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(54) IMAGE SENSOR AND METHOD OF FORMING THE SAME

BILDSENSOR UND VERFAHREN ZUR HERSTELLUNG DAVON

CAPTEUR D'IMAGES ET SON PROCÉDÉ DE FABRICATION

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(73) Proprietor: **VisEra Technologies Company Limited**
Hsin-Chu City 30078 (TW)

(72) Inventors:
- **TSAI, Wei-Lung**
  Tainan City 701040 (TW)
- **KUO, Shin-Hong**
  New Taipei City 235 (TW)
- **CHEN, Huang-Jen**
  Hsin-Chu City 30078 (TW)
- **CHANG, Yu-Chi**
  Hukou Township (TW)
- **WU, Ching-Chiang**
  Zhubei City 302 (TW)
- **WU, Han-Lin**
  Hsin-Chu City 30078 (TW)
- **TSAI, Hung-Jen**
  Hsin-Chu City 30078 (TW)

(74) Representative: **Ter Meer Steinmeister & Partner**
Patentanwälte mbB
Nymphenburger Straße 4
80335 München (DE)

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EP 4 131 379 B1

Description

BACKGROUND

Technical Field

[0001] The present disclosure relates in general to an image sensor, and in particular, it relates to an image sensor having an isolation structure.

Description of the Related Art

[0002] Solid-state image sensors (e.g., charge-coupled device (CCD) image sensors, complementary metal-oxide semiconductor (CMOS) image sensors, and so on) have been widely used in various image-capturing apparatuses such as digital still-image cameras, digital video cameras, and the like. The light-sensing portion of a solid-state image sensor may be formed at each of a plurality of pixels, and signal electric charges may be generated according to the amount of light received by the light-sensing portion. In addition, the signal electric charges generated in the light-sensing portion may be transmitted and amplified, whereby an image signal is obtained.

[0003] Recently, the trend has been for the pixel size of image sensors typified by CMOS image sensors to be reduced for the purpose of increasing the number of pixels per unit area so as to provide high-resolution images. An image sensor which has been designed with the aim of providing a high resolution image is, amongst others, known from US 2015/0091115 A1 and WO 2012/035702 A1. However, while pixel size continues to decrease, there are still various challenges in the design and manufacturing of image sensors. For example, cross-talk of electrical signals among pixels will be a serious problem with smaller pixel sizes, which may have an adverse influence on the performance of the image sensors. New manufacturing techniques are also needed to decrease the pixel size further without leading to serious cross-talk of electrical signals among pixels. Therefore, these and related issues need to be addressed by improving the design and manufacture of image sensors.

SUMMARY

[0004] In accordance with some embodiments of the invention, an image sensor is provided. The features of this image sensor are defined in independent claim 1.

[0005] Amongst others, the image sensor includes a substrate, an isolation structure on the substrate, a photoelectric conversion layer, a transparent electrode layer, an encapsulation layer, a color filter layer, and a micro-lens layer. The isolation structure is electrically non-conductive and defines a plurality of pixel regions on the substrate. The isolation structure prevents cross-talk of electrical signals among pixels. The photoelectric conversion layer is disposed on the pixel regions defined by the isolation structure. The transparent electrode layer is disposed over the isolation structure and the photoelectric conversion layer. The encapsulation layer is disposed over the transparent electrode layer. The micro-lens is disposed on the color filter layer.

[0006] The isolation structure comprises isolation walls.

[0007] The isolation walls are portions of the isolation structure between adjacent ones of the plurality of pixel regions.

[0008] The photoelectric conversion layer exposes at least a portion of sidewalls of the isolation walls.

[0009] In accordance with some other embodiments of the invention, a method of forming an image sensor is provided. The features of this method are defined in independent claim 9.

[0010] Amongst others, the method includes providing a substrate. The method also includes forming an isolation structure on the substrate, wherein the isolation structure is electrically non-conductive and defines a plurality of pixel regions on the substrate. The method also includes forming a photoelectric conversion layer disposed on the pixel regions defined by the isolation structure, wherein the isolation structure prevents electrical signals in the photoelectric conversion layer among the pixel regions. The method also includes forming a transparent electrode layer over the isolation structure and the photoelectric conversion layer. The method also includes forming an encapsulation layer over the transparent electrode layer. The method also includes forming a color filter layer disposed over the encapsulation layer corresponding to the pixel regions. The method further includes forming a micro-lens layer disposed on the color filter layer.

[0011] Forming the isolation structure comprises forming the isolation structure having isolation walls.

[0012] The aspects of the present invention may be further embodied or equipped with one or more of the following optional features:

[0013] An angle between a sidewall and a bottom surface of the isolation walls may be between 60° and 120°.

[0014] In one or more embodiments, the isolation walls may have a rectangular, triangular, trapezoidal, or an inversely trapezoidal shape in a cross-sectional view

[0015] In one or more embodiments, a height of the isolation walls may be between 0.5 μm and 1.5 μm.

[0016] In one or more embodiments, an average width of each of the isolation walls may be between 10 nm and 100 nm

[0017] In one or more embodiments, a sum of an average width of each of the isolation walls and an average width of the pixel regions may be less than 20 μm.

[0018] In one or more embodiments, the image sensor may further comprise an isolation cap disposed on a top surface of the isolation structure.

[0019] In one or more embodiments, a width of the isolation walls may be less than a width of the isolation cap.

[0020] In one or more embodiments, the isolation cap may comprise an inorganic material.

[0021] In one or more embodiments, the isolation structure may comprise an organic material.

[0022] In one or more embodiments, the photoelectric conversion layer may extend continuously across adjacent ones of the pixel regions.

[0023] In one or more embodiments, a refractive index of the isolation structure may be between 1.1 and 2.5.

[0024] In one or more embodiments, the isolation structure may comprise at least one of silicon nitride, silicon oxide, aluminum oxide, photoresist, or combination thereof.

[0025] In one or more embodiments, the image sensor may further comprise a sensing device embedded in each of the pixel regions of the substrate.

[0026] In one or more embodiments, the sensing device may be electrically connected to the photoelectric conversion layer through a conductive portion.

[0027] In one or more embodiments, forming the isolation structure may comprise forming an organic material layer on the substrate; forming an inorganic material layer covering a top surface of the organic material layer; forming a patterned mask layer on the inorganic material layer; etching the inorganic material layer to form an isolation cap.

[0028] The inorganic material layer is etched by an anisotropic etching process until at least a portion of the organic material layer is exposed.

[0029] In one or more embodiments, etching the organic material layer until the substrate may be exposed to form the isolation structure with the isolation walls

[0030] In one or more embodiments, the organic material layer may be etched by an isotropic etching process until a width of the isolation walls is less than a width of the isolation cap.

[0031] In one or more embodiments, etching the inorganic material layer may comprise using an etchant comprising CF_4, C_4F_8, or a combination thereof

[0032] In one or more embodiments, etching the organic material layer may comprise using an etchant comprising CO_2, N_2, or a combination thereof.

[0033] In one or more embodiments, the method may further comprise forming a sensing device embedded in each of the pixel regions of the substrate.

[0034] The sensing device may be electrically connected to the photoelectric conversion layer.

[0035] A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The invention may be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

Figs. 1A-1D illustrate cross-sectional views of various stages in the manufacturing of an image sensor in accordance with an illustrative example, whereas the principles that can be derived from Figs. 1C and 1D can also be applied to a sensor in which, in accordance with the invention, the photoelectric conversion layer exposes at least a portion of sidewalls of the isolation walls.

Fig. 2 illustrates a schematic diagram of an intermediate stage in the manufacturing of the image sensor corresponding to Fig. 1B, in accordance with some illustrative embodiments of the present disclosure, falling outside the scope of the invention as claimed.

Figs. 3A-3C illustrate cross-sectional views of intermediate stages in the manufacturing of image sensors. The principles that can be derived from Figs. 3A and 3B can also be applied to a sensor in which, in accordance with the invention, the photoelectric conversion layer exposes at least a portion of sidewalls of the isolation walls. Figures 3A and 3B show illustrative examples. Figure 3C is an embodiment of the claimed invention.

Figs. 4A-4C illustrate cross-sectional views of intermediate stages in the manufacturing of an image sensor in accordance with some other embodiments of the present invention.

Figs. 4E and 4F show manufacturing steps of an image sensor which has rectangular isolation walls. However, triangular, trapezoidal, or inversely trapezoidal shaped side walls can be produced in an analogous way.

DETAILED DESCRIPTION

[0037] The image sensor of the present disclosure is described in detail in the following description. In the following detailed description, for purposes of explanation, numerous specific details and embodiments are set forth in order to provide a thorough understanding of the present invention. The specific elements and configurations described in the following detailed description are set forth in order to clearly describe the present disclosure. It will be apparent, however, that the exemplary embodiments set forth herein are used merely for the purpose of illustration, and the concept of the present invention may be embodied in various forms without being limited to those exemplary embodiments, as long as they fall within the scope of the appended claims.

[0038] In addition, the drawings of different embodiments may use like and/or corresponding numerals to denote like and/or corresponding elements in order to clearly describe the present disclosure. However, the use of like and/or corresponding numerals in the drawings of different embodiments does not suggest any correlation between different embodiments. It should be understood that this description of the exemplary embodiments is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description. The drawings are not drawn to scale.

In addition, structures and devices are shown schematically in order to simplify the drawing.

[0039] In addition, the expressions "a layer overlying another layer", "a layer is disposed above another layer", "a layer is disposed on another layer" and "a layer is disposed over another layer" may indicate that the layer is in direct contact with the other layer, or that the layer is not in direct contact with the other layer, there being one or more intermediate layers disposed between the layer and the other layer.

[0040] In addition, in this specification, relative expressions are used. For example, "lower", "bottom", "upper" or "top" are used to describe the position of one element relative to another. It should be appreciated that if a device is flipped upside down, an element that is "lower" will become an element that is "upper".

[0041] It should be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, layers, portions and/or sections, these elements, components, regions, layers, portions and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer, portion or section from another element, component, region, layer or section. Thus, a first element, component, region, layer, portion or section discussed below could be termed a second element, component, region, layer, portion or section without departing from the teachings of the present disclosure.

[0042] The terms "about" and "substantially" typically mean +/- 10% of the stated value, more typically mean +/- 5% of the stated value, more typically +/- 3% of the stated value, more typically +/- 2% of the stated value, more typically +/- 1% of the stated value and even more typically +/- 0.5% of the stated value. The stated value of the present disclosure is an approximate value. When there is no specific description, the stated value includes the meaning of "about" or "substantially".

[0043] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. It should be appreciated that, in each case, the term, which is defined in a commonly used dictionary, should be interpreted as having a meaning that conforms to the relative skills of the present disclosure and the background or the context of the present disclosure, and should not be interpreted in an idealized or overly formal manner unless so defined.

[0044] In accordance with some embodiments of the disclosure, an image sensor including an electrically non-conductive isolation structure among pixels is provided. In particular, a photovoltaic material for an image sensor may be patterned by the isolation structure to form a photoelectric conversion layer covering at least a portion of the isolation structure. By forming the above isolation structure, electron/hole cross-talk in the organic material among pixels will be prevented, which allows the image sensor with smaller pixel size to be formed without cross-talk adversely affecting the performance of the image sensor.

