the back electrode 121 is arranged near the first sputter or CVD apparatus.

[118] A P1 processing laser is arranged near the second sputter or CVD apparatus to perform P1 laser scribing.

[119] A cleaning apparatus to remove burrs produced during P1 laser scribing is arranged near the P1 processing laser.

[120] A plasma enhanced chemical vapor deposition (PECVD) apparatus to form the semiconductor layer 130 on the anti-diffusion layer 122 is arranged near the cleaning apparatus to remove burrs. PECVD is a method for depositing a film using ion activation using plasma.

[121] A P2 processing laser to perform P2 laser scribing is arranged near the PECVD apparatus. A third sputter or CVD apparatus to form the front electrode 140 on the semiconductor layer 130 is arranged near the P2 processing laser. A P3 processing laser to perform P3 laser scribing is arranged near the third sputter or CVD apparatus.

[122] Meanwhile, in the view illustrating the configuration of the apparatus to which the

present invention is applied, a PECVD apparatus is arranged near the P1 processing laser, thus eliminating the necessity of any cleaning apparatus to remove burrs. This is the reason that burrs produced during P1 laser scribing can be easily removed by primary, secondary and tertiary laser scribing processes using the P1 processing laser.

[123] As compared to conventional wet cleaning and drying processes to remove burrs, the present invention provides an apparatus to manufacture a solar cell, the configuration of which is considerably simple. In addition, the present invention enables considerable shortening in the overall process time required to manufacture the solar cell, thus reducing manufacturing costs.

[124] As apparent from the fore-going, the present invention provides a solar cell and a method for manufacturing the same, wherein deterioration in insulation and efficiency of solar cells can be prevented by removing burrs produced during P1 laser scribing via a series of laser processing.

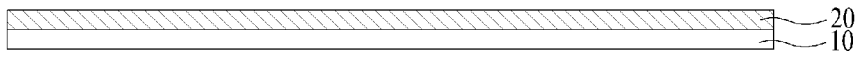
[125] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

Claims

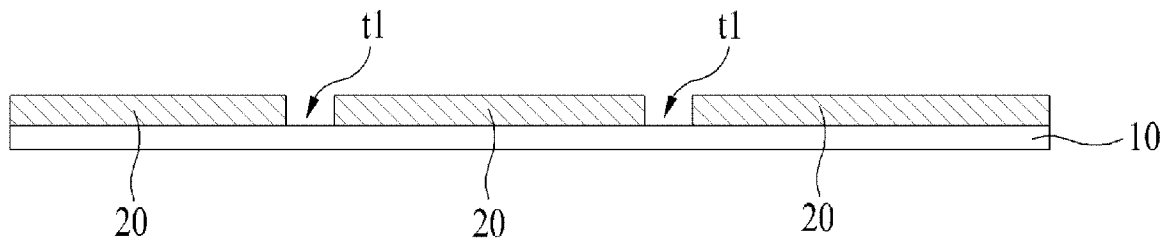
- [Claim 1] A method for manufacturing a solar cell, comprising:
forming a back electrode on a substrate;
forming an anti-diffusion layer on the back electrode;
performing primary laser scribing to divide the back electrode into a plurality of unit back electrodes;
performing secondary laser scribing along one side of a first line formed by the primary laser scribing such that a process region of secondary laser scribing overlaps the first line to remove a burr produced by the primary laser scribing; and
performing tertiary laser scribing along the other side of the first line such that a process region of tertiary laser scribing overlaps the first line to remove the burr.
- [Claim 2] The method according to claim 1, wherein the secondary laser scribing and the tertiary laser scribing are performed simultaneously or sequentially.
- [Claim 3] The method according to claim 1, wherein, assuming that the line formed by secondary laser scribing is defined as a second line and a line formed by tertiary laser scribing is defined as a third line, the width of the second line and the third line is 1/2 or less of the width of the first line.
- [Claim 4] The method according to claim 3, wherein the width of the second line and the third line overlaps the width of the first line by about 10 μ m or more.
- [Claim 5] The method according to claim 3, wherein the first line has a width of about 50 to about 60 μ m, and the width of the second line and the third line has a width of about 20 to about 30 μ m.
- [Claim 6] The method according to claim 1, wherein the secondary laser scribing and the tertiary laser scribing are carried out at a low frequency lower and at a low power, as compared to the secondary laser scribing.
- [Claim 7] The method according to claim 1, wherein the substrate is a flexible substrate selected from an aluminum foil, a SUS foil and a semi-transparent film.
- [Claim 8] The method according to claim 1, wherein the back electrode is selected from the group consisting of Ag, Al, Ag+Al, Ag+Mg, Ag+Mn, Ag+Sb, Ag+Zn, Ag+Mo, Ag+Ni, Ag+Cu and Ag+Al+Zn.
- [Claim 9] The method according to claim 1, wherein the anti-diffusion layer

- contains any one of ZnO, ZnO:B, ZnO:Al, Ge, Al₂O₃ and SiO₂.
- [Claim 10] A method for manufacturing a solar cell, comprising:
forming a back electrode on a substrate;
performing primary laser scribing to divide the back electrode into a plurality of unit back electrodes;
performing secondary laser scribing along one side of a first line formed by the primary laser scribing such that a process region of secondary laser scribing overlaps the first line, to remove a burr produced by primary laser scribing; and
performing tertiary laser scribing along the other side of the first line such that a process region of tertiary laser scribing overlaps the first line to remove the burr.
- [Claim 11] A method for manufacturing a solar cell, comprising:
forming a back electrode on a substrate;
forming an anti-diffusion layer on the back electrode;
performing primary laser scribing to divide the back electrode into a plurality of unit back electrodes; and
performing secondary laser scribing along both sides of a first line formed by the primary laser scribing such that a process region of secondary laser scribing overlaps the first line, to remove a burr produced by primary laser scribing.
- [Claim 12] The method according to claim 11, wherein the area of region, where the secondary laser scribing is performed, is larger than the area of region, where the primary laser scribing is performed.
- [Claim 13] A solar cell comprising:
a substrate;
a back electrode and an anti-diffusion layer spaced by a first trench on the substrate;
a semiconductor layer spaced by a second trench (t2) on the anti-diffusion layer; and
a front electrode spaced by a third trench on the semiconductor layer, wherein the edge of the anti-diffusion layer adjacent to the first trench has a step lower than the top of the anti-diffusion layer.
- [Claim 14] The solar cell according to claim 13, wherein the width of the step is 1/4 or less of the width of the first trench.

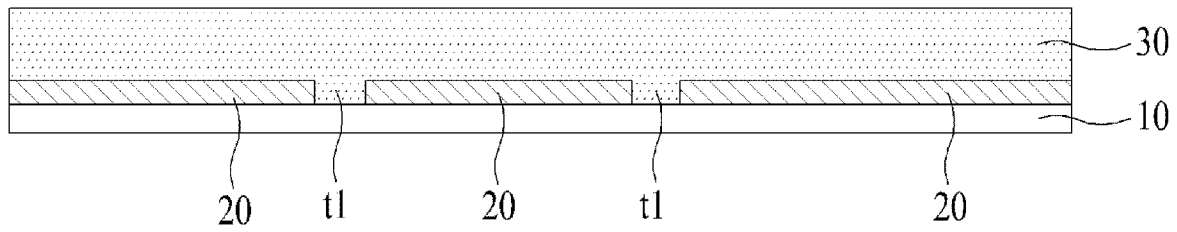
[Fig. 1a]



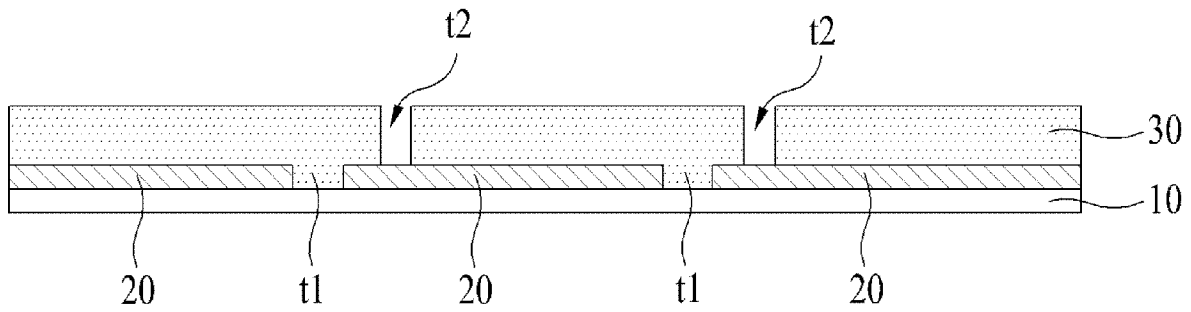
[Fig. 1b]



