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(54) MEASURING METHOD OF INCIDENT LIGHT AND SENSOR HAVING SPECTROSCOPIC MECHANISM EMPLOYING IT

MESSVERFAHREN FÜR EINFALLENDES LICHT UND SENSOR MIT EINEM SPEKTROSKOPISCHEN MECHANISMUS DAMIT

PROCEDE DE MESURE DE LUMIERE INCIDENTE ET CAPTEUR A MECANISME SPECTROSCOPIQUE UTILISANT CE PROCEDE

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(73) Proprietor: **Japan Science and Technology Agency**
Kawaguchi-shi,
Saitama 332-0012 (JP)

(72) Inventors:
- **SAWADA, Kazuaki**
  Toyohashi-shi, Aichi 441-8066 (JP)
- **ISHIDA, Makoto**
  Toyohashi-shi, Aichi 441-8125 (JP)
- **MARUYAMA, Yuki**
  Toyohashi-shi, Aichi 441-8063 (JP)
- **MUTO, Hideki**
  Odawara-shi, Kanagawa 250-0055 (JP)

(74) Representative: **Hoarton, Lloyd Douglas Charles et al**
Forresters
Skygarden
Erika-Mann-Strasse 11
80636 München (DE)

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Description

Technical Field

[0001] The present invention relates to a method for measuring incident light and a spectroscopic sensor employing the same, and in particular, to a method for measuring incident light, the method for detecting wavelength and intensity of light incident on a semiconductor device, and a sensor having a spectroscopic mechanism employing the same.

Background Art

[0002] In an image sensor used in single-CCD video cameras, red, green, and blue filters are provided on each photo detector (e.g., photodiode) to produce color images.

[0003] In three-CCD video cameras, incident light is separated into three light components, i.e., red, green, and blue with an optical prism and each of the light components is detected with three separate image sensors.

[0004] Hitherto, in order to check wavelength and intensity of incident light, a spectroscopic separation is performed using a grating or the like and the intensity distribution of each light component is then measured with a power meter or the like.

[0005] A trial for obtaining color information of red, green, and blue with a single photodiode is also known (refer US 5,965,875 : the fourth column to the fifth column, Fig.6). According to this approach, three diffusion layers having a depth of 0.2 μm, 0.6 μm, and 2 μm are disposed on a silicon substrate so as to overlap with each other, and currents generated from each junction are detected.

Disclosure of Invention

[0006] However, in the above-described single-CCD video cameras, since three photo detectors are required to produce color images, the resolution is decreased to one third. In addition, the sensitivity is decreased because of an optical absorption by the color filters.

[0007] In the three-CCD video cameras, the presence of the optical prism increases the size of the camera itself.

[0008] Furthermore, the size of the spectroscopic instrument is increased because a grating or the like is used.

[0009] In the method of color separation by an active pixel imaging array having a triple-well structure, which is disclosed in US 5,965,875, red is also unintentionally detected in the nearest junction that detects blue, and thus the resolution of color information of red, green, and blue is low. Furthermore, disadvantageously, this method does not provide information about the relationship between wavelength and intensity.

[0010] Also, in the method described in Patent Document 1, the depth (position) of electrons to be captured cannot be varied.

[0011] US 3,459,944 discloses a photosensitive insulated gate field effect transistor. The transistor can be controlled by both radiant energy and electrical signal inputs.

[0012] US 4, 057, 819 discloses a photo-sensitive solid-state electronic device whose anode-cathode current is modified by photon induced changes in the electrical condition of a dielectric layer on the semiconductor body.

[0013] In view of the above situation, it is an object of the present invention to provide a method for measuring incident light employing a simple semiconductor structure provided with a single electron-capturing section corresponding to incident light, and a sensor having a spectroscopic mechanism employing the same.

[0014] In order to achieve the above object, the present invention provides a method as claimed in claim 1 and a sensor as claimed in claim 4.

Brief Description of the Drawings

[0015]

Fig. 1 is a perspective view showing a partial cross-sectional view of a spectroscopic sensor that measures incident light, according to an embodiment of the present invention.
Fig. 2 is a characteristic diagram of the spectroscopic sensor in the case where Vg is -1 V.
Fig. 3 is a characteristic diagram of the spectroscopic sensor in the case where Vg is 0 V.
Fig. 4 is a characteristic diagram of the spectroscopic sensor in the case where Vg is 1 V.
Fig. 5 is a characteristic diagram of the spectroscopic sensor in the case where Vg is 2 V.
Fig. 6 is a characteristic diagram of the spectroscopic sensor in the case where Vg is 3 V.
Fig. 7 is a characteristic diagram of the spectroscopic sensor in the case where Vg is 4 V.
Fig. 8 is a characteristic diagram of the spectroscopic sensor in the case where Vg is 5 V.

Fig. 9 is a characteristic diagram of a spectroscopic sensor according to an embodiment of the present invention in the case where the voltage applied to a substrate is 5 V and Vg is 0 V (corresponding to Fig. 3), and the depth of a p-type diffusion layer is 10 μm (full scale in the Z coordinate).

Fig. 10 is a characteristic diagram of the spectroscopic sensor according to the embodiment of the present invention in the case where the voltage applied to the substrate is 10 V and Vg is 0 V, and the depth of the p-type diffusion layer is 10 μm (full scale in the Z coordinate).