[0045] Figs. 1A-1D illustrate cross-sectional views of various stages in the manufacturing of an image sensor, in accordance with some embodiments of the present disclosure.

[0046] Referring to Fig. 1A, a substrate 100 is provided. In some embodiments, the substrate 100 may be, for example, a wafer or a chip, but the present disclosure is not limited thereto. In some embodiments, the substrate 100 may be a semiconductor substrate, for example, silicon substrate. Furthermore, in some embodiments, the semiconductor substrate may also be an elemental semiconductor including germanium, a compound semiconductor including gallium nitride (GaN), silicon carbide (SiC), gallium arsenide (GaAs), gallium phosphide (GaP), indium phosphide (InP), indium arsenide (InAs), and/or indium antimonide (InSb), an alloy semiconductor including silicon germanium (SiGe) alloy, gallium arsenide phosphide (GaAsP) alloy, aluminum indium arsenide (AlInAs) alloy, aluminum gallium arsenide (AlGaAs) alloy, gallium indium arsenide (GaInAs) alloy, gallium indium phosphide (GaInP) alloy, and/or gallium indium arsenide phosphide (GaInAsP) alloy, or a combination thereof.

[0047] Then, referring to Fig. 1A, a plurality of sensing devices 102 are embedded in the substrate 100, in accordance with some embodiments of the present disclosure. The plurality of sensing devices 102 may be disposed corresponding to each of the pixel regions which will be defined on the substrate 100 in subsequent manufacturing stages. In some embodiments, the sensing devices 102 are isolated from each other by isolation regions (not shown) in the substrate 100, such as shallow trench isolation (STI) regions or deep trench isolation (DTI) regions. The isolation regions may be formed in the substrate 100 using etching process to form trenches and filling the trenches with an insulating or dielectric material.

[0048] The sensing devices 102 may include a variety of elements depending on the function of the resulting image sensor. For example, in some embodiments, the sensing devices 102 include charge storage portions, which serve to store signal charges generated in a subsequently formed photoelectric conversion layer in each pixel. In some embodiments, the sensing devices 102 include signal readout circuits, each of which serves to output a voltage signal corresponding to the signal charge stored in an associated charge storage portion.

[0049] Then, as shown in Fig. 1A, each of the sensing devices 102 may be electrically connected to a conductive portion 104. The conductive portion 104 may further extend to a top surface of the substrate 100 to electrically connect to a subsequently formed photoelectric conversion layer (for example, a photoelectric conversion layer 120 as described below) over the substrate 100.

[0050] Referring to Fig. 1B, an isolation structure 110 is formed on the substrate 100, wherein the isolation structure 110 defines a plurality of pixel regions 114 on the substrate 100. The isolation structure 110 is formed with isolation walls 112, and the isolation walls 112 are portions of the isolation structure 110 between adjacent ones of the pixel regions 114. In some embodiments, the angle between the sidewall and the bottom surface of the isolation walls 112 (referred to hereinafter as the sidewall angle of the isolation walls 112) is between 60° and 120°. According to some embodiments of the present disclosure, the isolation walls 112 have a rectangular, trapezoidal, inversely trapezoidal, or a triangular shape in a cross-sectional view.

[0051] Fig. 2 illustrates a schematic diagram of an intermediate stage in the manufacturing of the image sensor corresponding to Fig. 1B, in accordance with some embodiments of the present disclosure. The isolation structure 110 may define an array of the pixel regions 114 on the substrate 100, wherein the conductive portions 104 are exposed in each of the pixel regions 114. In addition, as shown in Fig. 2, the isolation walls 112 are portions of the isolation structure 110 between adjacent ones of the pixel regions, wherein each of the plurality of the pixel regions 114 is surrounded by the isolation walls 112, and the pixel regions 114 are separated from each other by these isolation walls 112 of the isolation structure 110. By forming the isolation structure 110, a subsequently formed organic photoelectric layer (for example, a subsequently formed photoelectric conversion layer 120) can be formed within the corresponding pixel regions 114, and thus electron/hole cross-talk in the organic photoelectric layer among pixel regions 114 will be prevented.

[0052] The isolation structure 110 may include electrically non-conductive materials, such as silicon nitride, silicon oxide, aluminum oxide, photoresist, other suitable materials, or a combination thereof. The formation of the isolation structure 110 may include using suitable deposition techniques, such as physical vapor deposition (PVD), chemical vapor deposition (CVD), atomic layer deposition (ALD), spin coating, combinations thereof, or the like. After the materials for the isolation structure 110 is deposited, photolithography and etching processes are performed to form the isolation structure 110. The cross-sectional profile of the isolation walls 112 may be adjusted by the etching conditions to obtain desired shapes.

[0053] After the formation of the isolation structure 110, referring to Fig. 1C, a photoelectric conversion layer 120 is formed on the pixel regions 114 defined by the isolation structure 110. The photoelectric conversion layer 120 in the reference embodiment in Fig.1C extends continuously across adjacent ones of the pixel regions 114. The photoelectric conversion layer 120 according to the present invention exposes at least a portion of the sidewalls of the isolation walls 112. For example, an upper portion of the sidewalls of the isolation walls 112 may be exposed. In some embodiments, the thickness of the photoelectric conversion layer 120 on a top surface of the substrate 100 is about 100 nm to about 700 nm. By forming the above isolation structure, electron/hole cross-talk in the photoelectric conversion layer 120 among pixel regions 114 will be prevented, which allows the image sensor with smaller pixel size to be formed without cross-talk adversely affecting the performance of the image sensor.

[0054] In some embodiments, as shown in Fig. 1C, the photoelectric conversion layer 120 may be electrically connected to the conductive portion 104 exposed in each of the pixel regions 114, and the photoelectric conversion layer 120 is thus electrically connected to the sensing devices 102. In such configuration, the signal charges generated by the photoelectric conversion layer 120 are collected by the sensing devices 102 through the conductive portion 104. Therefore, these signal charges are processed in elements (such as a charge storage portion, a signal readout circuit, combinations thereof, or the like) contained in the sensing devices 102.

[0055] The photoelectric conversion layer 120 may include a photoelectric conversion material that absorbs light irradiation and generates signal charges corresponding to an amount of the absorbed light, such as an organic material, a perovskite material, a quantum dots material, other suitable materials, or a combination thereof. The photoelectric conversion layer 120 may be formed by a deposition process including spin coating, thermal evaporation, combinations thereof, or the like.

[0056] According to some embodiments of the present disclosure, as shown in Fig. 1D, a pixel width W1 of the isolation structure 110 is defined as the sum of the average width W2 of each of the isolation walls 112 and the average width W3 of the pixel regions 114. The value of the pixel width W1 is not particularly limited in the present disclosure. In some embodiments, the pixel width W1 of the resulting image sensor is less than 20 μm.

[0057] The refractive index of the isolation structure 110 is not particularly limited in the present disclosure. In some embodiments of the present disclosure, the refractive index of the isolation structure 110 may be between 1.1 and 2.5. For example, the refractive index of the isolation structure 110 may be between 1.1 and 1.6. In some embodiments, a material with a higher refractive index (such as silicon nitride, aluminum oxide, or the like with a refractive index higher than 1.6) may provide the isolation structure 110 with better water/oxygen resistance. In some other embodiments, a material with a lower refractive index (such as silicon oxide, photoresist, or the like with a refractive index lower than 1.6), may provide the isolation structure 110 with higher optical efficiency. In the case where the isolation structure 110 is formed with a lower refractive index, light penetrating the isolation walls 112 is decreased due to the total internal reflection, thereby improving the light absorption and quantum efficiency of the image sensor.

[0058] Again, with reference to Fig. 1C, the height H and the average width W2 of each of the isolation walls 112 are not particularly limited in the present disclosure.

For example, the height H of the isolation structure 110 may be between 0.5 μm and 1.5 μm, and the average width W2 of each of the isolation walls 112 may be between 10 nm and 100 nm. In reference embodiments where the photoelectric conversion layer 120 extends continuously across adjacent ones of the pixel regions 114, the portion of the photoelectric conversion layer 120 on the surface of the isolation walls forms a passage for electron/hole drifting. Therefore, the electron/hole generated in the photoelectric conversion layer 120 may drift in the passage along the isolation walls 112.

[0059] It should be noted that the passage length for electron/hole generated in the photoelectric conversion layer 120 is determined by controlling the sidewall angle, the average width W2, and the height H of the isolation walls 112. In the present disclosure, the above passage length is defined as the shortest distance for electron/hole drifting across two adjacent ones of the pixel regions 114. Since the diffusion length of electron/hole in the photoelectric conversion layer 120 varies in different kinds of materials of the photoelectric conversion layer 120, the sidewall angle, the average width W2, and the height H of the isolation walls 112 may be chosen corresponding to the material of the photoelectric conversion layer 120, such that the passage length for electron/hole drifting is longer than the diffusion length of electron/hole in the photoelectric conversion layer 120. For example, the passage length for electron/hole drifting may be configured to be longer than 1 μm, while in some other embodiments, the passage length is configured to be longer than 2 μm. Once the passage length is configured to be longer than the diffusion length of electron/hole in the photoelectric conversion layer 120, the electron/hole will be blocked by the isolation structure 110 and will not drift to other pixel regions 114 directly, and thereby electron/hole cross-talk in the photoelectric conversion layer 120 among pixel regions 114 will be prevented.

[0060] Figs. 3A-3C illustrate cross-sectional views of structural variants of the isolation structure 110, in accordance with some other embodiments of the present disclosure. As illustrated in Figs. 3A-3C, the isolation walls 112 are formed as different shapes in a cross-sectional view, such as a triangular shape, a trapezoidal shape, or an inversely trapezoidal shape. In addition, depending on the sidewall angles of the isolation walls 112, the photoelectric conversion layer 120 may or may not extend continuously across adjacent ones of the pixel regions 114.

[0061] In a conventional image sensor as illustrated in Fig. 3A, the sidewall angles of the isolation walls 112 is formed to be a right angle, and the shape of the isolation walls 112 is rectangular in a cross-sectional view. In this case, the photoelectric conversion layer 120 extends continuously across adjacent ones of the pixel regions 114, and the photoelectric conversion layer 120 completely covers the top surface and the sidewalls of each of the isolation walls 112.

[0062] Referring to Fig. 3B, in some other conventional embodiments, the sidewall angles of the isolation walls 112 is formed to be smaller than 90°, and the shape of the isolation walls 112 is triangular in a cross-sectional view. Also, the shape of the isolation walls 112 may be trapezoidal shapes, wherein there is a flat top surface on each of the isolation walls 112 (for example, the isolation walls 112 in Figs. 1C). In these cases where the sidewall angles are smaller than 90°, the photoelectric conversion layer 120 may also extend continuously across adjacent ones of the pixel regions 114. Therefore, in the embodiments where the sidewall angles of the isolation walls 112 is formed to be smaller than 90°, the photoelectric conversion layer 120 may completely cover the top surface and the sidewalls of each of the isolation walls 112.