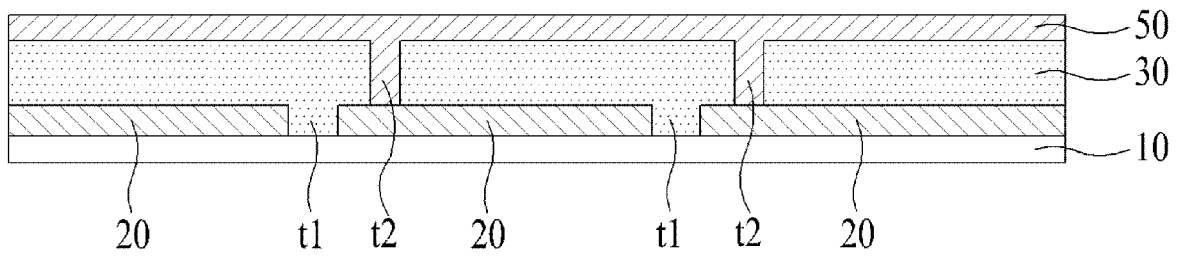
[Fig. 1c]



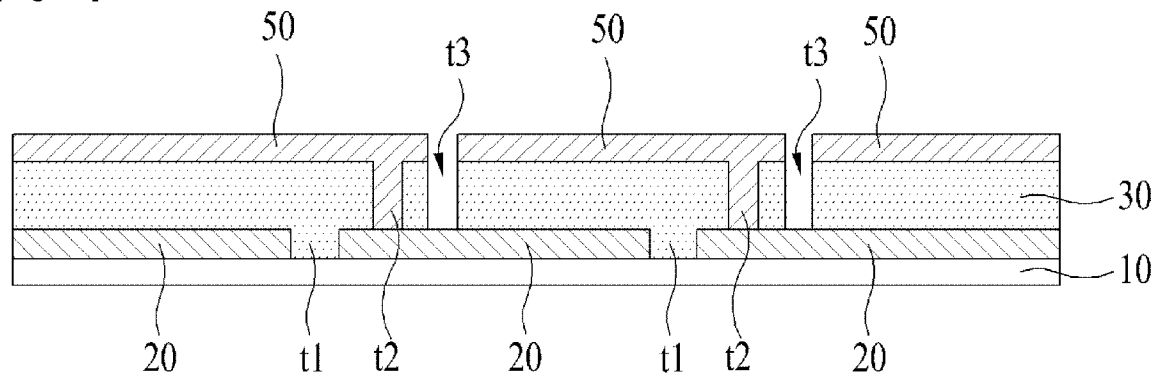
[Fig. 1d]



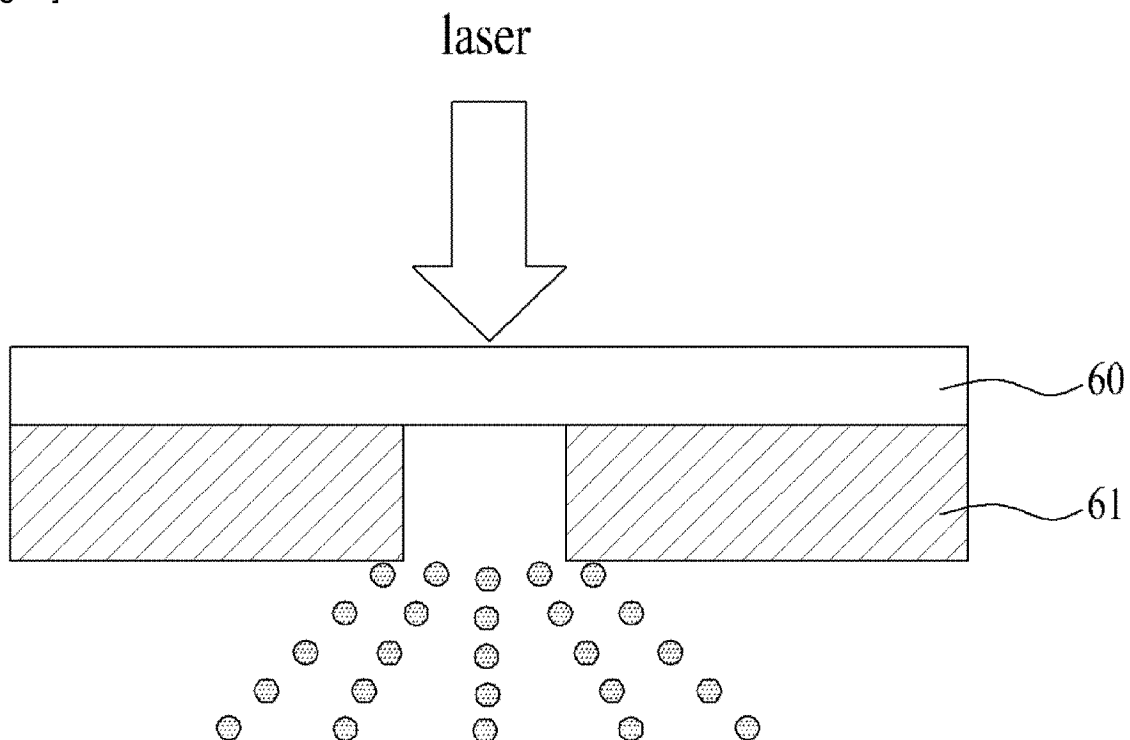
[Fig. 1e]



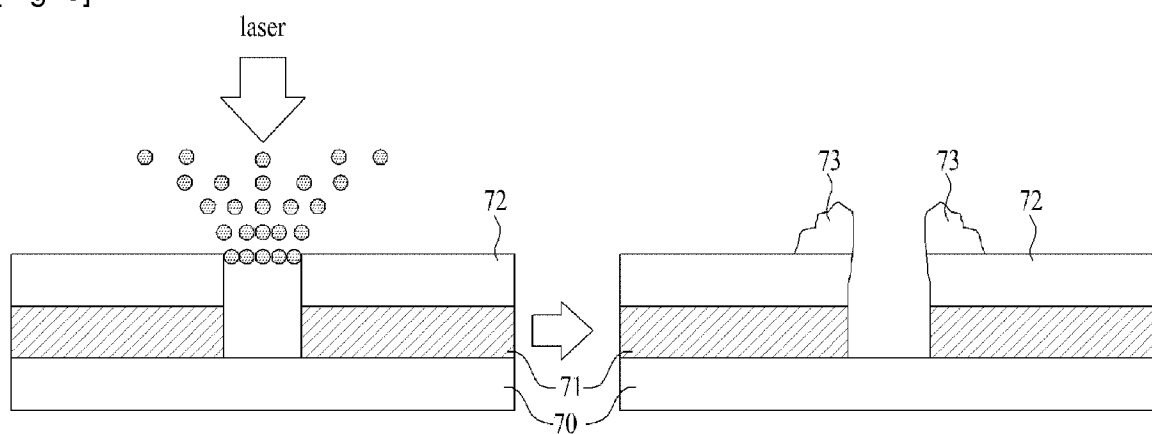
[Fig. 1f]



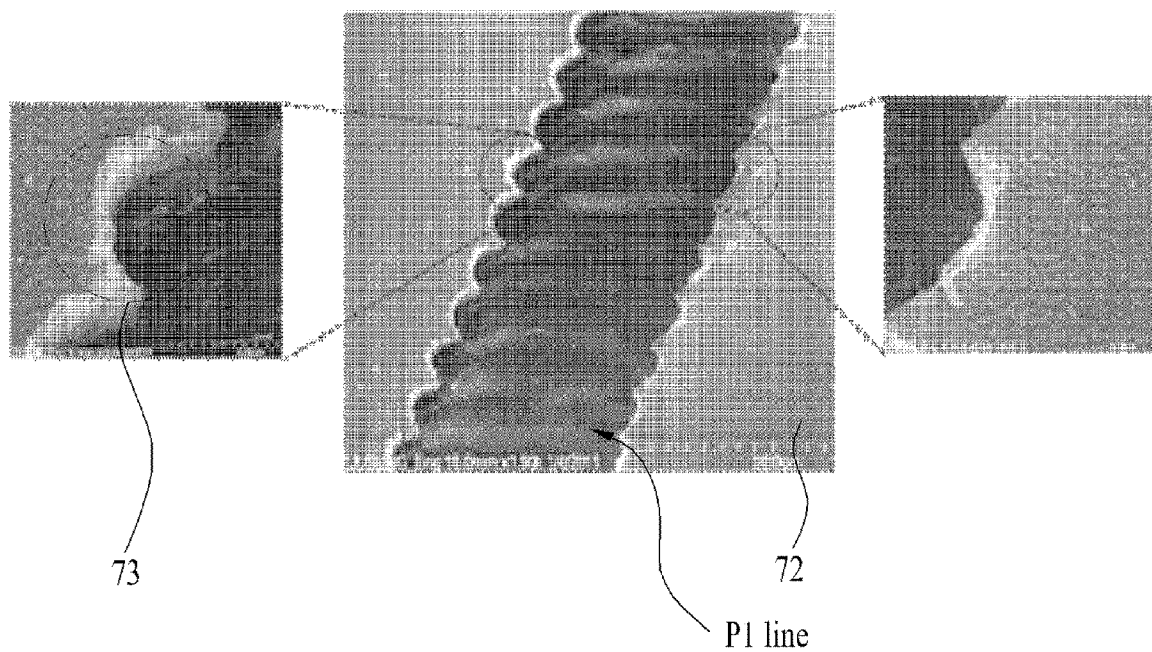
[Fig. 2]