Fig. 11 is a plan view of a unit of a spectroscopic sensor of the present invention.

Fig. 12 is a plan view of the overall spectroscopic sensors (4 × 4) of the present invention.

Fig. 13 is a block diagram of a color image sensor system without a color filter, according to an application of the present invention.

Best Mode for Carrying Out the Invention

[0016] Embodiments of the present invention will now be described in detail.

[0017] First, a fundamental principle for obtaining wavelength information of incident light will be described.

[0018] Light irradiated on a semiconductor device enters the semiconductor device and is attenuated while being absorbed. The degree of attenuation depends on the wavelength of the incident light.

[0019] Consequently, the present invention focuses attention on the following: If a depth (position) capable of collecting electrons generated by light can be varied and the currents thereof can then be measured, wavelength information of incident light can be obtained by the following method (of course, electron holes that are simultaneously formed with the electrons may be accumulated). For example, suppose that two light components having wavelengths of λ1 and λ2 are simultaneously incident with intensities of A_1 and A_2, respectively. Suppose that when the current generated by electrons in a distance from the surface to an electron-capturing position W_1 is measured, the current is represented by current I_1.

[0020] Subsequently, suppose that when the current generated by electrons in a distance to an electron-capturing position W_2 is measured, the current is represented by current I_2. This phenomenon can be represented by the following equations [refer to Supplementary explanation 1] :
[Equation 1]

$$\begin{cases} I_1 = \dfrac{A_1 S q}{h\nu_1}\left(1 - e^{-\alpha_1 W_1}\right) + \dfrac{A_2 S q}{h\nu_2}\left(1 - e^{-\alpha_2 W_1}\right) \\ I_2 = \dfrac{A_1 S q}{h\nu_1}\left(1 - e^{-\alpha_1 W_2}\right) + \dfrac{A_2 S q}{h\nu_2}\left(1 - e^{-\alpha_2 W_2}\right) \end{cases} \quad \cdots (1)$$

[0021] In the equations, each parameter is as follows:

A_1 and A_2: intensity of incident light [W/cm^2]
S: sensor area [cm^2]
W_1 and W_2: electron-capturing position [cm]
α_1 and α_2: absorption coefficient at each wavelength [cm^{-1}]
I_1: observed value of current [A] when the electron-capturing position is W_1
I_2: observed value of current [A] when the electron-capturing position is W_2

$$\text{Frequency } \nu_1 = c/\lambda_1$$

$$\text{Frequency } \nu_2 = c/\lambda_2$$

[0022] Here, c represents the light velocity, S represents an area of light-receiving section, hv represents photon energy, and q represents an electron volt. All the values except for the intensities A_1 and A_2 of incident light are known values. Accordingly, the intensities A_1 and A_2 of incident light can be determined by solving simultaneous equations from the two equations.

[0023] For example, the intensities A_1 and A_2 of incident light are represented as follows:
[Equation 2]

$$\begin{cases} A_1 = \dfrac{I_1 Z - I_2 X}{WZ - XY} \\ A_2 = \dfrac{I_2 W - I_1 Y}{WZ - XY} \end{cases} \quad \cdots (2)$$

[0024] Each parameter is as follows:
[Equation 3]

$$W = \frac{Sq(1 - e^{-\alpha_1 W_1})}{h\nu_1} \qquad X = \frac{Sq(1 - e^{-\alpha_2 W_1})}{h\nu_2}$$
$$Y = \frac{Sq(1 - e^{-\alpha_1 W_2})}{h\nu_1} \qquad Z = \frac{Sq(1 - e^{-\alpha_2 W_2})}{h\nu_2} \quad \cdots (3)$$

[0025] For example, when incident light is separated into three wavelengths, a current I_3 when the electron-capturing position is W_3 is added to equation (1). Subsequently, the calculation is performed as in the case of two wavelengths, thus separating the incident light into three wavelengths.

[0026] Similarly, when light incident with 100 wavelengths is spectroscopically separated, the electron-capturing position should be varied 100 times and the measurement is then performed.

[Supplementary explanation 1]

[0027] When monochromatic light is incident, a current generated to a depth (position) W in a semiconductor can be determined by a calculation. When light is incident on a semiconductor, the light intensity is exponentially attenuated. Accordingly, a light intensity Φ at a depth x is represented as follows:
[Equation 4]

$$\phi = \phi_0 e^{-\alpha x} \quad \cdots (4)$$

wherein Φ_0: intensity of incident light [W/cm^2]
α: absorption coefficient [cm^{-1}]

[0028] From this equation, the ratio absorbed to a depth W is determined as follows:
[Equation 5]

$$\frac{\int_0^W \phi_0 e^{-\alpha x} dx}{\int_0^\infty \phi_0 e^{-\alpha x} dx} = 1 - e^{-\alpha W} \quad \cdots (5)$$

[0029] From these equations, a current generated to the depth W is determined by the following equation:
[Equation 6]

$$I = \frac{\phi_0 Sq}{h\nu} (1 - e^{-\alpha W}) \quad \cdots (6)$$

wherein S: area [cm^2] of light-receiving section
hv: photon energy [J]
q: electron volt [J]

[0030] It is equation (1) that these equations are represented with respect to each wavelength.