[0063] Referring to the inventive embodiment in Fig. 3C, the sidewall angles of the isolation walls 112 is formed to be larger than 90°, and the shape of the isolation walls 112 is inversely trapezoidal in a cross-sectional view, wherein the top surface of isolation walls 112 is larger than the bottom surface of the isolation walls 112. Since the photoelectric conversion layer 120 does not extend continuously across adjacent ones of the pixel regions 114 and exposes, in accordance with the invention, at least a portion of the sidewalls of the isolation walls 112, the portions of photoelectric conversion layer 120 between the adjacent ones of the pixel regions 114 fails to form a passage for electron/hole drifting, and thereby electron/hole cross-talk in the photoelectric conversion layer 120 among pixel regions 114 will be further prevented.

[0064] Next, referring to Fig. 1D, subsequent layers are formed over the isolation structure 110 and the photoelectric conversion layer 120 to complete the formation of the image sensor. First, a transparent electrode layer 130 may be formed over the photoelectric conversion layer 120. The transparent electrode layer 130 may be used as a top electrode of the photoelectric conversion layer 120 in order to read out electrical signals of the photoelectric conversion layer 120. With its high transmittance (for example, larger than 50%), the transparent electrode layer 130 may allow the incident light to pass through and enter the photoelectric conversion layer 120. As shown in Fig. 1D, the transparent electrode layer 130 may be formed to completely cover the underlying photoelectric conversion layer 120, wherein a top surface of the transparent electrode layer 130 may be uneven and correspond to the underlying topography of the photoelectric conversion layer 120. The transparent electrode layer 130 may include a transparent conductive material, such as ITO, IZO, ZnO, PEDOT-PSS, other suitable materials, or a combination thereof. The formation of the transparent electrode layer 130 may include using suitable deposition techniques, such as sputtering deposition, spin coating, thermal evaporation, combinations thereof, or the like. In some embodiments, the transparent electrode layer 130 is formed as a thickness from about 0.5 μm to about 1 μm. However, any suitable thickness may be utilized.

[0065] Once the transparent electrode layer 130 is formed, an encapsulation layer 140 may be formed over the transparent electrode layer 130. In some embodiments, the encapsulation layer 140 may be formed as a flat top surface. For example, the encapsulation layer 140 may be planarized with a planarization process, such as a chemical mechanical polishing (CMP) process, to form a substantially flat top surface. Therefore, the conductive transparent electrode layer 130 may be encapsulated by the encapsulation layer 140, and the encapsulation layer 140 may provide a flat top surface for subsequent formation of a color filter layer and a micro-lens layer which includes, for example, color filters CF and micro-lens ML, respectively. The encapsulation layer 140 may include silicon nitride, silicon oxide, aluminum oxide, other suitable materials, or a combination thereof. The formation of the encapsulation layer 140 may include using suitable deposition techniques, such as CVD, ALD, spin-on coating combinations thereof, or the like. In some embodiments, the encapsulation layer 140 is formed as a thickness larger than about 0.3 μm. However, any suitable thickness may be utilized.

[0066] Next, a color filter layer may be formed over the encapsulation layer 140. The color filter layer may include a plurality of color filters CF disposed corresponding to the pixel regions 114, wherein the plurality of color filters CF may include color filters for allowing different wavelengths of light to penetrate, such as a red color filter, a green color filter, and a blue color filter, other kinds of color filters, or a combination thereof. Although each of the color filters CF in Fig. 1D are illustrated as corresponding to each of the pixel regions 114, it should be noted that the present disclosure is not limited to such configuration. In some embodiments, one color filter CF is disposed corresponding to a plurality of pixel regions 114, while in some other embodiments, a plurality of color filters CF are disposed corresponding to the same pixel region 114. In yet some other embodiments, some of the pixel regions 114 may not be covered by the color filter layer. In some embodiments, the color filters CF may be disposed in certain regular pattern. For example, the color filters CF may be disposed according to a Bayer Pattern. However, any suitable pattern and configuration of color filters CF may be utilized. In addition, the color filter layer may be formed in a deposition process at a lower temperature, such as a temperature lower than 120°C, and thereby the materials of the photoelectric conversion layer 120 may undergo less decomposition and the performance of the resulting image sensor may be improved.

[0067] Following the formation of the color filter layer, a micro-lens layer may be formed on the color filter layer. The micro-lens layer may include a plurality of micro-lenses ML disposed corresponding to the color filters CF. Although each of the micro-lens ML in Fig. 1D are illustrated as corresponding to each of the color filters CF, it should be noted that the present disclosure is not limited to such configuration. In some embodiments, one micro-lenses ML is disposed corresponding to a plurality of color filters CF, while in some other embodiments, a plurality of micro-lens are disposed corresponding to the same color filter CF. In yet some other embodiments, some of the color filters CF may not be covered by the micro-lenses ML. The material of the micro-lenses ML may include glass, epoxy resin, silicone resin, polyurethane, any other applicable material, or a combination thereof, but the present disclosure is not limited thereto. As described above, the micro-lens layer may be formed at a lower temperature, such as a temperature lower than 120°C, and thereby the materials of the photoelectric conversion layer 120 may undergo less decomposition and the performance of the resulting image sensor may be improved.

[0068] Each of the micro-lens ML may be a semi-convex lens or a convex lens, but the present disclosure is not limited thereto. In some other embodiments, each of the micro-lenses ML may be replaced with a condensing structure, such as a micro-pyramid structures (e.g., circular cone, quadrangular pyramid, and so on), or a micro-trapezoidal structures (e.g., flat top cone, truncated square pyramid, and so on). Alternatively, the condensing structure may be a gradient-index structure.

[0069] Figs. 4A-4G illustrate cross-sectional views of intermediate stages in the manufacturing of an image sensor, in accordance with yet other embodiments of the present disclosure. In these embodiments, different from the embodiments of forming an image sensor in Figs. 1A-1D, the image sensor is formed to include an isolation cap disposed on a top surface of the isolation structure, wherein a width of the isolation walls is smaller than a width of the isolation cap. In addition, the isolation cap comprises an inorganic material and the isolation structure comprises an organic material. By forming this isolation cap, the electron/hole cross-talk in the photoelectric conversion layer among the pixel regions will be further prevented. The detailed manufacturing process of forming the image sensor including the isolation cap are illustrated and described below with respect to Figs. 4A-4G, wherein similar elements are indicated with similar reference numerals as recited in Figs. 1A-1D.

[0070] Referring to Fig. 4A, an organic material layer 400 may be formed on the substrate 100. The thickness of the organic material layer 400 is not particularly limited in the present disclosure. For example, the thickness of the organic material layer 400 may be between 0.5 μm and 1.5 μm. The organic material layer 400 may include an organic material feasible for subsequent patterning processes, such as a photoresist, although any suitable materials may be utilized. The formation of the organic material 400 may include using suitable deposition techniques, such as spin coating, bar coating, ink-jet coating, combinations thereof, or the like.

[0071] Referring to Fig. 4B, an inorganic material layer 402 may be formed covering a top surface of the organic material layer 400. The thickness of the inorganic material layer 402 is not particularly limited in the present disclosure. For example, the thickness of the organic material layer 400 may be between 200 nm and 800 nm. The inorganic material layer 402 may include silicon nitride, silicon oxide, aluminum oxide, combinations thereof, or the like, although any suitable materials may be utilized. The formation of the inorganic material 402 may include using suitable deposition techniques, such as physical vapor deposition (PVD), chemical vapor deposition (CVD), atomic layer deposition (ALD), spin coating, combinations thereof, or the like.

[0072] Then, referring to Fig. 4C, a patterned mask layer 404 may be formed on the inorganic material layer 402 to serve as an etch mask for subsequent etching of the inorganic material layer 402. The patterned mask layer 404 may, for example, include photoresist, epoxy, resin, other suitable materials, or a combination thereof. The formation of the patterned mask layer 404 may include using suitable deposition techniques, such as physical vapor deposition (PVD), chemical vapor deposition (CVD), atomic layer deposition (ALD), spin coating, combinations thereof, or the like. Then, the above deposition techniques are followed by suitable photolithography and etching processes to form a desired pattern corresponding to subsequently formed pixel regions.

[0073] After the formation of the patterned mask layer 404, referring to Fig. 4D, a first etching process 406 is performed on the inorganic material layer 402 to form openings 408 and an isolation cap 410 surrounding the openings 408, wherein the first etching process 406 is performed until at least a portion of the organic material layer 400 is exposed. The first etching process 406 may be an anisotropic etching process, such that a portion of the inorganic material layer 402 directly under the patterned mask layer 404 remains substantially unetched. In some embodiments, the inorganic material layer 402 is removed using, for example, a wet or dry etching process that utilizes etchants that are selective to the material of the inorganic material layer 402, while the underlying organic material layer 400 remains unetched. For example, the first etching process 406 may utilize an etchant including CF_4, C_4F_8, combinations thereof, or the like to remove the portion of the inorganic material layer 402 not covered by the patterned mask layer 404. However, any suitable removal process for the inorganic material layer 402 may be utilized.

[0074] Additionally, the patterned mask layer 404 that covers the isolation cap 410 may be removed after the first etching process 406. In an embodiment the patterned mask layer 404 may be removed using, for example, a wet or dry etching process that is selective to the material of the patterned mask layer 404. However, the patterned mask layer 404 may also remain on the isolation cap 410 during subsequent etching processes.

[0075] After the organic material layer 400 is exposed by the first etching process 406, a second etching process 412 may be performed on the organic material layer 400 to form the isolation structure 414 with the isolation walls 416. The second etching process 412 is performed until the substrate 100 is exposed by the second etching process 412. The second etching process 412 may be an isotropic etching process so that the width of the isolation walls 416 is less than the width of the isolation cap 410. In addition, pixel regions 418 are defined by the resulting isolation structure 414. In some embodiments, the organic material layer 400 is removed using, for example, a wet etching or isotropic dry etching process that utilizes etchants that are selective to the material of the organic material layer 400, while the above isolation cap 410 and the underlying substrate 100 and exposed conductive portion 104 remain unetched. For example, the second etching process 412 may utilize an etchant including CO_2, N_2, combinations thereof, or the like to remove a portion of the inorganic material layer 402. However, any suitable removal process for the organic material layer 400 may be utilized. Then, the remained patterned mask layer 404 (if any) that covers the isolation cap 410 may be removed after the second etching process 412. In an embodiment the patterned mask layer 404 may be removed using, for example, a wet or dry etching process that is selective to the material of the patterned mask layer 404.

[0076] After the formation of the isolation structure 414, referring to Fig. 4F, a photoelectric conversion layer 420 is formed on the pixel regions 418 defined by the isolation structure 414. As shown in Fig. 4F, the photoelectric conversion layer 420 may not extend continuously across adjacent ones of the pixel regions 418, and the photoelectric conversion layer 420 exposes, in accordance with the invention, at least a portion of sidewalls of the isolation walls 416. Since the photoelectric conversion layer 420 do not extend continuously across adjacent ones of the pixel regions 418, the portions of photoelectric conversion layer 420 between the adjacent ones of the pixel regions 418 fails to form a passage for electron/hole drifting, and thereby electron/hole cross-talk in the photoelectric conversion layer 420 among pixel regions 418 will be further prevented.

[0077] In some embodiments, as shown in Fig. 4F, the photoelectric conversion layer 420 may be electrically connected to the conductive portion 104 exposed in each of the pixel regions 418, and the photoelectric conversion layer 420 is thus electrically connected to the sensing devices 102. In such configuration, the signal charges generated by the photoelectric conversion layer 420 are collected by the sensing devices 102 through the conductive portion 104. Therefore, these signal charges are processed in elements (such as a charge storage portion, a signal readout circuit, combinations thereof, or the like) included in the sensing devices 102.