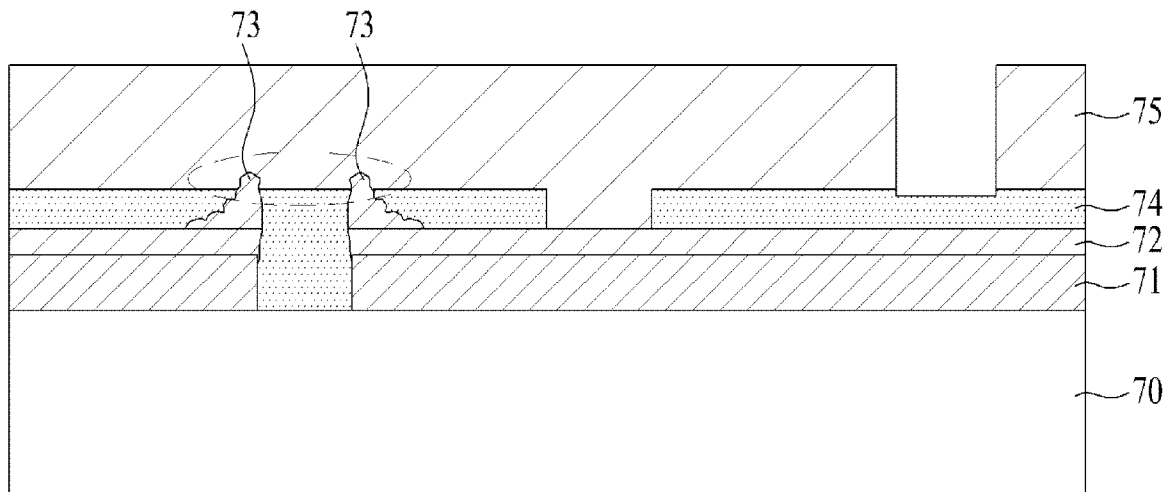
[Fig. 3]



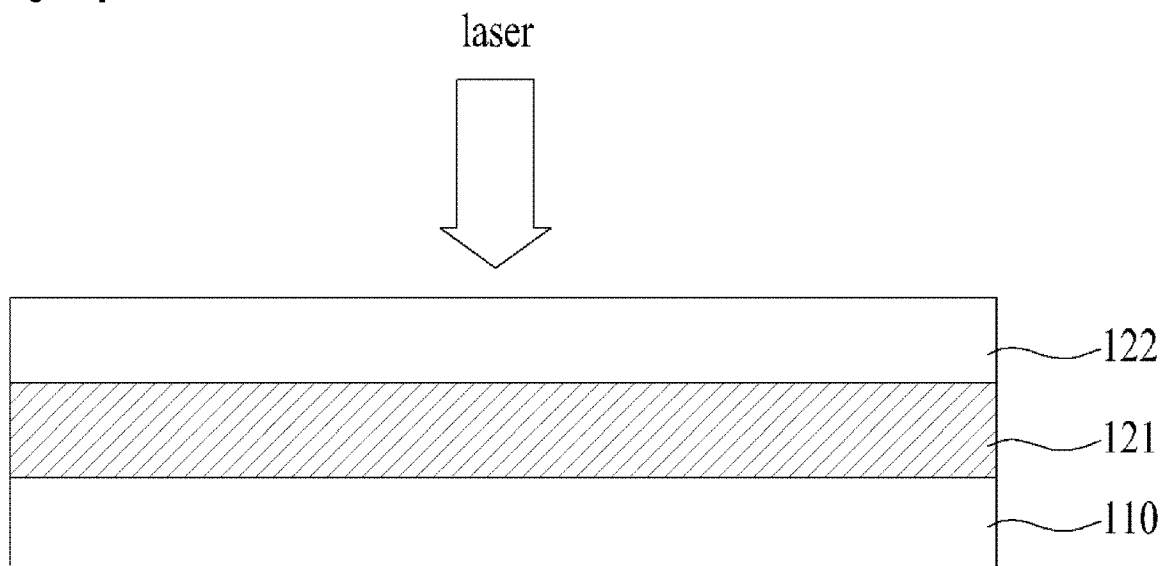
[Fig. 4]



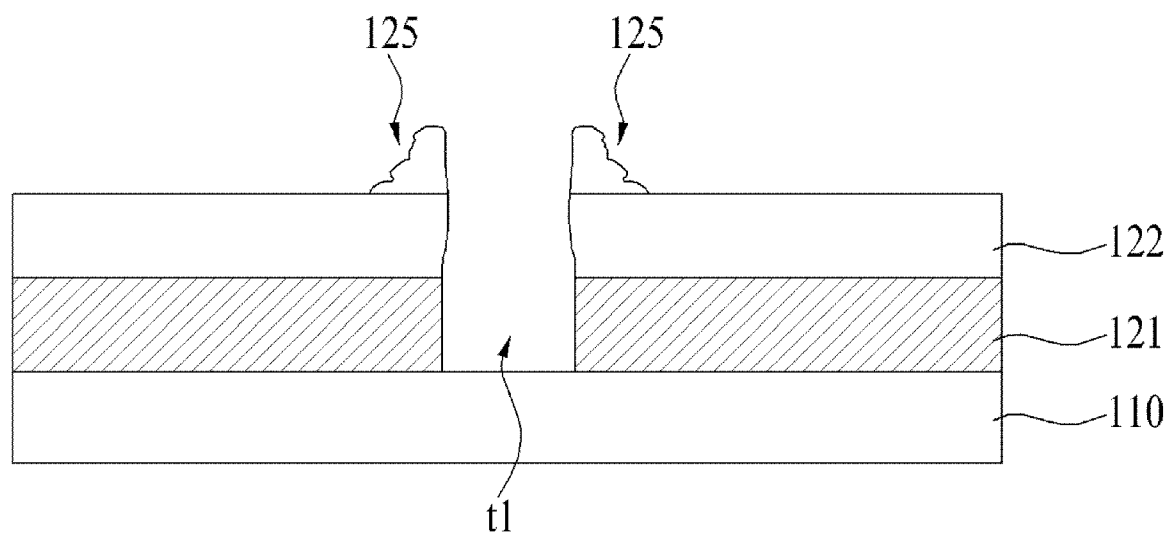
[Fig. 5]



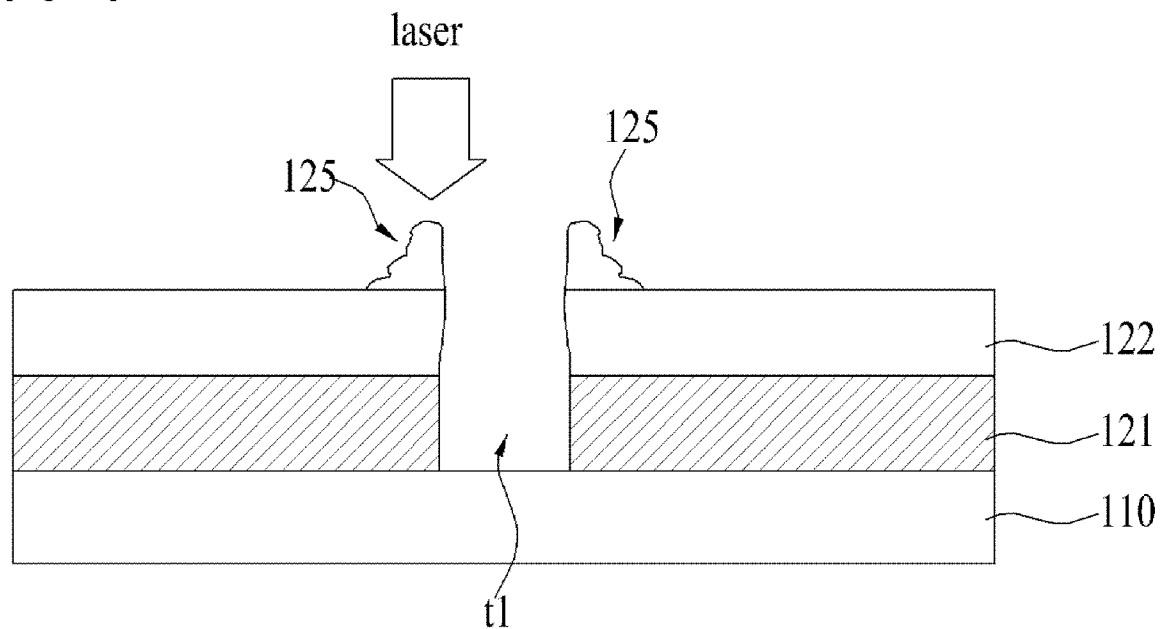
[Fig. 6a]