[0031] Embodiments of the present invention will now be described in detail.

[0032] Fig. 1 is a perspective view showing a partial cross-sectional view of a spectroscopic sensor that measures incident light, according to an embodiment of the present invention.

[0033] In this figure, reference numeral 1 indicates an n-type silicon substrate (n-type substrate), reference numeral 2 indicates a p-type diffusion layer (p-type well) formed in the n-type silicon substrate 1, reference numeral 3 indicates an n^+ diffusion layer formed at a part of the p-type diffusion layer 2, reference numeral 4 indicates a silicon oxide (SiO_2) film formed on the p-type diffusion layer 2, reference numeral 5 indicates an A1 electrode connected to the n^+ diffusion layer 3 and being applied with a reference voltage, reference numeral 6 indicates an electrode that is connected to the p-type diffusion layer 2 and is connected to ground, reference numeral 7 indicates a polycrystalline silicon (poly-Si) film formed on the upper part of the silicon oxide film 4 and being doped with an impurity, and reference numeral 8 indicates a gate electrode connected to the polycrystalline silicon film 7. The polycrystalline silicon film 7 functions as an electrode capable of transmitting light via the silicon oxide film 4.

[0034] In order to vary a depth (position) from the surface of the p-type diffusion layer 2 in which electrons are captured, for example, the spectroscopic sensor has a structure in which the p-type diffusion layer 2 is provided in the n-type silicon substrate 1 and the polycrystalline silicon (poly-Si) film 7 doped with an impurity and functioning as an electrode capable of transmitting light via the silicon oxide film 4 disposed on the upper part of the p-type diffusion layer 2 is disposed. The n^+ diffusion layer 3 is disposed beside the polycrystalline silicon film 7 capable of transmitting light and being doped with an impurity in order that captured electrons are taken out to the outside. The p-type diffusion layer 2 and the n-type silicon substrate 1 include contacts for extending wiring to keep the electric potential of these constant.

[0035] Figs. 2 to 8 are characteristic diagrams of the spectroscopic sensor shown in Fig. 1. Fig. 2 shows the case where Vg is -1 V, Fig. 3 shows the case where Vg is 0 V, Fig. 4 shows the case where Vg is 1 V, Fig. 5 shows the case where Vg is 2 V, Fig. 6 shows the case where Vg is 3 V, Fig. 7 shows the case where Vg is 4 V, and Fig. 8 shows the case where Vg is 5 V. Here, Vg represents a gate voltage (electric potential of the gate electrode 8). In each figure, the value 0.0 in the Z coordinate axis represents the surface of the p-type diffusion layer, the actual line represents a depth (position) W from the surface of the p-type diffusion layer in which electrons are captured, B represents a p-well part, and C represents a pn junction part with the substrate (these are representatively shown in Fig. 2 but are the same in Figs. 3 to 8).

[0036] For example, in the case where the concentration of impurity in the p-type diffusion layer 2 is 2×10^{15} cm^{-3} (junction depth: 5 μm), the concentration of impurity in the n-type silicon substrate 1 is 1.5×10^{14} cm^{-3}, and the thickness of the silicon oxide film 4 is 65 nm, when the electric potential of the gate electrode 8 is varied from -1 V to 5 V (Fig. 2 to Fig. 8) (while 5 V is applied on the n-type silicon substrate 1), the depth W from the surface of the p-type diffusion layer 2 in which electrons are captured, is varied from 0 μm to 2.3 μm.

[0037] The figures show the results of a simulation when 5 V is applied on the silicon substrate 1. However, the voltage applied on the substrate is not fixed to 5 V but is variable.

[0038] Fig. 9 is a characteristic diagram of a spectroscopic sensor according to an embodiment of the present invention in the case where the voltage applied to the substrate is 5 V and Vg is 0 V (corresponding to Fig. 3), and the depth of the p-type diffusion layer is 10 μm (full scale in the Z coordinate). Fig. 10 is a characteristic diagram of the spectroscopic sensor according to the embodiment of the present invention in the case where the voltage applied to the substrate is 10 V and Vg is 0 V, and the depth of the p-type diffusion layer is 10 μm (full scale in the Z coordinate). In these figures, the value 0.0 in the Z coordinate axis represents the surface of the p-type diffusion layer and the value 10.0 in the Z coordinate axis represents the bottom surface of the p-type diffusion layer (the surface of the silicon substrate). When Fig. 9 and Fig. 10 are compared, the variation in the voltage applied on the substrate somewhat affects the pn junction part C with the substrate, the p-well part B, and the depth W from the surface of the p-well in which electrons are captured (mainly, the degree of decrease in the pn junction part C with the substrate is increased), but a significant difference does not occur. Therefore, in the present invention, the function of the spectroscopic sensor can be carried out by varying Vg while the voltage applied on the substrate is constant, thereby varying the depth W from the surface of the diffusion layer in which electrons are captured.

[0039] Figs. 11 and 12 show (photographs of) spectroscopic sensors having this structure, which have been actually produced. Fig. 11 shows a plan view of a unit of the spectroscopic sensor and Fig. 12 shows a plan view of the overall spectroscopic sensors (4 × 4).