[0078] The photoelectric conversion layer 420 may include similar materials and may be formed by similar deposition process as the photoelectric conversion layer 120 as described above. For example, the photoelectric conversion layer 420 may include a photoelectric conversion material that absorbs light irradiation and generates signal charges corresponding to an amount of the absorbed light, such as an organic material, a perovskite material, a quantum dots material, other suitable materials, or a combination thereof. The photoelectric conversion layer 420 may be formed by a deposition process including spin coating, thermal evaporation, combinations thereof, or the like.

[0079] After the formation of the photoelectric conversion layer 420, a transparent electrode layer, encapsulation layer, color filter layer, and a micro-lens layer may be formed sequentially over the photoelectric conversion layer 420 according to the suitable materials and manufacturing processes described above, which is not repeated here for the sake of brevity.

[0080] In summary, according to some embodiments of the disclosure, an image sensor including an electrically non-conductive isolation structure among pixels is provided. In particular, a photovoltaic material for an image sensor may be patterned by the isolation structure to form a photoelectric conversion layer covering at least a portion of the isolation structure. By forming the above isolation structure, electron/hole cross-talk in the organic material among pixels will be prevented, which allows the image sensor with smaller pixel size to be formed without cross-talk adversely affecting the performance of the image sensor.

[0081] Although some embodiments of the present disclosure and their advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the scope of the disclosure as defined by the appended claims. For example, it will be readily understood by one of ordinary skill in the art that many of the features, functions, processes, and materials described herein may be varied while remaining within the scope of the present disclosure. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the present disclosure, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present disclosure. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

Claims

1. An image sensor, comprising:

   a substrate (100);

   an isolation structure (110) disposed on the substrate (100), wherein the isolation structure (110) is electrically non-conductive and defines a plurality of pixel regions (114) on the substrate (100);

   a photoelectric conversion layer (120) disposed on the pixel regions (114) defined by the isolation structure (110), wherein the isolation structure (110) prevents cross-talk of electrical signals in the photoelectric conversion layer (120) among the pixel regions (114);

   a transparent electrode layer (130) disposed over the isolation structure (110) and the photoelectric conversion layer (120);

   an encapsulation layer (140) disposed over the transparent electrode layer (130);

   a color filter layer (CF) disposed over the encapsulation layer (140) corresponding to the pixel regions (114); and

   a micro-lens layer (ML) disposed on the color filter layer (CF), wherein

   the isolation structure (110) comprises isolation walls (112), wherein the isolation walls (112) are portions of the isolation structure (110) between adjacent ones of the plurality of pixel regions (114),

   characterized in that

   the photoelectric conversion layer (120) exposes at least a portion of sidewalls of the isolation walls (112).

2. The image sensor as claimed in claim 1, wherein an angle between a sidewall and a bottom surface of the isolation walls (112) is between 60° and 120°.

3. The image sensor as claimed in claim 1 or 2, wherein the isolation walls (112) have one of a rectangular, triangular, trapezoidal, or an inversely trapezoidal shape in a cross-sectional view.

4. The image sensor as claimed in any one of the preceding claims, wherein a height of the isolation walls (112) is between 0.5 μm and 1.5 μm, and/or an average width of each of the isolation walls (112) is between 10 nm and 100 nm, and/or a sum of an average width of each of the isolation walls (112) and an average width of the pixel regions (114) is less than 20 μm.

5. The image sensor as claimed in any one of the preceding claims, further comprising an isolation cap (410) disposed on a top surface of the isolation structure (110).

6. The image sensor as claimed in claim 5, wherein a width of the isolation walls (112) is less than a width of the isolation cap (410), and/or the isolation cap (410) comprises an inorganic material and the iso-

lation structure (112) comprises an organic material.

7. The image sensor as claimed in any one of the preceding claims, wherein a refractive index of the isolation structure (110) is between 1.1 and 2.5, and/or the isolation structure (110) comprises at least one of silicon nitride, silicon oxide, aluminum oxide, photoresist, or combination thereof.

8. The image sensor as claimed in any one of the preceding claims, further comprising a sensing device (102) embedded in each of the pixel regions (114) of the substrate (100), preferably the sensing device (102) is electrically connected to the photoelectric conversion layer (120) through a conductive portion (104).

9. A method of forming an image sensor, comprising:

providing a substrate (100);
forming an isolation structure (110) on the substrate (100), wherein the isolation structure (110) is electrically non-conductive and defines a plurality of pixel regions (114) on the substrate (100);
forming a photoelectric conversion layer (120) disposed on the pixel regions (114) defined by the isolation structure (110), wherein the isolation structure (110) prevents cross-talk of electrical signals in the photoelectric conversion layer (120) among the pixel regions (114);
forming a transparent electrode layer (130) over the isolation structure (110) and the photoelectric conversion layer (120);
forming an encapsulation layer (140) over the transparent electrode layer (130);
forming a color filter layer (CF) disposed over the encapsulation layer (140) corresponding to the pixel regions (114); and
forming a micro-lens layer (ML) disposed on the color filter layer (CF), wherein
forming the isolation structure (110) comprises forming the isolation structure (110) having isolation walls (112),
characterized in that
the photoelectric conversion layer (120) is formed such that at least a portion of sidewalls of the isolation walls (112) is exposed.

10. The method of forming an image sensor of claim 9, wherein forming the isolation structure (110) comprises:

forming an organic material layer (400) on the substrate (100);
forming an inorganic material layer (402) covering a top surface of the organic material layer (400);
forming a patterned mask layer (404) on the inorganic material layer (402);
etching the inorganic material layer (402) to form an isolation cap (410), wherein the inorganic material layer (402) is etched by an anisotropic etching process until at least a portion of the organic material layer (400) is exposed; and
etching the organic material layer (400) until the substrate (100) is exposed to form the isolation structure (110) with the isolation walls (112), wherein the organic material layer (400) is etched by an isotropic etching process until a width of the isolation walls (112) is less than a width of the isolation cap (410).

11. The method of forming an image sensor of claim 10, wherein etching the inorganic material layer (402) comprises using an etchant comprising CF_4, C_4F_8, or a combination thereof, and/or etching the organic material layer (400) comprises using an etchant comprising CO_2, N_2, or a combination thereof.

12. The method of forming an image sensor of any one of the claims 9-11, further comprising forming a sensing device (102) embedded in each of the pixel regions (114) of the substrate (100).

Patentansprüche

1. Bildsensor, umfassend:

ein Substrat (100);
eine Isolationsstruktur (110), die auf dem Substrat (100) angeordnet ist, wobei die Isolationsstruktur (110) elektrisch nichtleitend ist und eine Vielzahl von Pixelbereichen (114) auf dem Substrat (100) definiert;
eine photoelektrische Konversionsschicht (120), die auf den durch die Isolationsstruktur (110) definierten Pixelbereichen (114) angeordnet ist, wobei die Isolationsstruktur (110) ein Übersprechen von elektrischen Signalen in der photoelektrischen Konversionsschicht (120) zwischen den Pixelbereichen (114) verhindert;
eine transparente Elektrodenschicht (130), die über der Isolationsstruktur (110) und der photoelektrischen Konversionsschicht (120) angeordnet ist;
eine Verkapselungsschicht (140), die über der transparenten Elektrodenschicht (130) angeordnet ist;
eine Farbfilterschicht (CF), die entsprechend den Pixelbereichen (114) über der Verkapselungsschicht (140) angeordnet ist; und
eine Mikrolinsenschicht (ML), die auf der Farbfilterschicht (CF) angeordnet ist,
wobei die Isolationsstruktur (110) Isolations-

wände (112) umfasst, wobei die Isolationswände (112) Abschnitte der Isolationsstruktur (110) zwischen benachbarten der Vielzahl von Pixelbereichen (114) sind,
dadurch gekennzeichnet, dass
die photoelektrische Konversionsschicht (120) wenigstens einen Abschnitt von Seitenwänden der Isolationswände (112) freilegt.

2. Bildsensor nach Anspruch 1, wobei ein Winkel zwischen einer Seitenwand und einer Bodenfläche der Isolationswände (112) zwischen 60° und 120° liegt.

3. Bildsensor nach Anspruch 1 oder 2, wobei die Isolationswände (112) in einer Querschnittsansicht eine rechteckige, eine dreieckige, eine trapezförmige oder eine umgekehrt trapezförmige Form aufweisen.

4. Bildsensor nach einem der vorhergehenden Ansprüche, wobei eine Höhe der Isolationswände (112) zwischen 0,5 μm und 1,5 μm liegt und/oder eine durchschnittliche Breite jeder der Isolationswände (112) zwischen 10 nm und 100 nm liegt und/oder eine Summe aus einer durchschnittlichen Breite jeder der Isolationswände (112) und einer durchschnittlichen Breite der Pixelbereiche (114) kleiner als 20 μm ist.

5. Bildsensor nach einem der vorhergehenden Ansprüche, ferner umfassend eine Isolationskappe (410), die auf einer oberen Oberfläche der Isolationsstruktur (110) angeordnet ist.

6. Bildsensor nach Anspruch 5, wobei eine Breite der Isolationswände (112) kleiner ist als eine Breite der Isolationskappe (410) und/oder die Isolationskappe (410) ein anorganisches Material umfasst und die Isolationsstruktur (112) ein organisches Material umfasst.

7. Bildsensor nach einem der vorhergehenden Ansprüche, wobei ein Brechungsindex der Isolationsstruktur (110) zwischen 1,1 und 2,5 liegt und/oder die Isolationsstruktur (110) wenigstens eines von Siliziumnitrid, Siliziumoxid, Aluminiumoxid, Fotolack oder einer Kombination davon umfasst.

8. Bildsensor nach einem der vorhergehenden Ansprüche, ferner umfassend eine Sensorvorrichtung (102), die in jeden der Pixelbereiche (114) des Substrats (100) eingebettet ist, wobei die Sensorvorrichtung (102) vorzugsweise über einen leitenden Abschnitt (104) elektrisch mit der photoelektrischen Konversionsschicht (120) verbunden ist.

9. Verfahren zum Bilden eines Bildsensors, umfassend:

Bereitstellen eines Substrats (100);
Bilden einer Isolationsstruktur (110) auf dem Substrat (100), wobei die Isolationsstruktur (110) elektrisch nichtleitend ist und eine Vielzahl von Pixelbereichen (114) auf dem Substrat (100) definiert;
Bilden einer photoelektrischen Konversionsschicht (120), die auf den durch die Isolationsstruktur (110) definierten Pixelbereichen (114) angeordnet ist, wobei die Isolationsstruktur (110) ein Übersprechen von elektrischen Signalen in der photoelektrischen Konversionsschicht (120) zwischen den Pixelbereichen (114) verhindert;
Bilden einer transparenten Elektrodenschicht (130) über der Isolationsstruktur (110) und der photoelektrischen Konversionsschicht (120);
Bilden einer Verkapselungsschicht (140) über der transparenten Elektrodenschicht (130);
Bilden einer Farbfilterschicht (CF), die entsprechend den Pixelbereichen (114) über der Verkapselungsschicht (140) angeordnet ist; und
Bilden einer Mikrolinsenschicht (ML), die auf der Farbfilterschicht (CF) angeordnet ist,
wobei das Bilden der Isolationsstruktur (110) ein Bilden der Isolationsstruktur (110) mit Isolationswänden (112) umfasst,
dadurch gekennzeichnet, dass
die photoelektrische Konversionsschicht (120) so gebildet wird, dass wenigstens ein Abschnitt von Seitenwänden der Isolationswände (112) freigelegt ist.