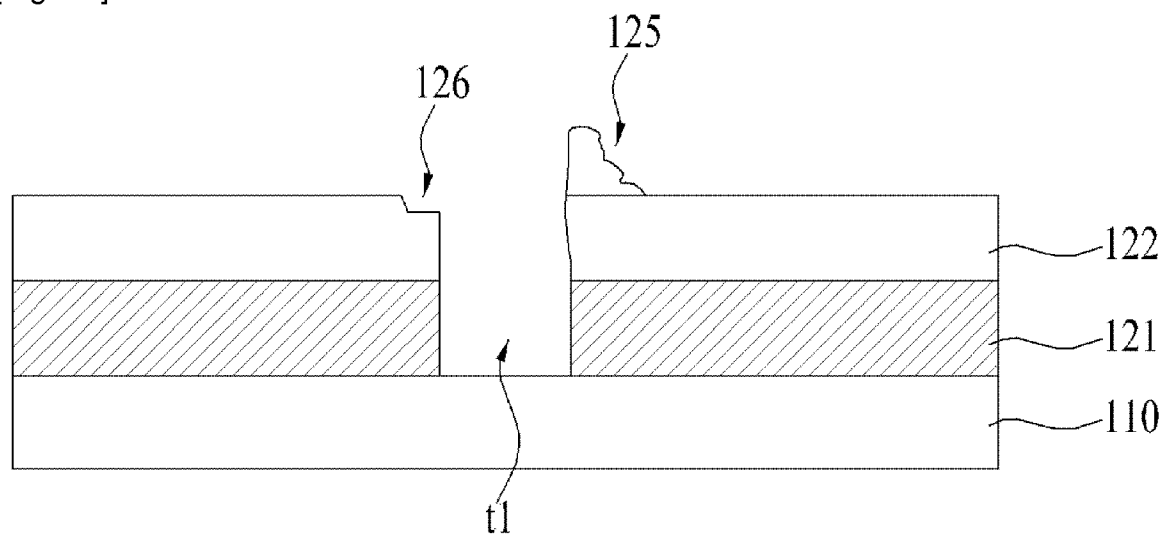
[Fig. 6b]



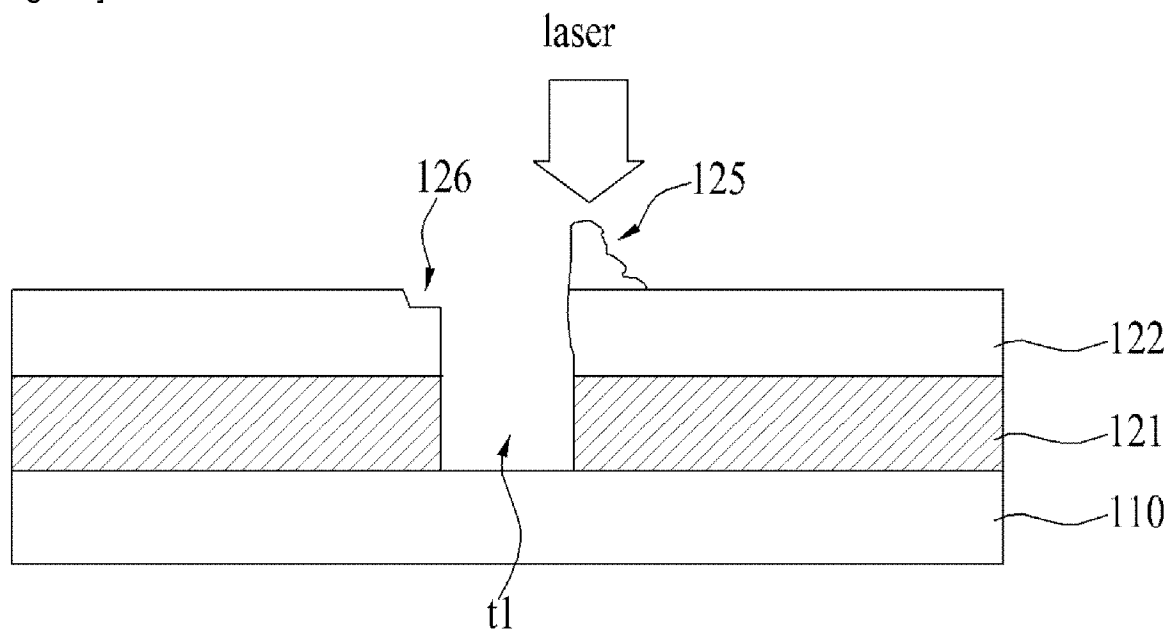
[Fig. 6c]



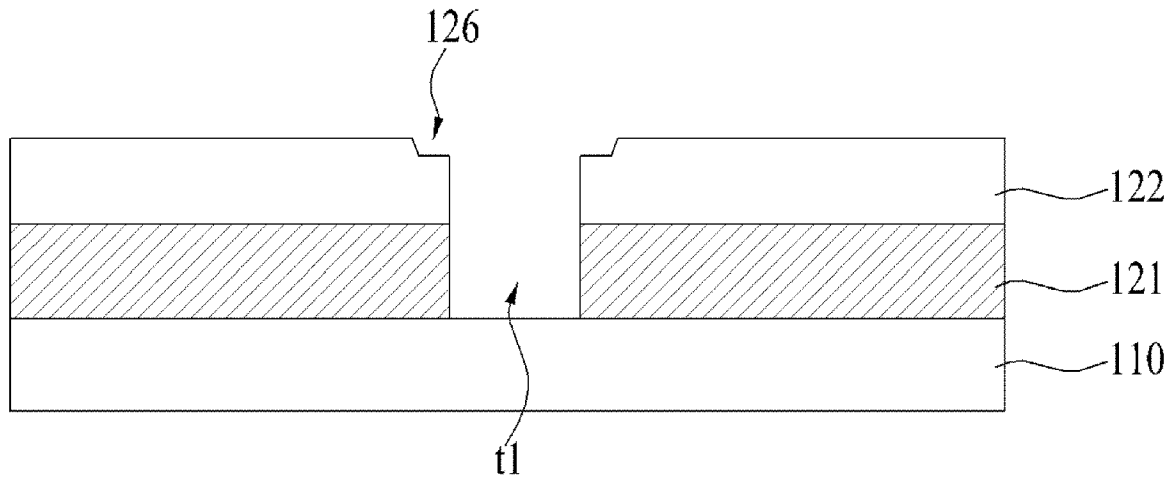
[Fig. 6d]



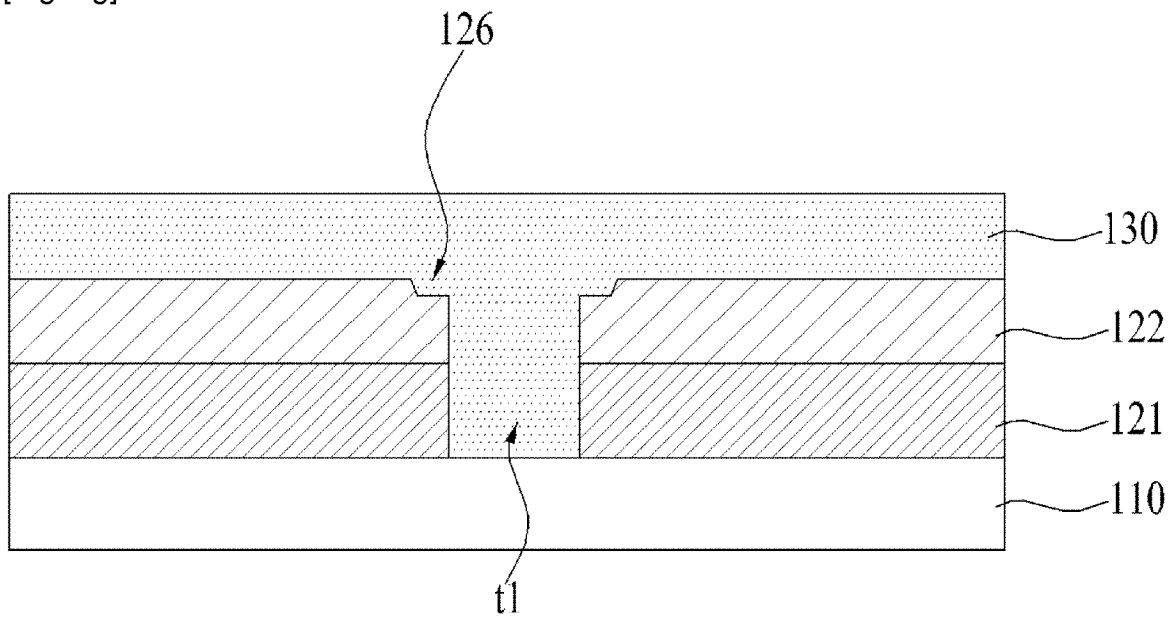
[Fig. 6e]