[0040] Table 1 shows a measurement result in the device actually produced according to the present invention using two types of light-emitting diodes (blue and red) whose wavelengths are actually known.

[Table 1]

	Blue (λ = 470 nm)	Red (λ = 640 nm)	Signal ratio (blue/red)
Intensity of incident light [μW/cm^2]	271	861	0.315
Detection result [μW/cm^2]	222	712	0.312

[0041] As is apparent from Table 1, although the absolute values of intensity of light are shifted from those that were actually incident, the ratios of the signals were the same. When optical reflection is considered, the detection can be accurately performed.

[Example of measuring method]

[0042] When three types of incident light are incident, the measurement is performed as follows:

(1) For example, a gate voltage of 1 V is applied to the polycrystalline silicon film 7 transmitting incident light and being doped with an impurity being applied with the gate voltage. The current flowing at the time is read.
(2) Subsequently, a gate voltage of 2 V is applied to the polycrystalline silicon film 7 and the current flowing at the time is read.
(3) Subsequently, a gate voltage of 5 V is applied to the polycrystalline silicon film 7 and the current flowing at the time is read.
(4) The intensities in each wavelength of the incident light are calculated by the above equations on the basis of the resulting current values.

[0043] As described above, hitherto, a mechanical instrument such as a grating is necessary to separate the wavelength of light. In contrast, according to the spectroscopic sensor of the present invention, wavelengths of incident light can be plotted with a resolution of 100 by performing the measurement while the depth (position) for capturing electrons in the diffusion layer is varied a plurality of times (e.g., 100 times). Thus, the light can be divided into wavelengths and a grating or the like is not required.

[0044] Furthermore, the present invention can be used for the following applications.

[Example 1] Color image sensor without color filter

[0045] Fig. 13 is a block diagram of a color image sensor system without a color filter, according to an application of the present invention.

[0046] In the figure, reference numeral 11 indicates a spectroscopic sensor array, reference numeral 12 indicates a vertical selector (v. scanner), reference numeral 13 indicates a noise-eliminating circuit (column CDS), reference numeral 14 indicates a horizontal selector (h. scanner), Vsig1 indicates an optical signal output 1, Vsig2 indicates an optical signal output 2, Vsig3 indicates an optical signal output 3, and V_{bN} and V_{bP} indicate biases for low current driving.

[0047] Thus, the spectroscopic sensors of the present invention are arrayed one-dimensionally or two-dimensionally and the spectroscopic sensor array 11 is switched with a shift register formed therewith to read signals. In order to suppress noise during each switching, the noise-eliminating circuit 13 is also mounted on an output part of the signals. For example, the depth (position) for capturing electrons is varied every 1/180 seconds and signals at each time are measured. The intensities of wavelengths of red, green, and blue are calculated from the signals to output color image signals.

[Example 2] Fluorescent sensor

[0048] Bio-reactions generally utilize fluorescent reactions. In general, fluorescence is generated by irradiating light (excitation light) having a short wavelength and the resulting fluorescence is observed. A band pass filter that does not transmit the excitation light but transmits only the fluorescence is used in general image sensors because the fluorescence is hidden by the excitation light. Consequently, the instrument has large dimensions.

[0049] Use of the spectroscopic sensor of the present invention allows only fluorescence excluding excitation light to be measured without using a band pass filter.

[0050] As described in detail, the present invention can provide the following advantages.

(A) A method for measuring incident light employing a simple semiconductor structure provided with a single electron-capturing section corresponding to incident light, and a spectroscopic sensor employing the same are provided.

(B) A color image sensor without a color filter can be provided as an application of the spectroscopic sensor.

Industrial Applicability

[0051] A method for measuring incident light according to the present invention and a sensor having a spectroscopic mechanism employing the same can be used as a spectroscopic sensor and a color image sensor without a color filter, which is an application of the spectroscopic sensor.

Claims

1. A method for measuring incident light employing a semiconductor structure comprising:

   a first diffusion layer (2) provided in a semiconductor substrate (1) at the surface of the substrate (1), for capturing electrons generated by the incident light, the first diffusion layer (2) being disposed under an electrode film (7) provided on the first diffusion layer (2), with an insulating film (4) provided therebetween, the electrode film (7) transmitting incident light and being applied with a gate voltage
   a second diffusion layer (3) for taking out electrons captured in the first diffusion layer (2) to the outside;
   a first electrode (6) connected to the first diffusion layer (2);
   a second electrode (5) connected to the second diffusion layer (3), the method comprising: selectively varying the gate voltage to vary the depth (W) from the surface of the first diffusion layer (2) at which electrons generated by the incident light are captured;
   measuring a current flowing for each gate voltage, the current indicating the quantity of the electrons captured in the first diffusion layer (2), **characterised by**:

      calculating an intensity of the incident light from the measured value of current flowing, and wherein:

         the second diffusion layer (3) is provided at a part of the first diffusion layer (2); and
         the semiconductor substrate (1) and the second diffusion layer (3) are of a first conductivity type and the first diffusion layer (2) is of a second conductivity type, opposite the first conductivity type.

2. The method for measuring incident light according to claim 1, wherein the number of times the gate voltage is varied is determined by the type of the incident light.