10. Verfahren zum Bilden eines Bildsensors nach Anspruch 9, wobei das Bilden der Isolationsstruktur (110) umfasst:

Bilden einer organischen Materialschicht (400) auf dem Substrat (100);
Bilden einer anorganischen Materialschicht (402), die eine obere Oberfläche der organischen Materialschicht (400) bedeckt;
Bilden einer gemusterten Maskenschicht (404) auf der anorganischen Materialschicht (402);
Ätzen der anorganischen Materialschicht (402), um eine Isolationskappe (410) zu bilden, wobei die anorganische Materialschicht (402) durch einen anisotropen Ätzprozess geätzt wird, bis wenigstens ein Abschnitt der organischen Materialschicht (400) freigelegt ist; und
Ätzen der organischen Materialschicht (400), bis das Substrat (100) freigelegt ist, um die Isolationsstruktur (110) mit den Isolationswänden (112) zu bilden, wobei die organische Materialschicht (400) durch einen isotropen Ätzprozess geätzt wird, bis eine Breite der Isolationswände (112) kleiner ist als eine Breite der Isolationskappe (410).

11. Verfahren zum Bilden eines Bildsensors nach Anspruch 10, wobei das Ätzen der anorganischen Materialschicht (402) ein Verwenden eines Ätzmittels umfasst, das CF4, C4F8 oder eine Kombination davon umfasst, und/oder wobei das Ätzen der organischen Materialschicht (400) ein Verwenden eines Ätzmittels umfasst, das CO2, N2 oder eine Kombination davon umfasst.

12. Verfahren zum Bilden eines Bildsensors nach einem der Ansprüche 9-11, ferner umfassend ein Bilden einer Sensorvorrichtung (102), die in jeden der Pixelbereiche (114) des Substrats (100) eingebettet ist.

Revendications

1. Capteur d'image, comportant :

un substrat (100) ;
une structure d'isolation (110) disposée sur le substrat (100), dans lequel la structure d'isolation (110) est électriquement non conductrice et définit une pluralité de régions de pixels (114) sur le substrat (100) ;
une couche de conversion photoélectrique (120) disposée sur les régions de pixels (114) définies par la structure d'isolation (110), dans lequel la structure d'isolation (110) empêche une diaphonie de signaux électriques dans la couche de conversion photoélectrique (120) parmi les régions de pixels (114) ;
une couche d'électrode transparente (130) disposée au-dessus de la structure d'isolation (110) et de la couche de conversion photoélectrique (120) ;
une couche d'encapsulation (140) disposée au-dessus de la couche d'électrode transparente (130) ;
une couche de filtre à couleur (CF) disposée au-dessus de la couche d'encapsulation (140) correspondant aux régions de pixels (114) ; et
une couche de microlentille (ML) disposée sur la couche de filtre à couleur (CF),
dans lequel la structure d'isolation (110) comporte des parois d'isolation (112), dans lequel les parois d'isolation (112) sont des parties de la structure d'isolation (110) entre des régions adjacentes de la pluralité de régions de pixels (114),
caractérisé en ce que
la couche de conversion photoélectrique (120) expose au moins une partie de parois latérales des parois d'isolation (112).

2. Capteur d'image selon la revendication 1, dans lequel un angle entre une paroi latérale et une surface inférieure des parois d'isolation (112) est comprise entre 60° et 120°.

3. Capteur d'image selon la revendication 1 ou 2, dans lequel les parois d'isolation (112) ont une forme parmi une forme rectangulaire, triangulaire, trapézoïdale ou inversement trapézoïdale dans une vue en coupe transversale.

4. Capteur d'image selon l'une quelconque des revendications précédentes, dans lequel une hauteur des parois d'isolation (112) est comprise entre 0,5 μm et 1,5 μm, et/ou une largeur moyenne de chacune des parois d'isolation (120) est comprise entre 10 nm et 100 nm, et/ou une somme d'une largeur moyenne de chacune des parois d'isolation (112) et d'une largeur moyenne des régions de pixels (114) est inférieure à 20 μm.

5. Capteur d'image selon l'une quelconque des revendications précédentes, comportant en outre une coiffe d'isolation (410) disposée sur une surface supérieure de la structure d'isolation (110).

6. Capteur d'image selon la revendication 5, dans lequel une largeur des parois d'isolation (112) est inférieure à une largeur de la coiffe d'isolation (410) et/ou la coiffe d'isolation (410) comporte un matériau inorganique et la structure d'isolation (112) comporte un matériau organique.

7. Capteur d'image selon l'une quelconque des revendications précédentes, dans lequel un indice de réfraction de la structure d'isolation (110) est compris entre 1,1 et 2,5 et/ou la structure d'isolation (110) comporte au moins un élément parmi du nitrure de silicium, de l'oxyde de silicium, de l'oxyde d'aluminium, une résine photosensible ou une combinaison de ceux-ci.

8. Capteur d'image selon l'une quelconque des revendications précédentes, comportant en outre un dispositif de détection (102) incorporé dans chacune des régions de pixels (114) du substrat (100), le dispositif de détection (102) étant de préférence électriquement connecté à la couche de conversion photoélectrique (120) via une partie conductrice (104).

9. Procédé de formation d'un capteur d'image, comportant les étapes consistant à :

fournir un substrat (100) ;
former une structure d'isolation (110) sur le substrat (100), dans lequel la structure d'isolation (110) est électriquement non conductrice et définit une pluralité de régions de pixels (114) sur le substrat (100) ;
former une couche de conversion photoélectri-

que (120) disposée sur les régions de pixels (114) définies par la structure d'isolation (110), dans lequel la structure d'isolation (110) empêche une diaphonie de signaux électriques dans la couche de conversion photoélectrique (120) parmi les régions de pixels (114) ;

former une couche d'électrode transparente (130) au-dessus de la structure d'isolation (110) et de la couche de conversion photoélectrique (120) ;

former une couche d'encapsulation (140) au-dessus de la couche d'électrode transparente (130) ;

former une couche de filtre à couleur (CF) disposée au-dessus de la couche d'encapsulation (140) correspondant aux régions de pixels (114) ; et

former une couche de microlentille (ML) disposée sur la couche de filtre à couleur (CF),

dans lequel la formation de la structure d'isolation (110) comporte la formation de la structure d'isolation (110) ayant des parois d'isolation (112),

caractérisé en ce que

la couche de conversion photoélectrique (120) est formée de telle sorte qu'au moins une partie de parois latérales des parois d'isolation (112) est exposée.

10. Procédé de formation d'un capteur d'image selon la revendication 9, dans lequel la formation de la structure d'isolation (110) comporte les étapes consistant à :

former une couche de matériau organique (400) sur le substrat (100) ;

former une couche de matériau inorganique (402) recouvrant une surface supérieure de la couche de matériau organique (400) ;

former une couche de masque à motifs (404) sur la couche de matériau inorganique (402) ;

graver la couche de matériau inorganique (402) pour former une coiffe d'isolation (410), dans lequel la couche de matériau inorganique (402) est gravée par un processus de gravure anisotrope jusqu'à ce qu'au moins une partie de la couche de matériau organique (400) soit exposée ; et

graver la couche de matériau organique (400) jusqu'à ce que le substrat (100) soit exposé pour former la structure d'isolation (110) avec les parois d'isolation (112), dans lequel la couche de matériau organique (400) est gravée par un processus de gravure isotrope jusqu'à ce qu'une largeur des parois d'isolation (112) soit inférieure à une largeur de la coiffe d'isolation (410).

11. Procédé de formation d'un capteur d'image selon la revendication 10, dans lequel la gravure de la couche de matériau inorganique (402) comporte l'utilisation d'un agent de gravure comportant CF_4, C_4F_8 ou une combinaison de ceux-ci et/ou la gravure de la couche de matériau organique (400) comporte l'utilisation d'un agent de gravure comportant CO_2, N_2 ou une combinaison de ceux-ci.

12. Procédé de formation d'un capteur d'image selon l'une quelconque des revendications 9 à 11, comportant en outre la formation d'un dispositif de détection (102) incorporé dans chacune des régions des pixels (114) du substrat (100).