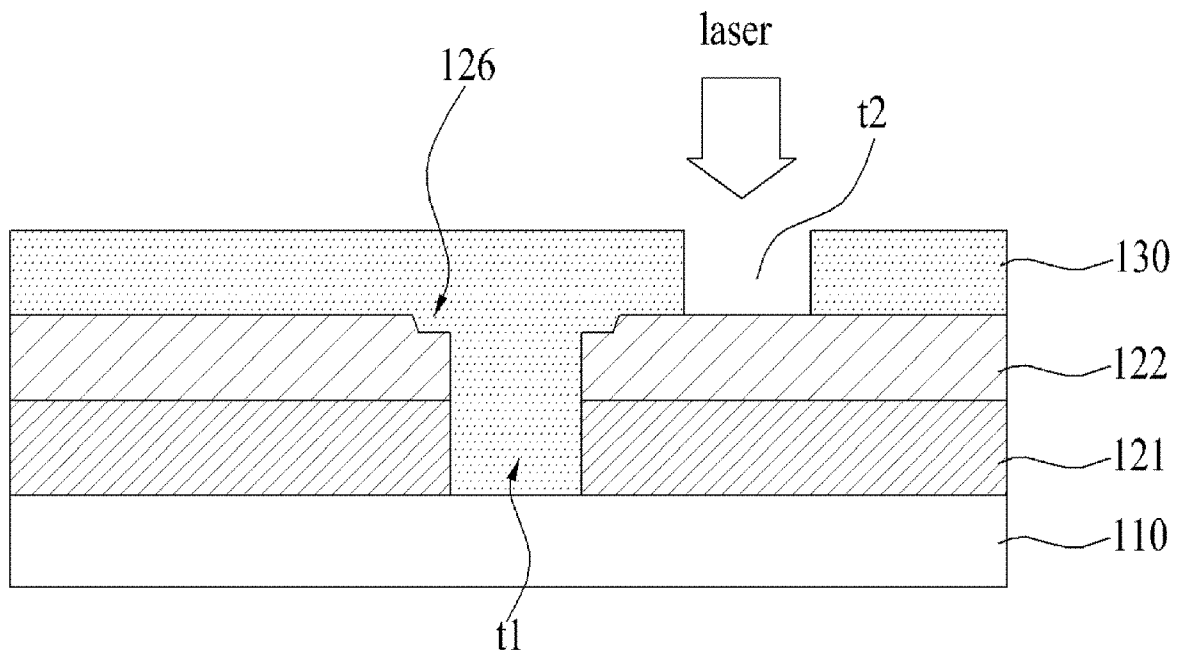
[Fig. 6f]



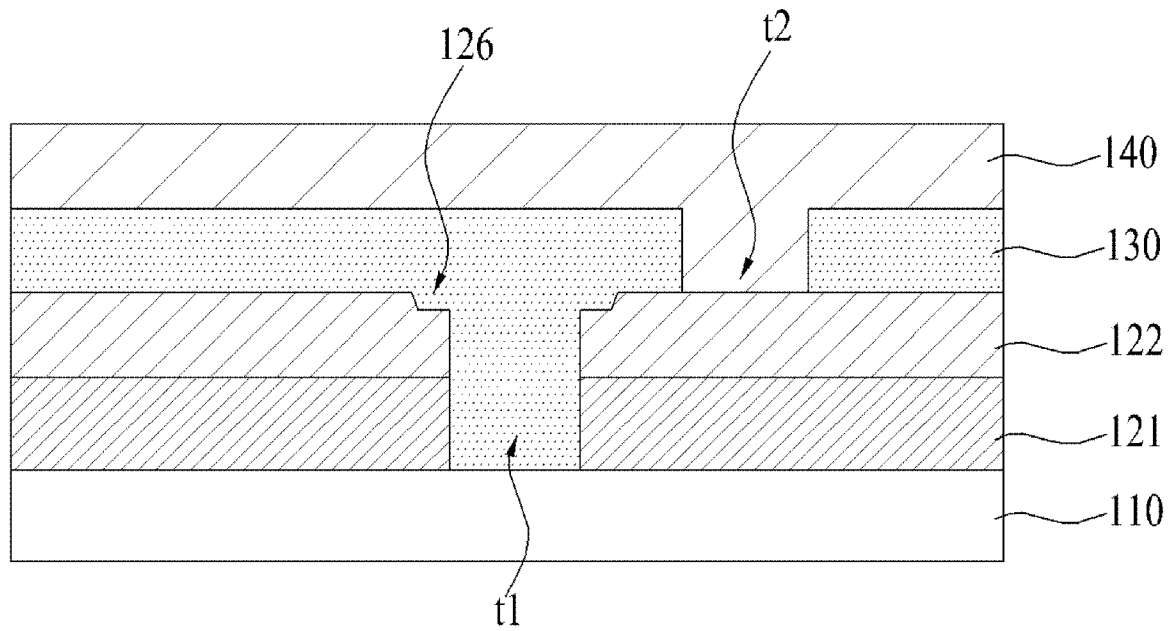
[Fig. 6g]



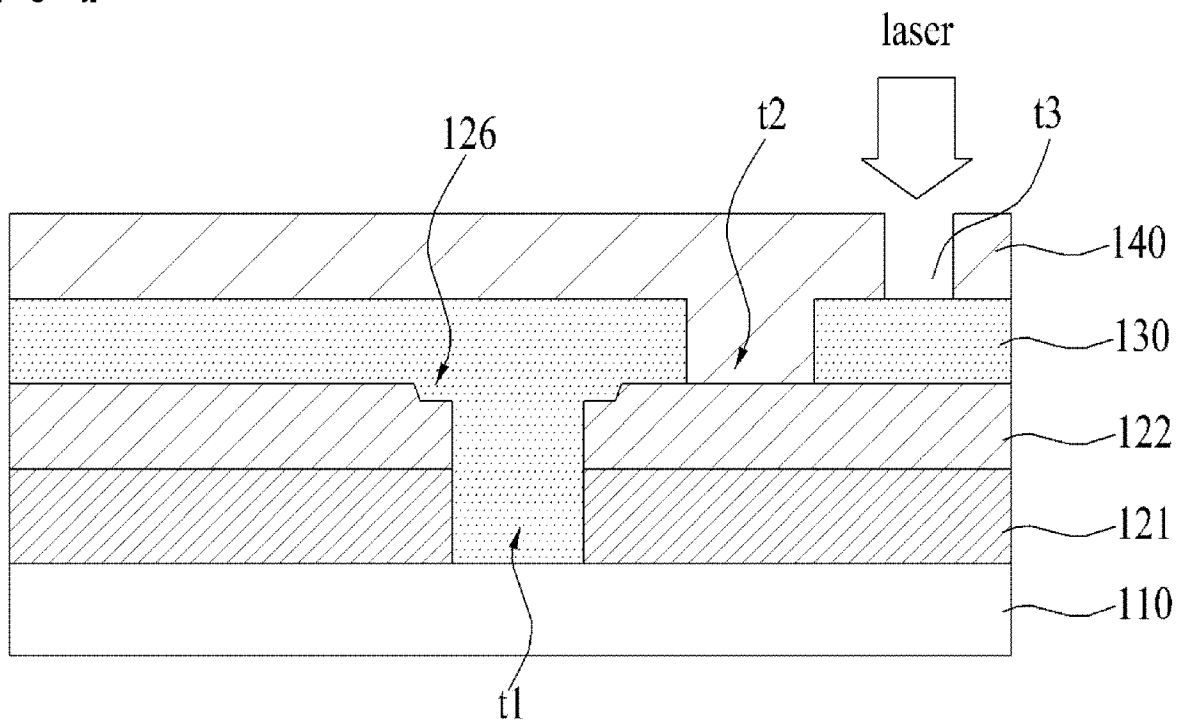
[Fig. 6h]



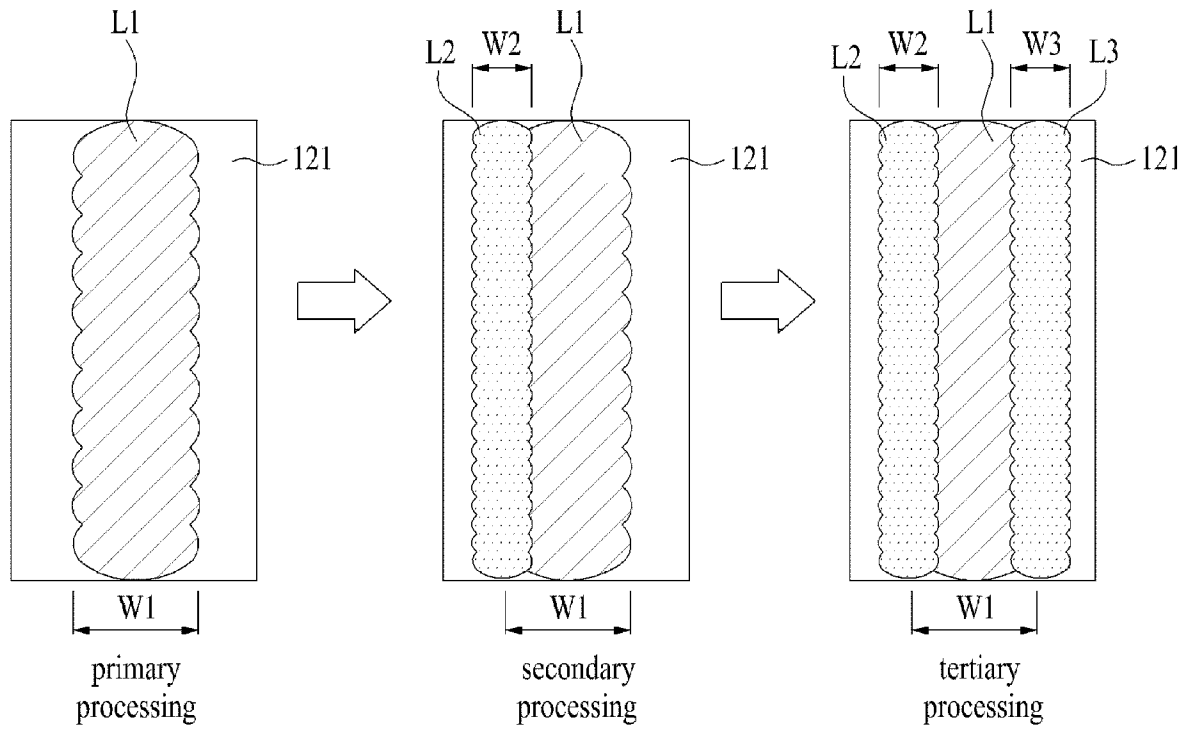
[Fig. 6i]