3. The method for measuring incident light according to claim 1 or 2, wherein the depth for capturing electrons is varied every 1/180 seconds.

4. A spectroscopic sensor comprising:

   a semiconductor substrate (1);
   a first diffusion layer (2) provided in the semiconductor substrate (1) at the surface of the substrate (1), for capturing electrons generated by the incident light;
   an electrode film (7) provided on the first diffusion layer (2) with an insulating film (4) provided therebetween, the electrode film (7) being capable of transmitting incident light and operable to be applied with a gate voltage;
   a second diffusion layer (3), for taking out electrons captured in the first diffusion layer (2) to the outside;
   means to selectively vary the gate voltage to vary a depth (W) from the surface of the first diffusion layer (2) at which electrons generated by the incident light are captured;
   means to measure a current flowing for each gate voltage, the current indicating the quantity of the electrons captured in the first diffusion layer (2);
   means for calculating an intensity of the incident light from the measured value of current flowing;
   a first electrode (6) connected to the first diffusion layer (2); and a second electrode (5) connected the second diffusion layer (3), wherein the spectroscopic sensor is **characterised by** the second diffusion layer (3) being provided at a part of the first diffusion layer (2), wherein the semiconductor substrate (1) and the second diffusion layer (3) are of a first conductivity type and the first diffusion layer (2) is of a second conductivity type, opposite the first conductivity type.

5. The spectroscopic sensor according to claim 4, wherein the first diffusion layer (2) comprises a p-type diffusion layer, the second diffusion layer (3) comprises an n^+ diffusion layer and the semiconductor substrate (1) comprises

an n-type semiconductor substrate.

6. The spectroscopic sensor according to claim 4, wherein the electrode film (7) being applied with a gate voltage is a polycrystalline silicon film doped with an impurity.

7. A color image sensor without a color filter comprising a spectroscopic sensor array (11) including spectroscopic sensors according to claim 4, the spectroscopic sensors being disposed one dimensionally or two-dimensionally and the color image sensor further comprising a noise-eliminating circuit (13) provided at an output part of a color image signal of the spectroscopic sensor array (11).

Patentansprüche

1. Verfahren zum Messen von einfallendem Licht unter Verwendung einer Halbleiterstruktur, umfassend:

> eine erste Diffusionsschicht (2), die in einem Halbleitersubstrat (1) an der Oberfläche des Substrats (1) vorgesehen ist, um von dem einfallenden Licht erzeugte Elektronen zu erfassen, wobei die erste Diffusionsschicht (2) unter einer Elektrodendünnschicht (7) angeordnet ist, die auf der ersten Diffusionsschicht (2) vorgesehen ist, wobei eine Isolierdünnschicht (4) zwischen ihnen vorgesehen ist, wobei die Elektrodendünnschicht (7) einfallendes Licht überträgt und eine Gatespannung an sie angelegt wird;
> eine zweite Diffusionsschicht (3) zum Herausnehmen von Elektroden, die in der ersten Diffusionsschicht (2) erfasst sind, nach außen;
> eine erste Elektrode (6), die mit der ersten Diffusionsschicht (2) verbunden ist;
> eine zweite Elektrode (5), die mit der zweiten Diffusionsschicht (3) verbunden ist, wobei das Verfahren umfasst:
> wahlweises Variieren der Gatespannung, um die Tiefe (W) von der Oberfläche der ersten Diffusionsschicht (2), an welcher von dem einfallenden Licht erzeugte Elektronen erfasst werden, zu variieren;
> Messen eines Stroms, der für jede Gatespannung fließt, wobei der Strom die Menge der Elektronen angibt, die in der ersten Diffusionsschicht (2) erfasst sind, **gekennzeichnet durch**:
>
>> Berechnen einer Stärke des einfallenden Lichts aus dem gemessenen Wert von fließendem Strom, und wobei:
>>
>>> die zweite Diffusionsschicht (3) an einem Teil der ersten Diffusionsschicht (2) vorgesehen ist; und
>>> das Halbleitersubstrat (1) und die zweite Diffusionsschicht (3) von einem ersten Leitfähigkeitstyp sind und die erste Diffusionsschicht (2) von einem zweiten Leitfähigkeitstyp ist, der dem ersten Leitfähigkeitstyp entgegengesetzt ist.

2. Verfahren zum Messen von einfallendem Licht nach Anspruch 1, wobei die Anzahl der Male, die die Gatespannung variiert wird, durch den Typ des einfallenden Lichts bestimmt wird.

3. Verfahren zum Messen von einfallendem Licht nach Anspruch 1 oder 2, wobei die Tiefe zum Erfassen von Elektronen alle 1/180 Sekunden variiert wird.