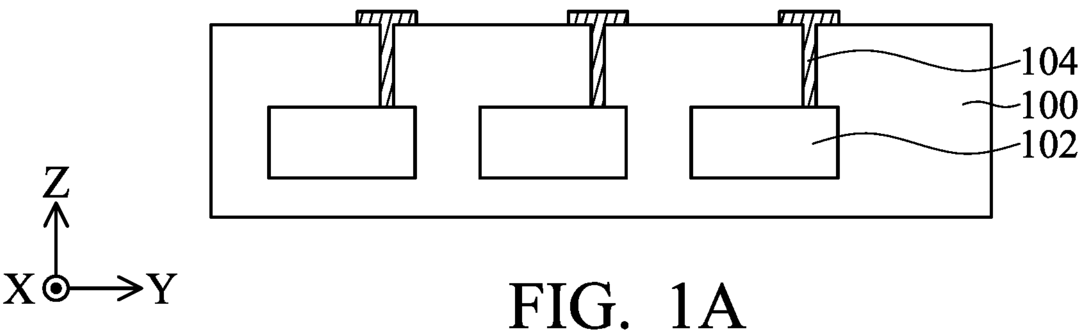

FIG. 1A

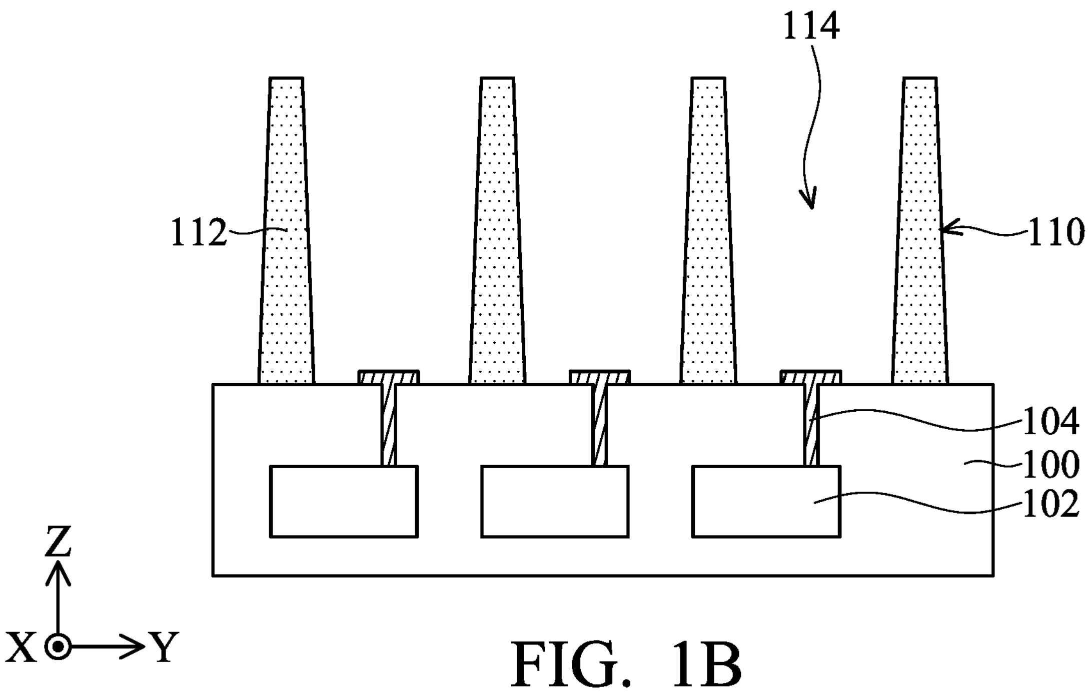

FIG. 1B

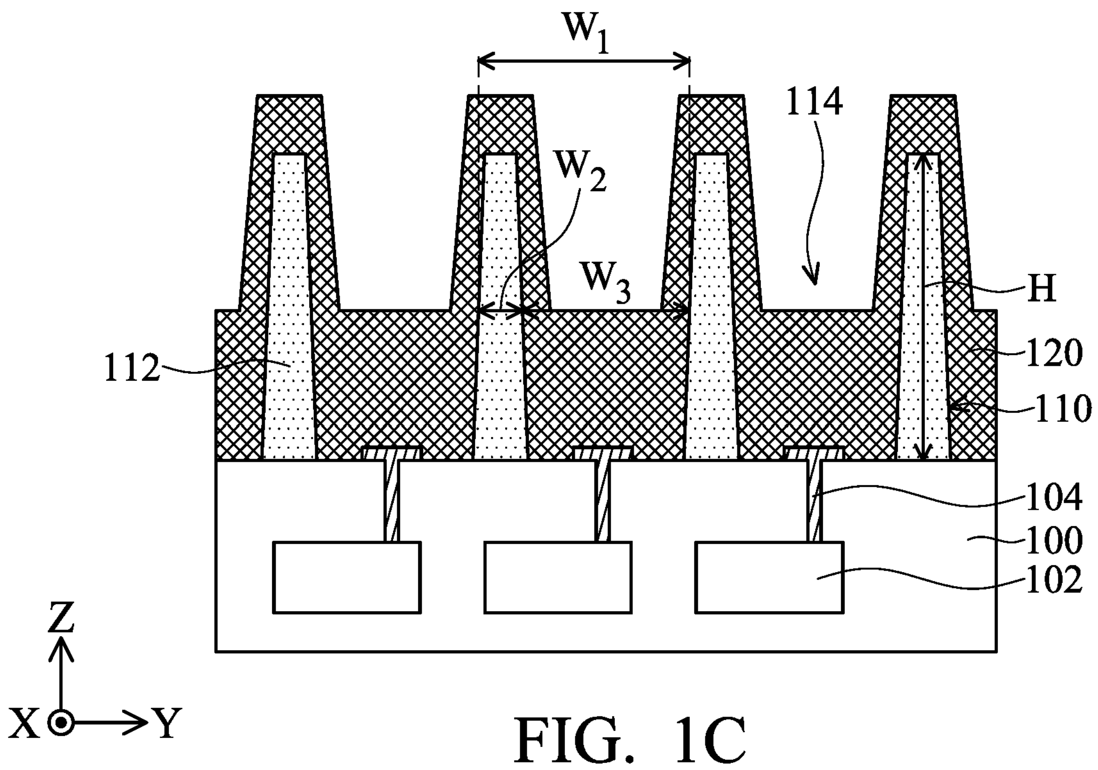

FIG. 1C

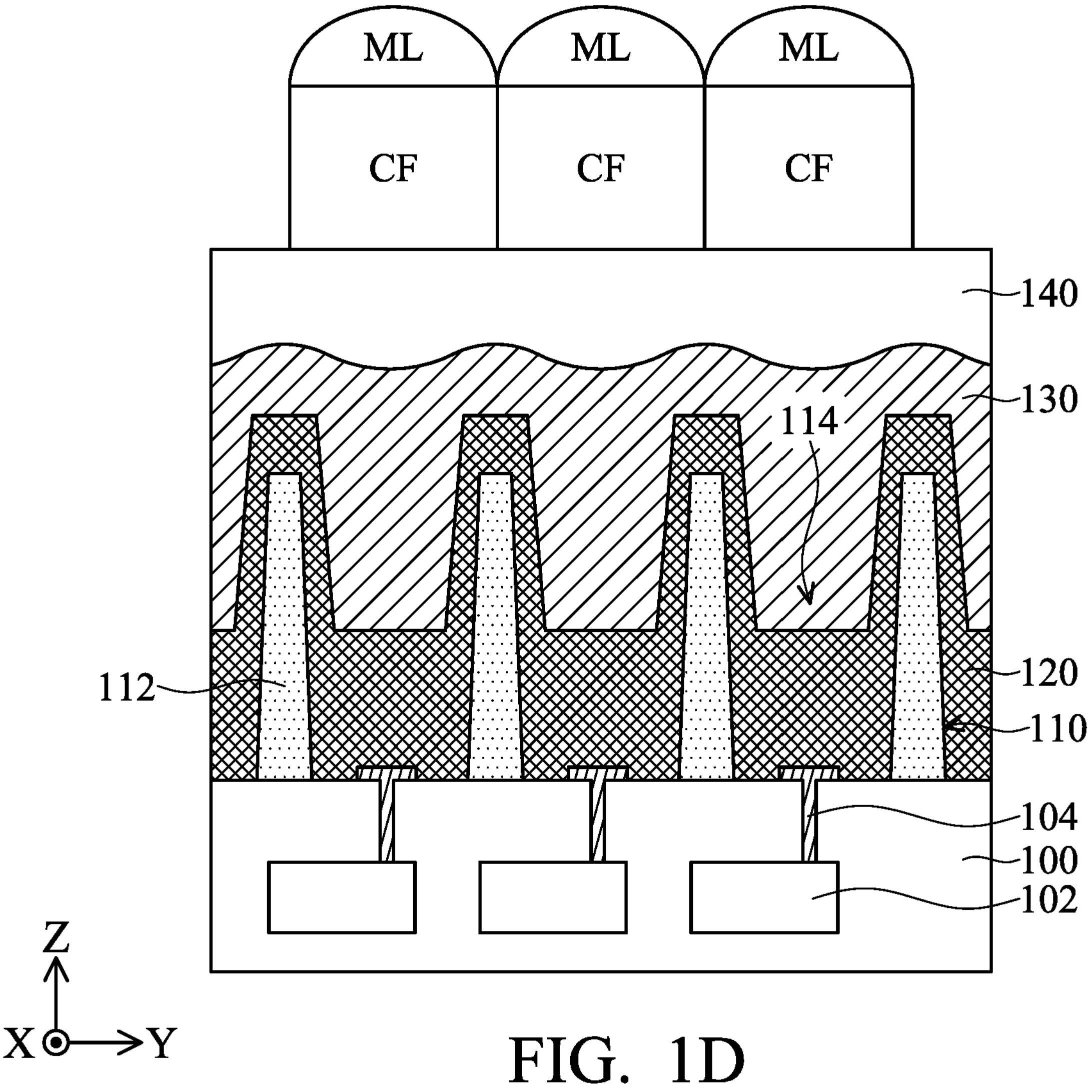

FIG. 1D

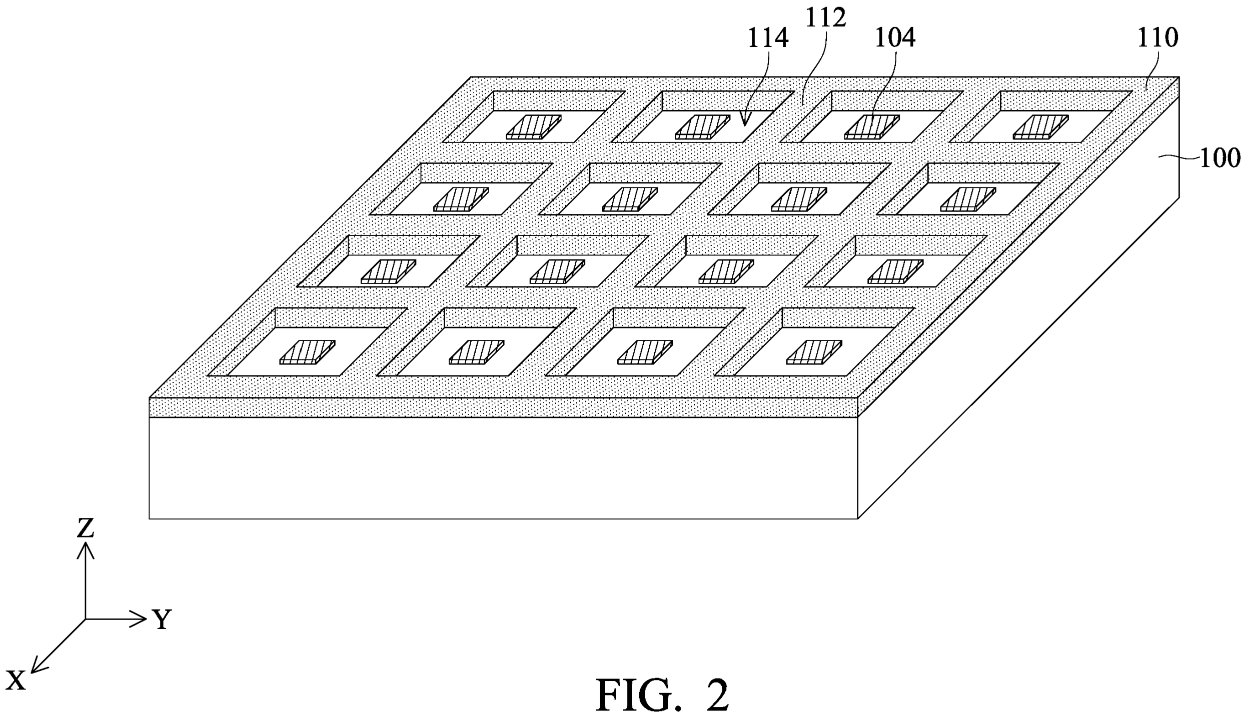

FIG. 2