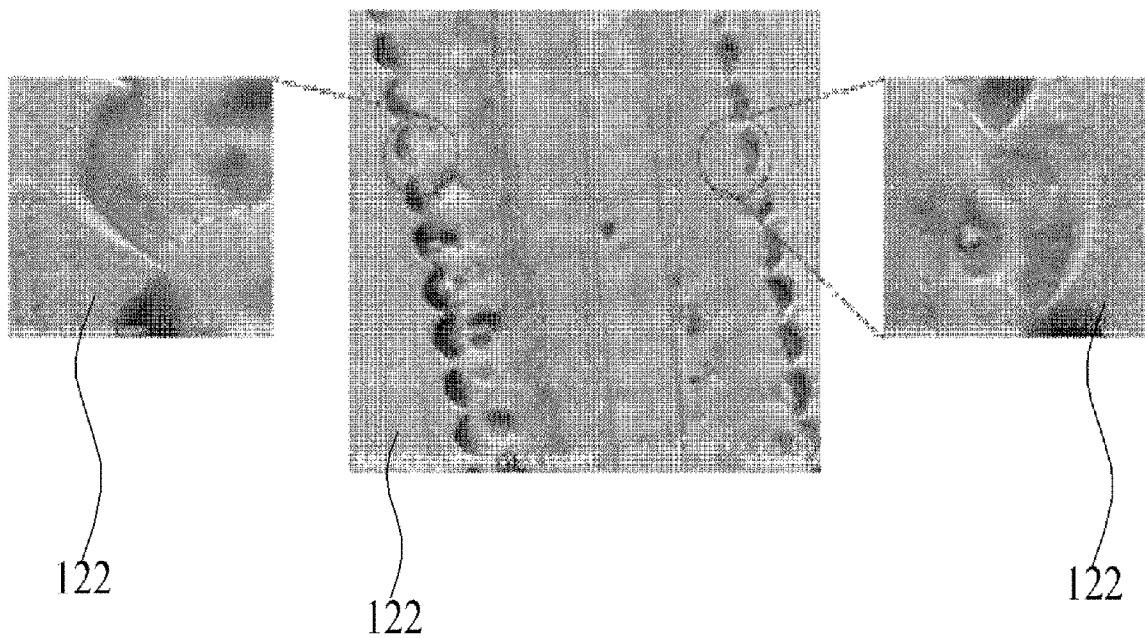
[Fig. 6j]



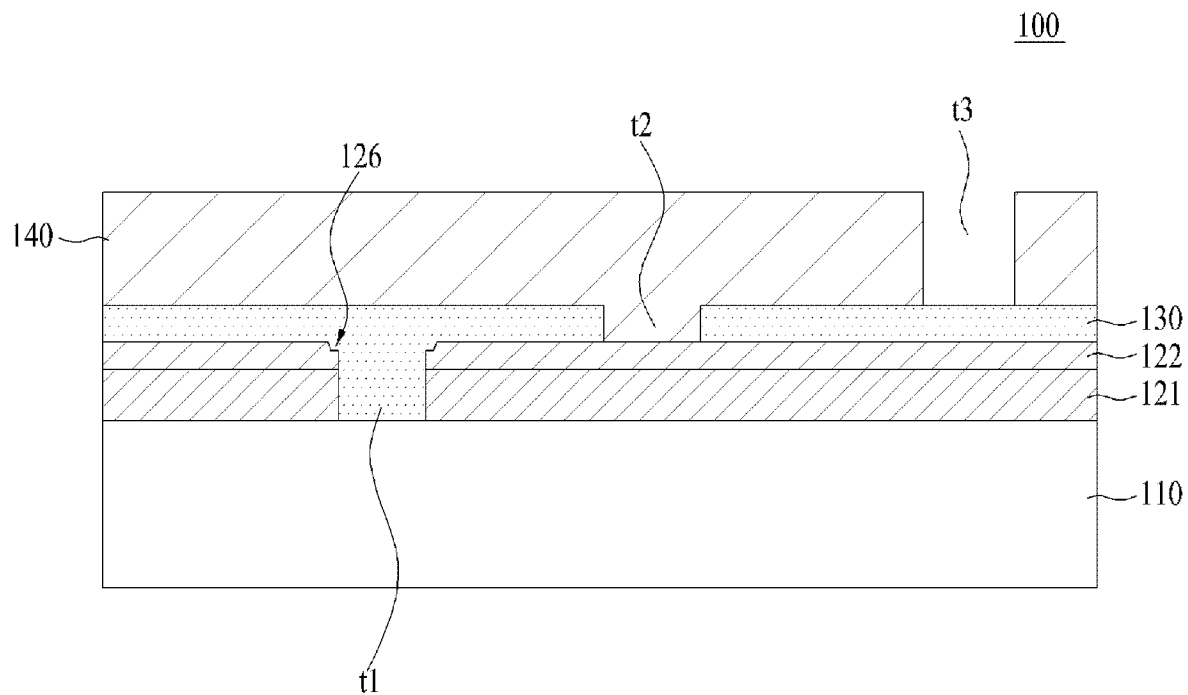
[Fig. 7]



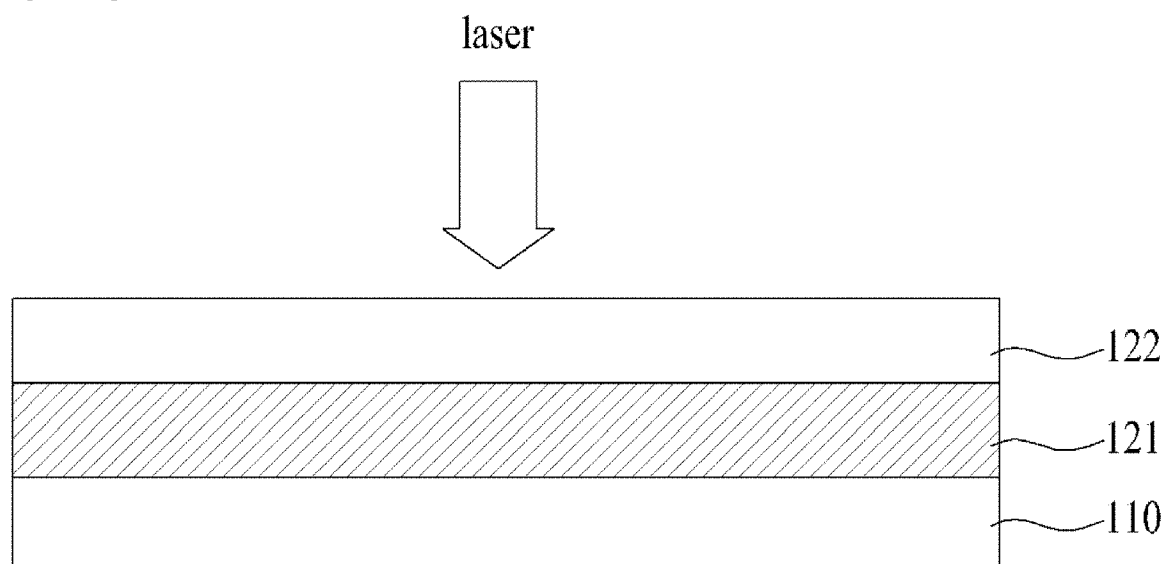
[Fig. 8]



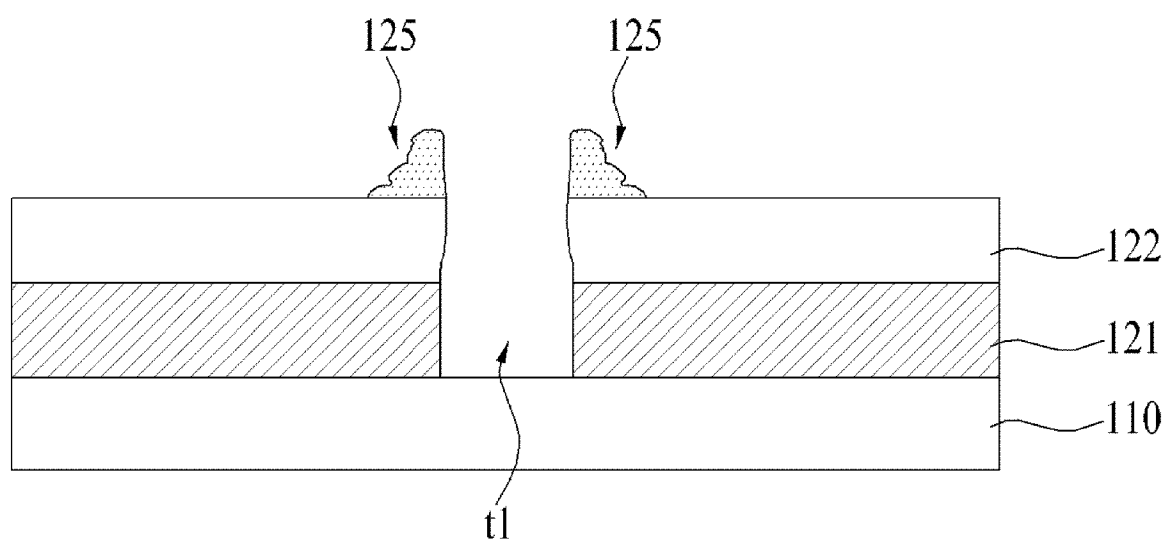
[Fig. 9]