4. Spektroskopischer Sensor, umfassend:

> ein Halbleitersubstrat (1);
> eine erste Diffusionsschicht (2), die in dem Halbleitersubstrat (1) an der Oberfläche des Substrats (1) vorgesehen ist, um von dem einfallenden Licht erzeugte Elektronen zu erfassen;
> eine Elektrodendünnschicht (7), die auf der ersten Diffusionsschicht (2) vorgesehen ist, mit einer Isolierdünnschicht (4), die zwischen ihnen vorgesehen ist, wobei die Elektrodendünnschicht (7) imstande ist, einfallendes Licht zu übertragen und so betriebsfähig ist, dass eine Gatespannung an sie angelegt wird;
> eine zweite Diffusionsschicht (3) zum Herausnehmen von Elektronen, die in der ersten Diffusionsschicht (2) erfasst sind, nach außen;
> eine Einrichtung zum wahlweisen Variieren der Gatespannung, um eine Tiefe (W) von der Oberfläche der ersten Diffusionsschicht (2), an welcher von dem einfallenden Licht erzeugte Elektronen erfasst werden, zu variieren;
> eine Einrichtung zum Messen eines Stroms, der für jede Gatespannung fließt, wobei der Strom die Menge der Elektronen angibt, die in der ersten Diffusionsschicht (2) erfasst sind;
> eine Einrichtung zum Berechnen einer Stärke des einfallenden Lichts aus dem gemessenen Wert von fließendem

Strom;

eine erste Elektrode (6), die mit der ersten Diffusionsschicht (2) verbunden ist; und eine zweite Elektrode (5), die mit der zweiten Diffusionsschicht (3) verbunden ist, wobei der spektroskopische Sensor **dadurch gekennzeichnet ist, dass** die zweite Diffusionsschicht (3) an einem Teil der ersten Diffusionsschicht (2) vorgesehen ist, wobei das Halbleitersubstrat (1) und die zweite Diffusionsschicht (3) von einem ersten Leitfähigkeitstyp sind und die erste Diffusionsschicht (2) von einem zweiten Leitfähigkeitstyp ist, der dem ersten Leitfähigkeitstyp entgegengesetzt ist.

5. Spektroskopischer Sensor nach Anspruch 4, wobei die erste Diffusionsschicht (2) eine p-Typ-Diffusionsschicht umfasst, die zweite Diffusionsschicht (3) n^+-Diffusionsschicht umfasst und das Halbleitersubstrat (1) ein n-Typ-Halbleitersubstrat umfasst.

6. Spektroskopischer Sensor nach Anspruch 4, wobei die Elektrodendünnschicht (7), an die eine Gatespannung angelegt wird, eine mit einem Fremdstoff dotierte polykristalline Siliciumdünnschicht ist.

7. Farbbildsensor ohne einen Farbfilter, umfassend eine spektroskopische Sensoranordnung (11), die spektroskopische Sensoren nach Anspruch 4 beinhaltet, wobei die spektroskopischen Sensoren eindimensional oder zweidimensional angeordnet sind und der Farbbildsensor ferner eine Störungsentfernungsschaltung (13) umfasst, die an einem Ausgabeteil eines Farbbildsignals der spektroskopischen Sensoranordnung (11) vorgesehen ist.

Revendications

1. Procédé de mesure d’une lumière incidente employant une structure à semiconducteurs, comprenant :

une première couche de diffusion (2) placée sur un substrat semiconducteur (1) à la surface du substrat (1) afin de capturer les électrons générés par la lumière incidente, la première couche de diffusion (2) étant disposée sous un film d’électrode (7) placé sur la première couche de diffusion (2), avec un film isolant (4) placé entre eux, le film d’électrode (7) transmettant la lumière incidente et étant appliqué avec une tension de grille ;
une deuxième couche de diffusion (3) pour extraire vers l’extérieur les électrons capturés dans la première couche de diffusion (2) ;
une première électrode (6) connectée à la première couche de diffusion (2) ;
une deuxième électrode (5) connectée à la deuxième couche de diffusion (3), le procédé comprenant les étapes consistant à : faire varier de manière sélective la tension de grille afin de faire varier la profondeur (W) par rapport à la surface de la première couche de diffusion (2) à laquelle les électrons générés par la lumière incidente sont capturés ;
mesurer un courant en circulation pour chaque tension de grille, le courant indiquant la quantité d’électrons capturés dans la première couche de diffusion (2), **caractérisé par** l’étape consistant à :

calculer une intensité de la lumière incidente à partir de la valeur mesurée du courant en circulation, et dans lequel :

la deuxième couche de diffusion (3) est placée au niveau d’une partie de la première couche de diffusion (2) ; et
le substrat semiconducteur (1) et la deuxième couche de diffusion (3) sont d’un premier type de conductivité, et la première couche de diffusion (2) est d’un deuxième type de conductivité, opposé au premier type de conductivité.

2. Procédé de mesure d’une lumière incidente selon la revendication 1, dans lequel le nom de fois que la tension de grille est variée est déterminé par le type de la lumière incidente.

3. Procédé de mesure d’une lumière incidente selon la revendication 1 ou 2, dans lequel la profondeur de capture des électrons est variée toutes les 1/180 secondes.