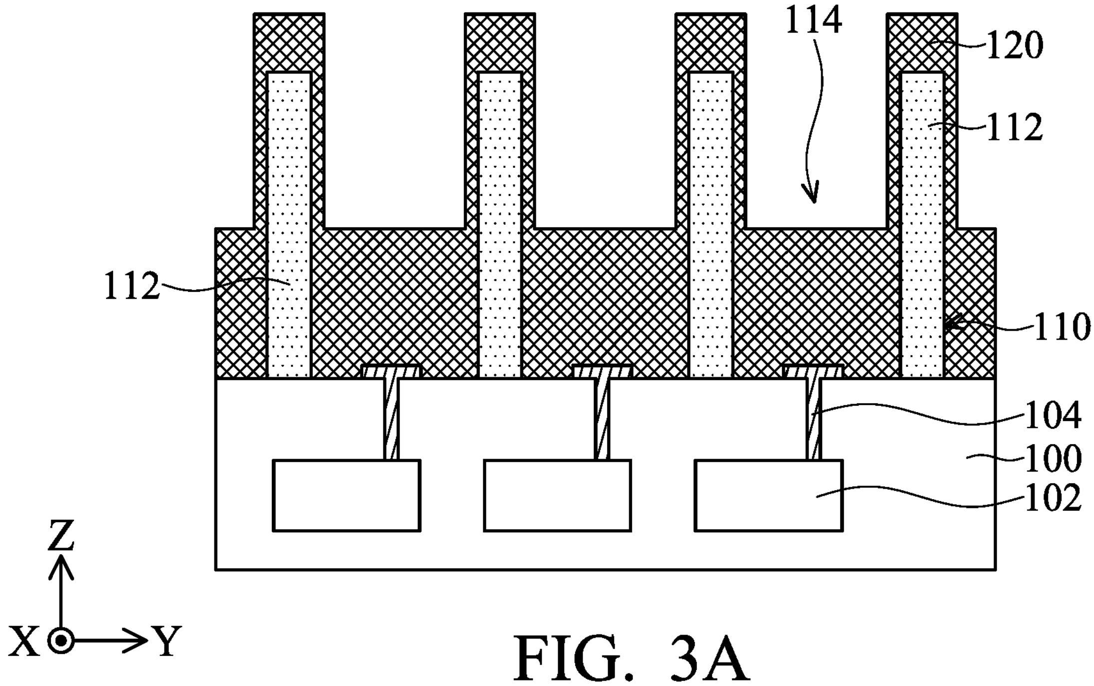

FIG. 3A

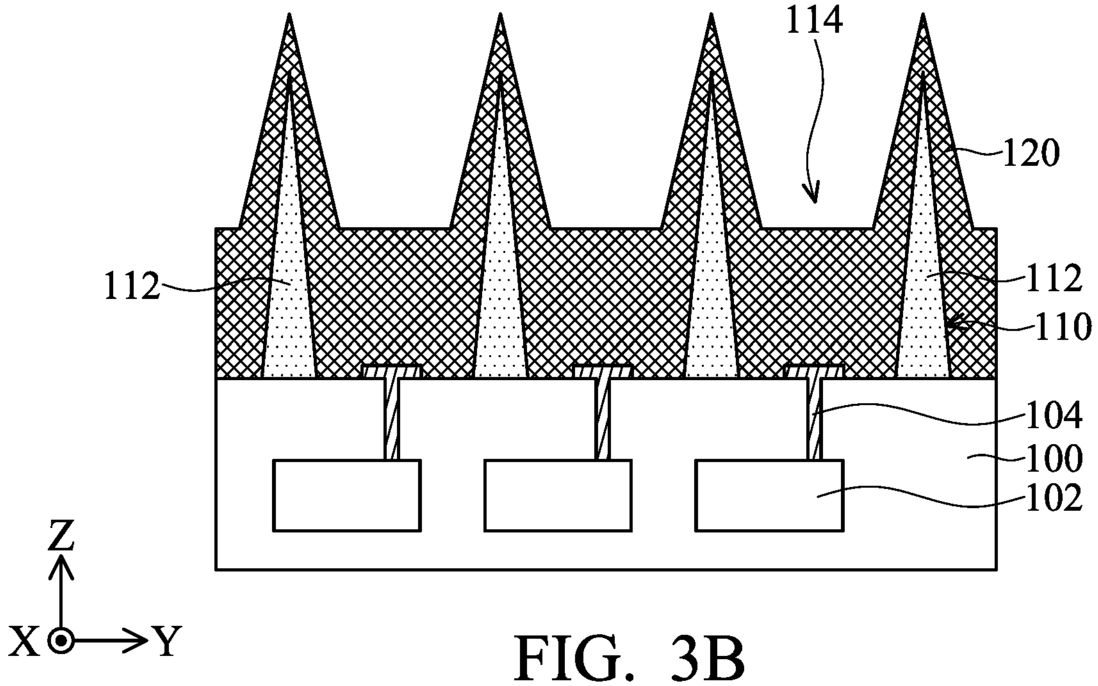

FIG. 3B

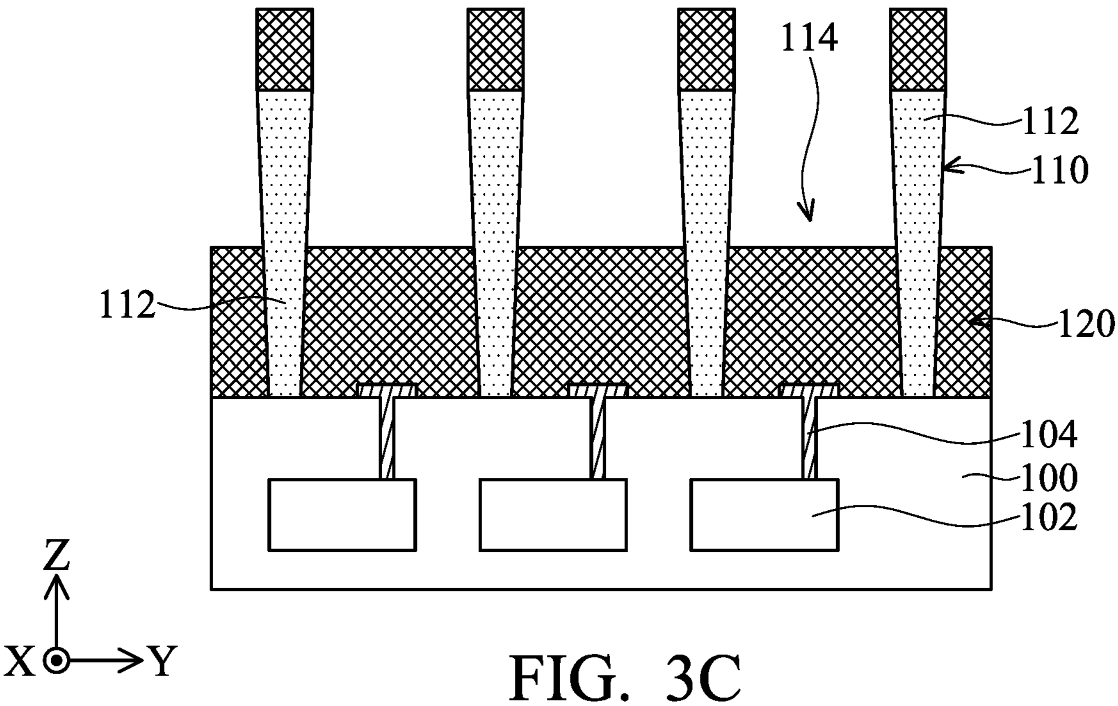

FIG. 3C

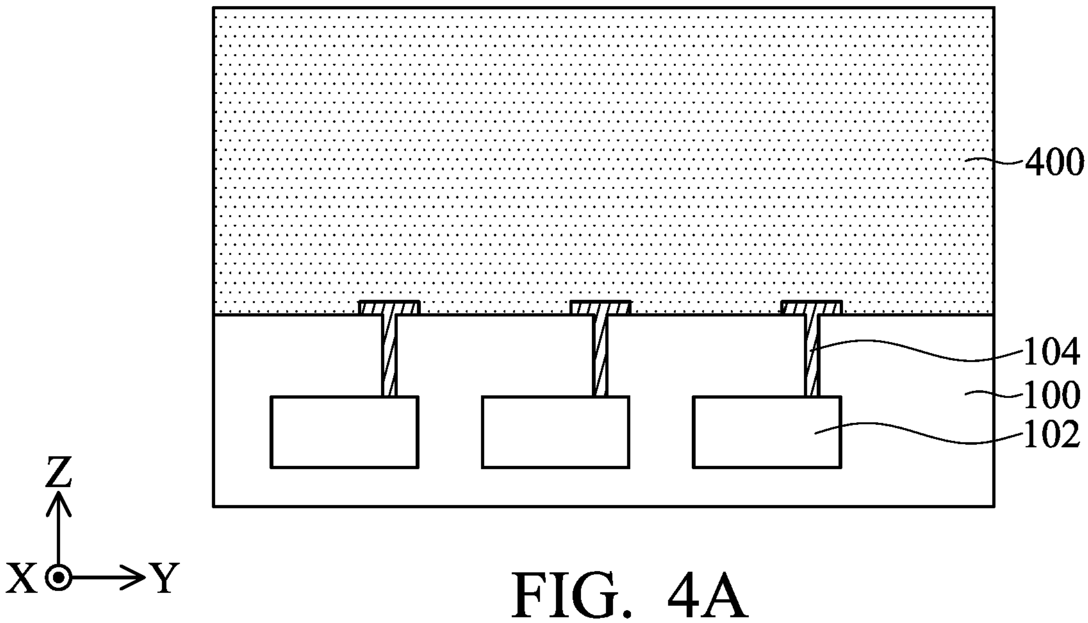

FIG. 4A

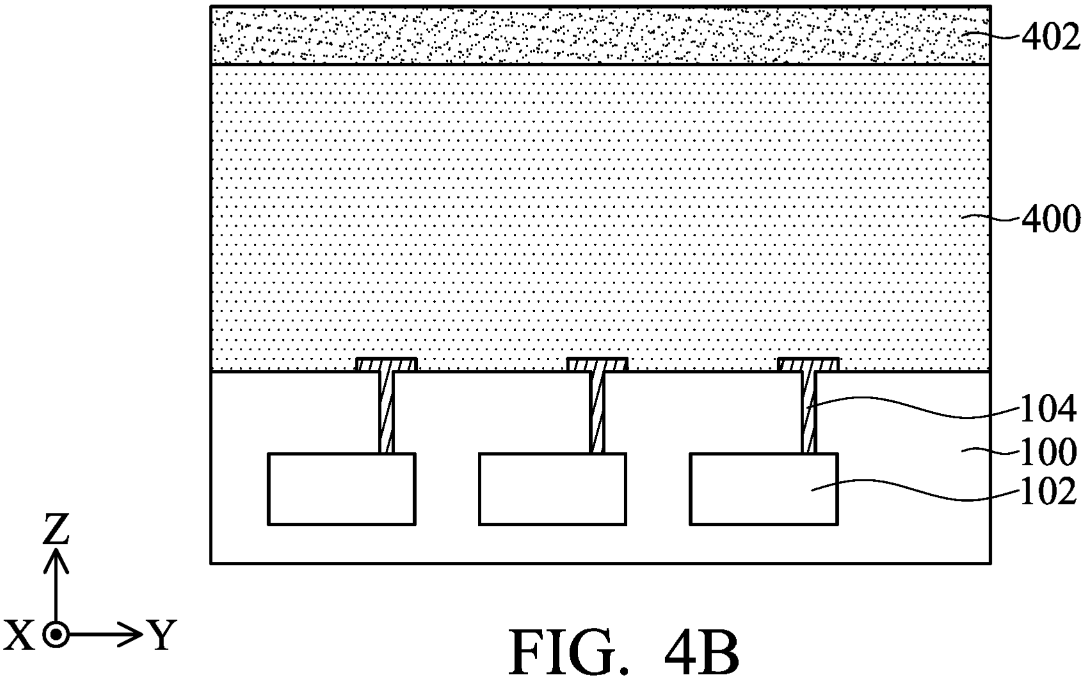

FIG. 4B

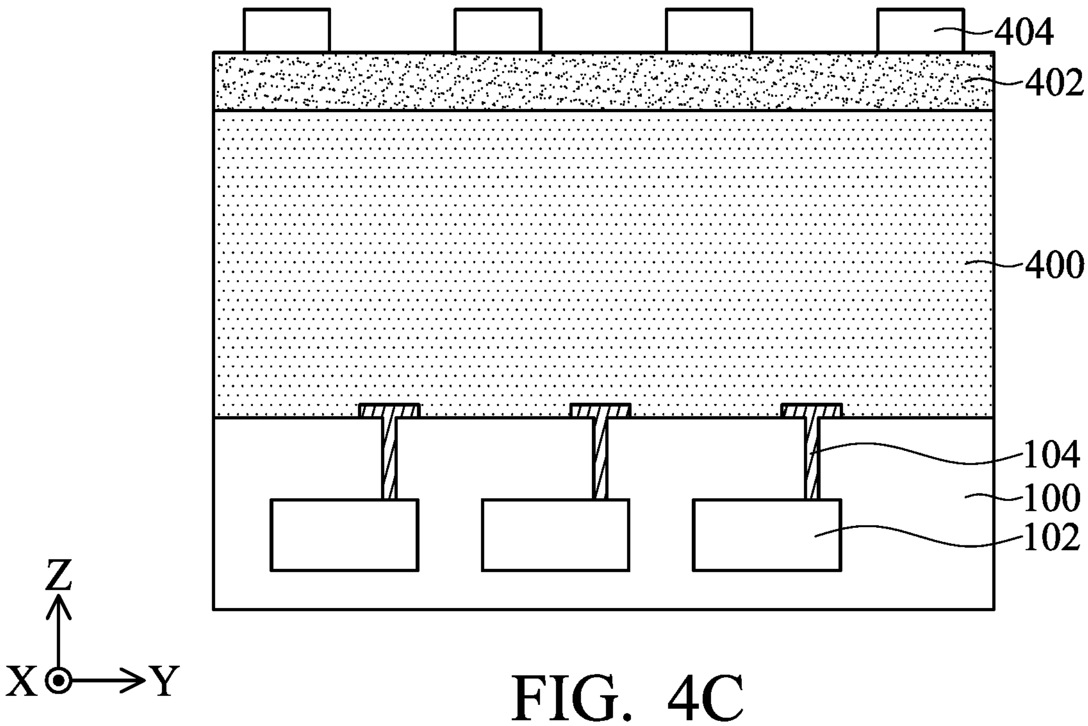