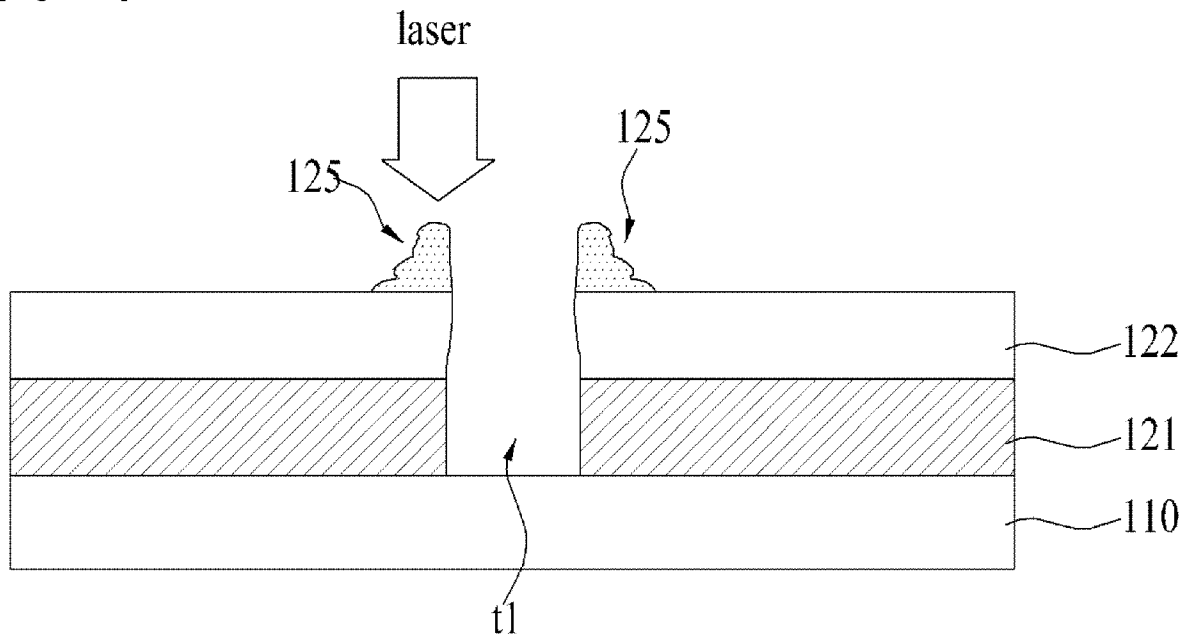
[Fig. 10a]



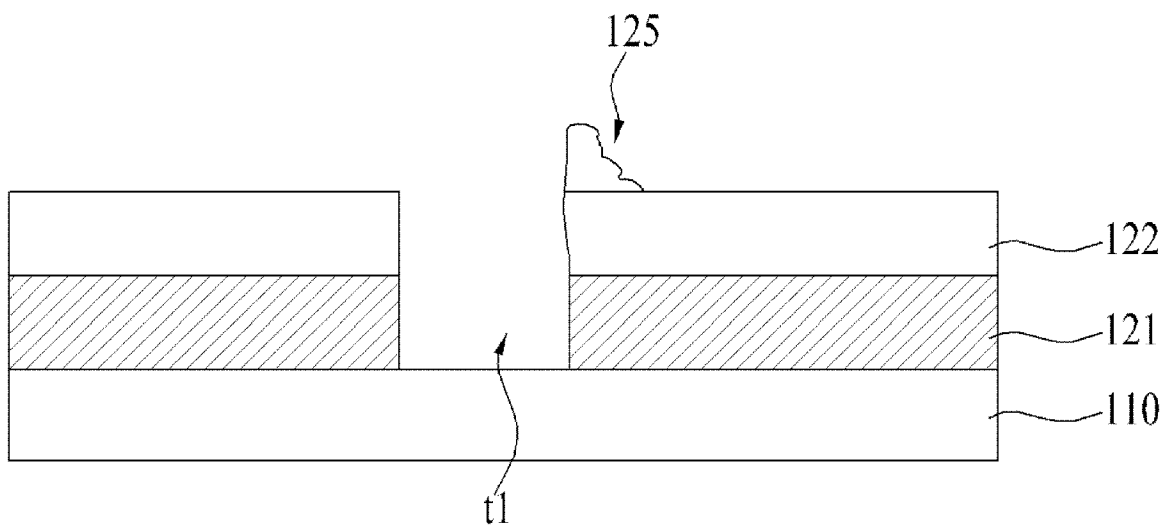
[Fig. 10b]



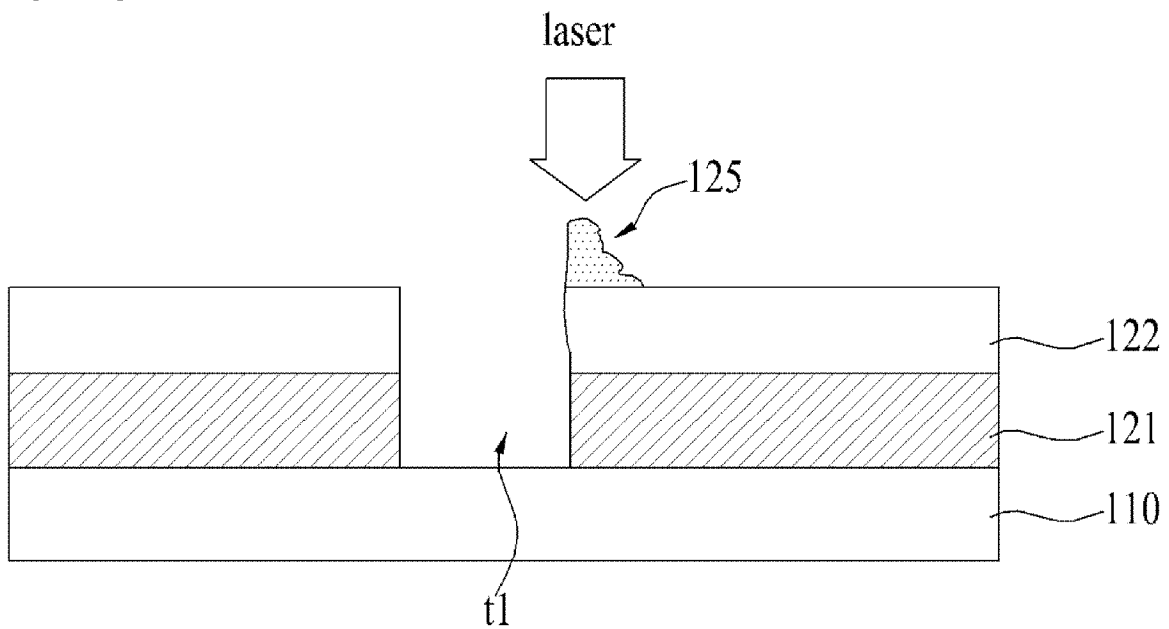
[Fig. 10c]



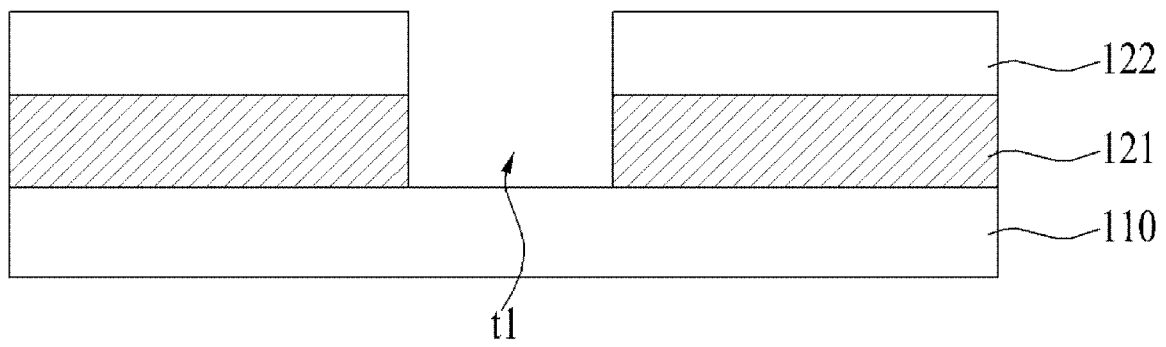
[Fig. 10d]



[Fig. 10e]