4. Capteur spectroscopique comprenant :

un substrat semiconducteur (1) ;
une première couche de diffusion (2) placée sur le substrat semiconducteur (1) à la surface du substrat (1) afin

de capturer les électrons générés par la lumière incidente ;
un film d'électrode (7) placé sur la première couche de diffusion (2) avec un film isolant (4) placé entre eux, le film d'électrode (7) étant capable de transmettre la lumière incidente et étant en mesure de fonctionner pour être appliqué avec une tension de grille ;
une deuxième couche de diffusion (3) pour extraire vers l'extérieur les électrons capturés dans la première couche de diffusion (2) ;
un moyen de faire varier de manière sélective la tension de grille afin de faire varier la profondeur (W) par rapport à la surface de la première couche de diffusion (2) à laquelle les électrons générés par la lumière incidente sont capturés ;
un moyen de mesurer un courant en circulation pour chaque tension de grille, le courant indiquant la quantité d'électrons capturés dans la première couche de diffusion (2) ;
un moyen de calculer une intensité de la lumière incidente à partir de la valeur mesurée du courant en circulation ;
une première électrode (6) connectée à la première couche de diffusion (2) ;

et une deuxième électrode (5) connectée à la deuxième couche de diffusion (3), le capteur spectroscopique étant **caractérisé en ce que** la deuxième couche de diffusion (3) est placée au niveau d'une partie de la première couche de diffusion (2), dans lequel le substrat semiconducteur (1) et la deuxième couche de diffusion (3) sont d'un premier type de conductivité, et la première couche de diffusion (2) est d'un deuxième type de conductivité, opposé au premier type de conductivité.

5. Capteur spectroscopique selon la revendication 4, dans lequel la première couche de diffusion (2) comprend une couche de diffusion de type p, la deuxième couche de diffusion (3) comprend une couche de diffusion n+, et le substrat semiconducteur (1) comprend un substrat semiconducteur de type n.

6. Capteur spectroscopique selon la revendication 4, dans lequel le film d'électrode (7) étant appliqué avec une tension de grille est un film de silicium polycristallin dopé avec une impureté.

7. Capteur d'image en couleur sans filtre de couleur comprenant une matrice de capteurs spectroscopiques (11) comportant des capteurs spectroscopiques selon la revendication 4, les capteurs spectroscopiques étant disposés dans une dimension ou dans deux dimensions, et le capteur d'image en couleur comprenant en outre un circuit d'élimination du bruit (13) placé au niveau d'une partie de sortie d'un signal d'image en couleur d'une matrice de capteurs spectroscopiques (11).