FIG. 4C

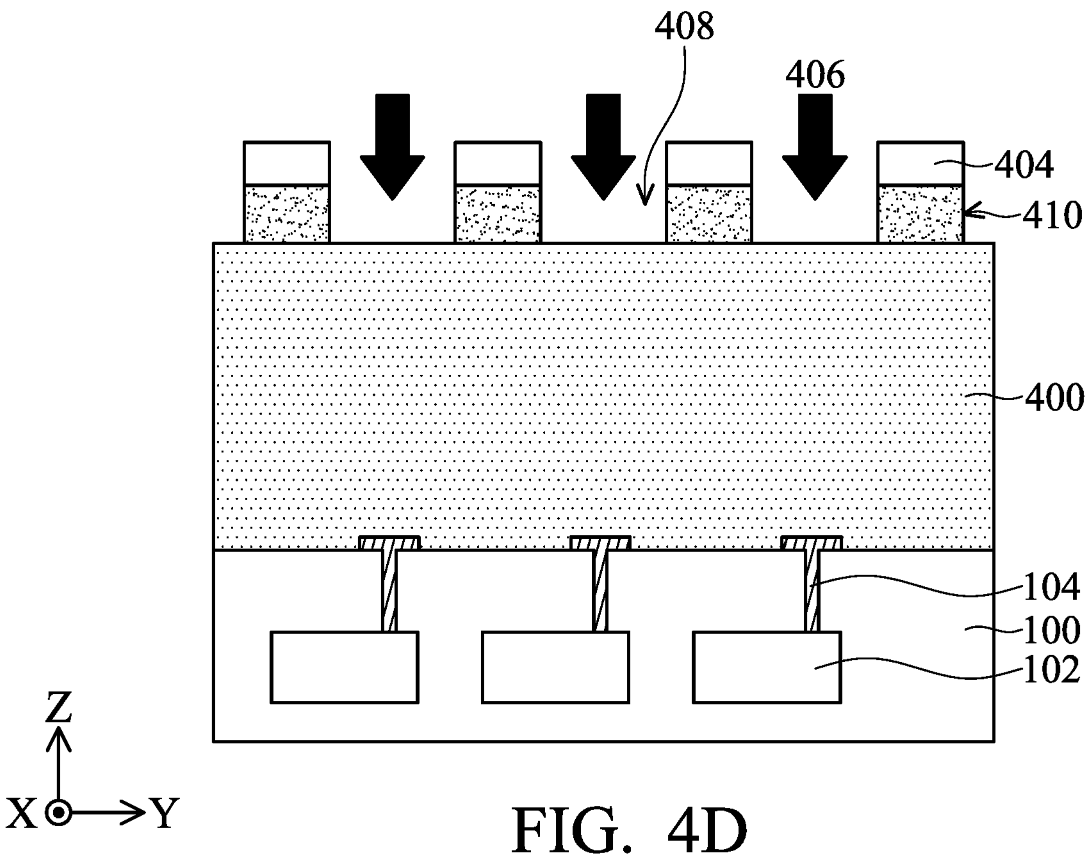

FIG. 4D

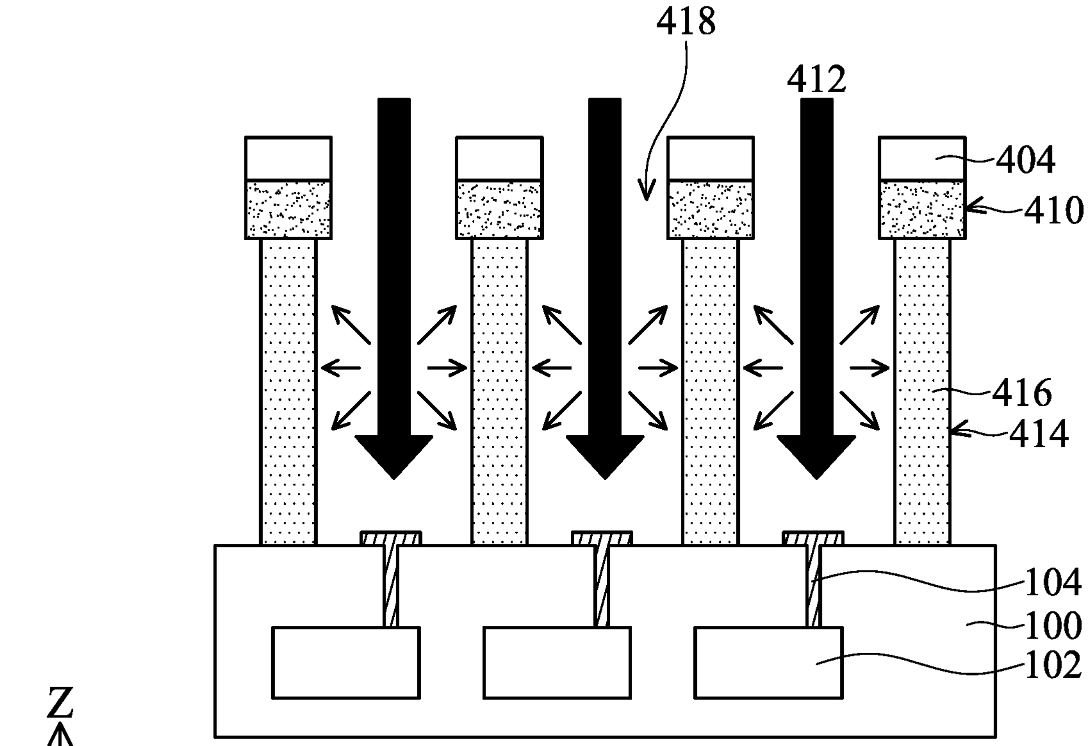

FIG. 4E

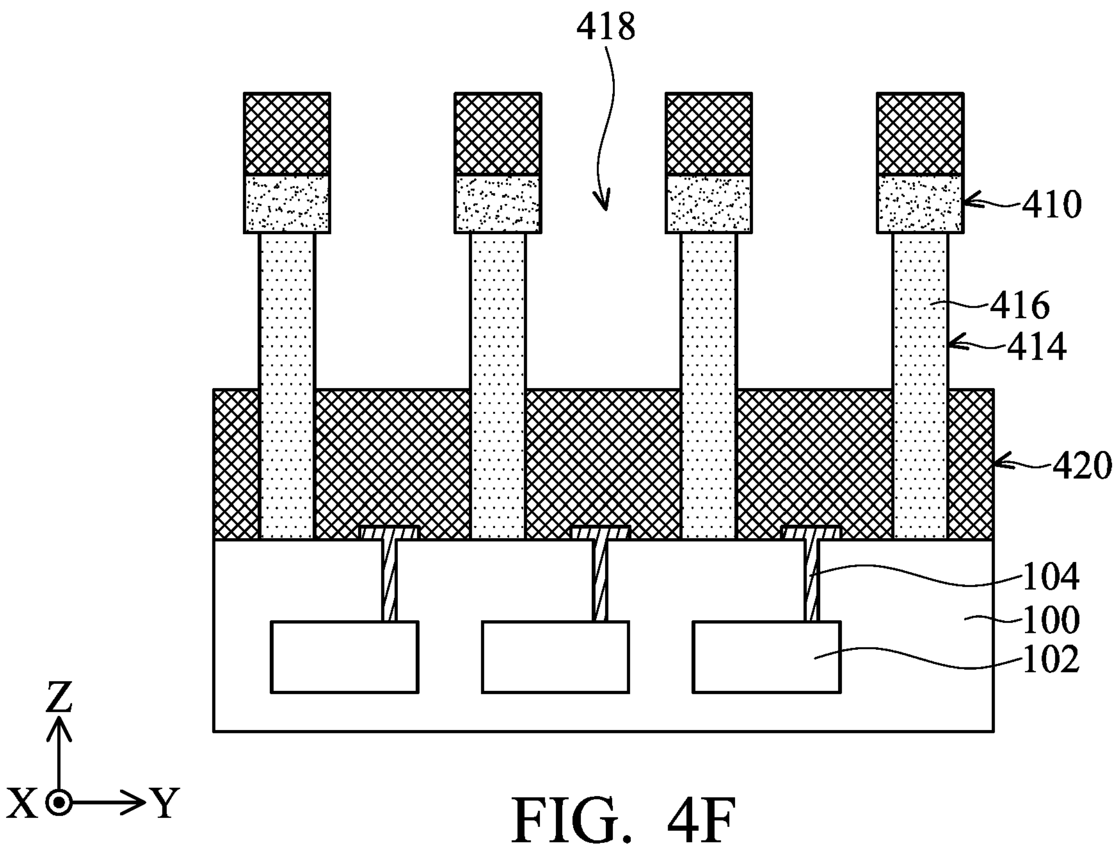

FIG. 4F

REFERENCES CITED IN THE DESCRIPTION

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