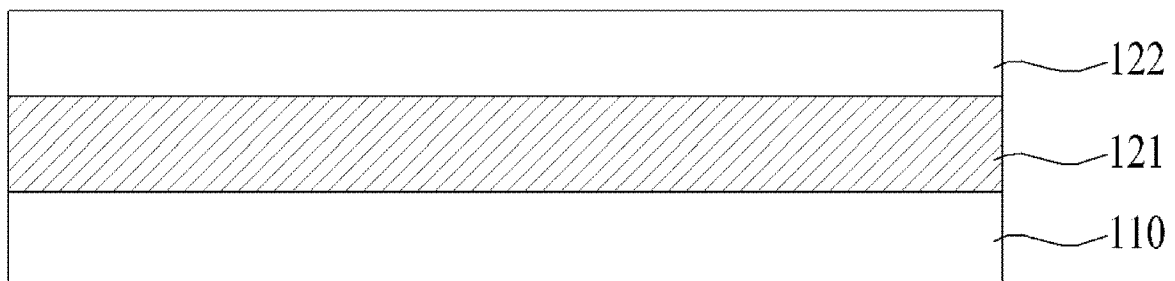
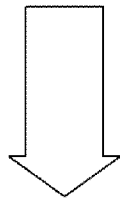


[Fig. 10f]

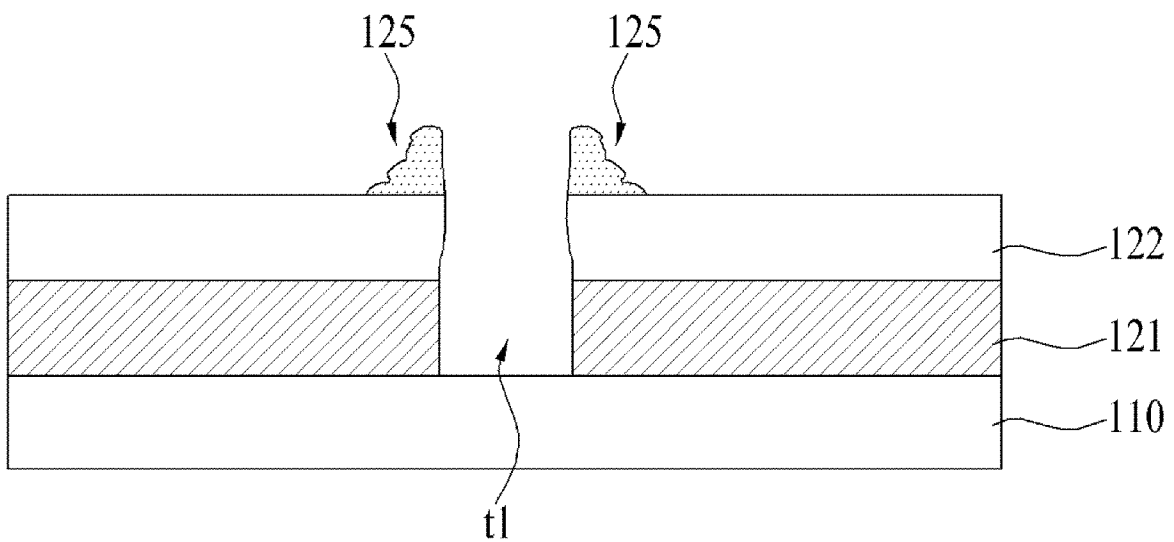


[Fig. 11a]

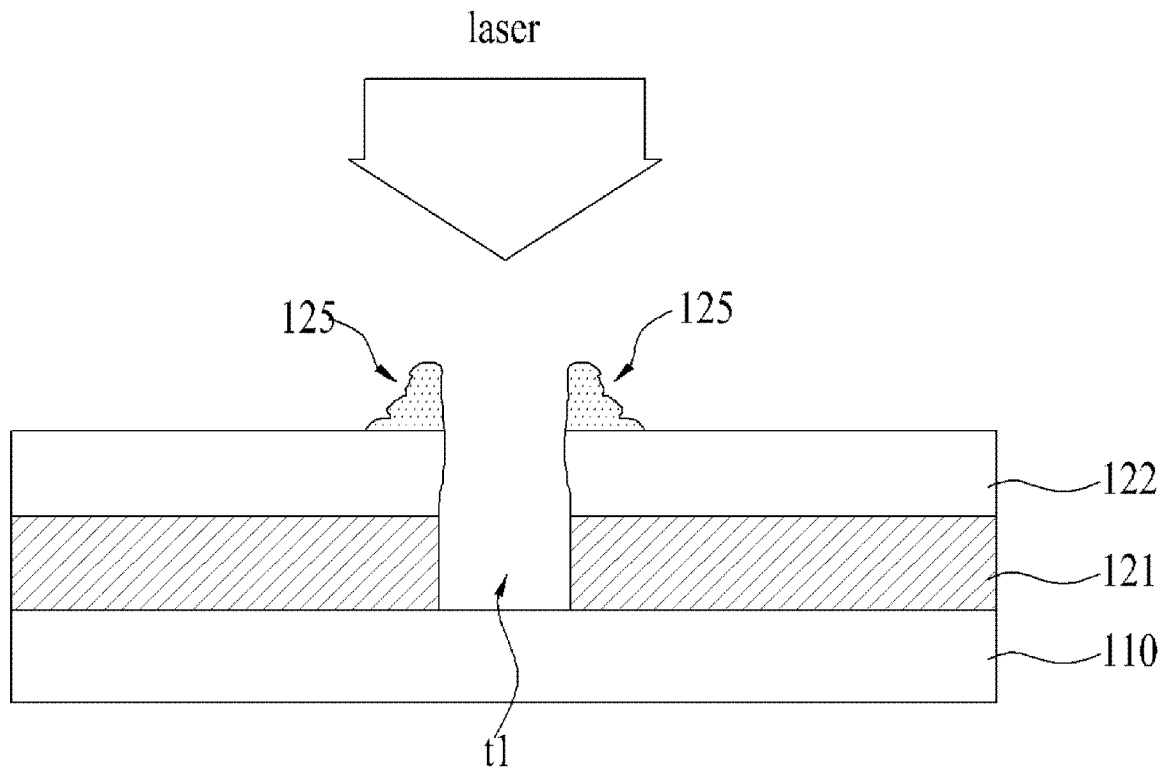
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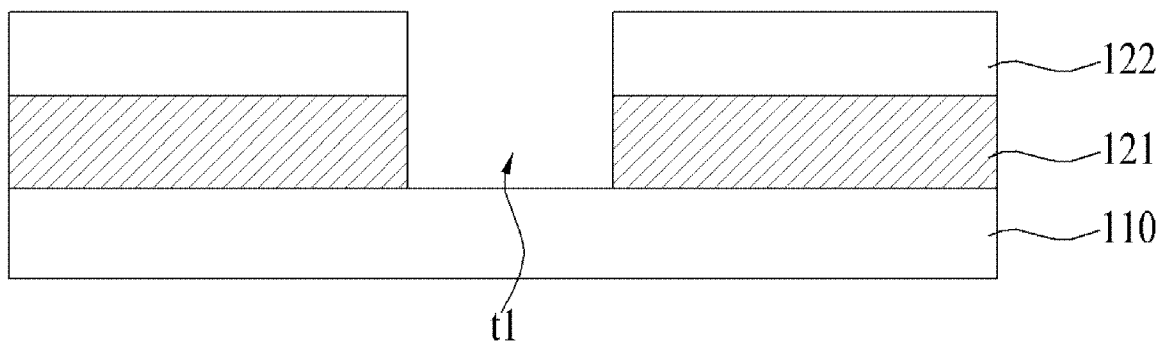
[Fig. 11b]



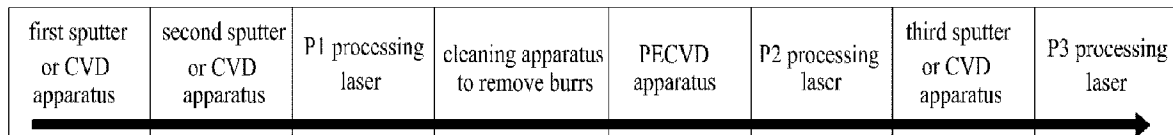
[Fig. 11c]



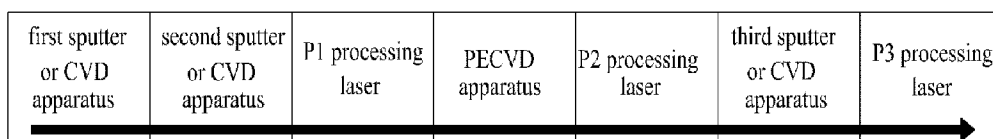
[Fig. 11d]



[Fig. 12]



view illustrating the configuration of conventional apparatus



view illustrating the configuration of apparatus to which the present invention is applied

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2011/004409**A. CLASSIFICATION OF SUBJECT MATTER*****H01L 31/18(2006.01)i, H01L 31/042(2006.01)i***

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)

H01L 31/18; H01L 31/042

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords:laser scribing, pattern, burr

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2011-0035771 A (LG INNOTEK CO., LTD.) 6 April 2011 See claim 1 and figure 9.	1-12
Y	KR 10-2011-0046522 A (ULVAC, INC.) 4 May 2011 See figures 7a-8b.	1-12
A	KR 10-2010-0137651 A (JUSUNG ENGINEERING CO., LTD.) 31 December 2010 See figures 4a-4f.	1-14

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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"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

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Date of the actual completion of the international search

01 MAY 2012 (01.05.2012)

Date of mailing of the international search report

02 MAY 2012 (02.05.2012)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2011/004409

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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KR 10-2010-0137651 A	31.12.2010	None	