FIG. 1

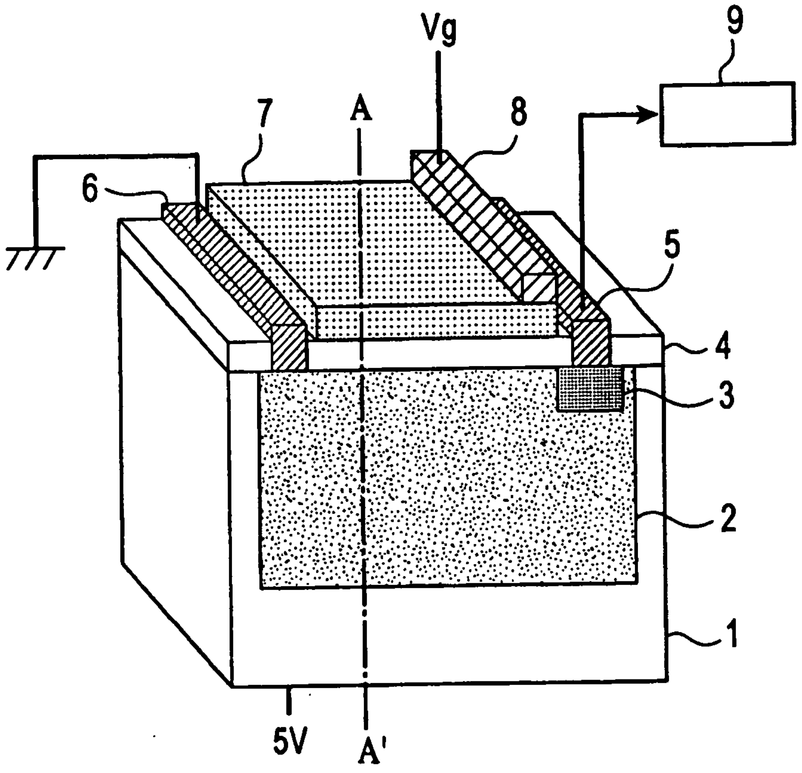


FIG. 2

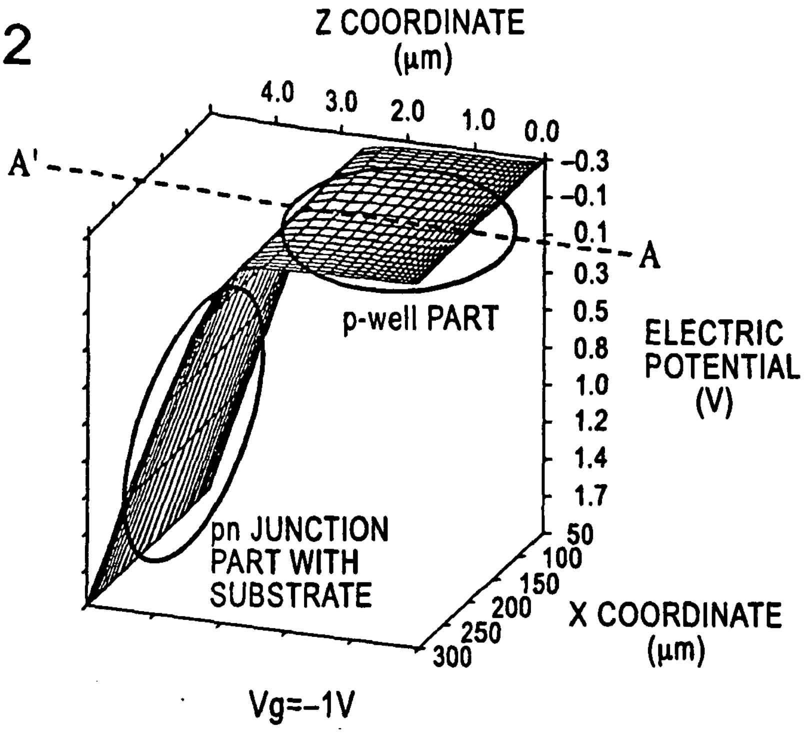

Z COORDINATE
(μm)
4.0
3.0
2.0
1.0
0.0
A'
A
-0.3
-0.1
0.1
0.3
0.5
0.8
1.0
1.2
1.4
1.7
ELECTRIC
POTENTIAL
(V)
p-well PART
pn JUNCTION
PART WITH
SUBSTRATE
50
100
150
200
250
300
X COORDINATE
(μm)
Vg=-1V

FIG. 3

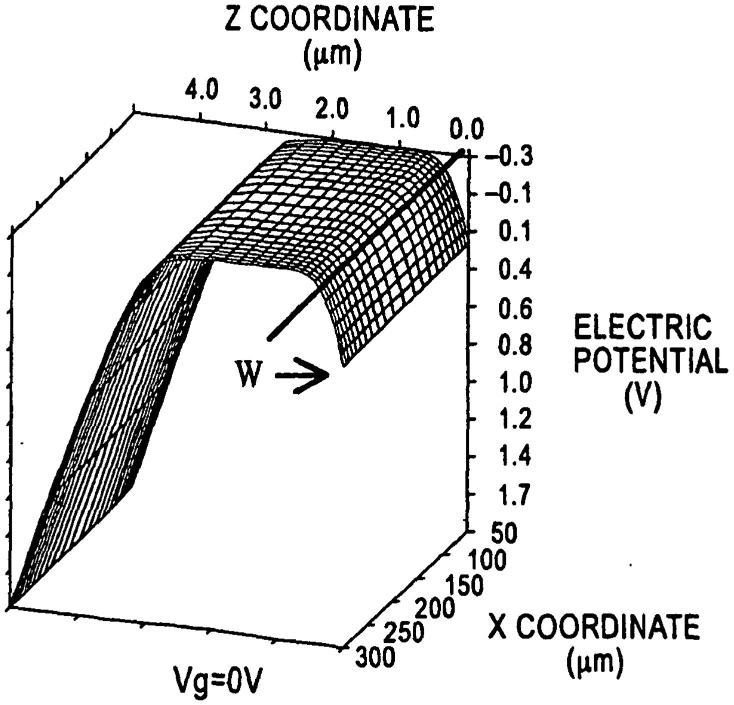

Z COORDINATE
(μm)
4.0
3.0
2.0
1.0
0.0
-0.3
-0.1
0.1
0.4
0.6
0.8
1.0
1.2
1.4
1.7
ELECTRIC
POTENTIAL
(V)
W
50
100
150
200
250
300
X COORDINATE
(μm)
Vg=0V

FIG. 4

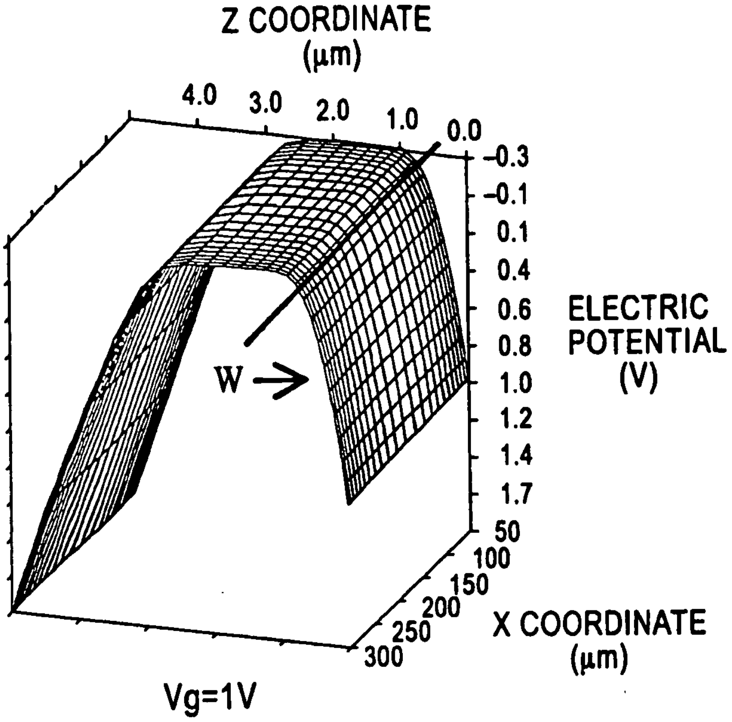

Z COORDINATE
(μm)
4.0
3.0
2.0
1.0
0.0
-0.3
-0.1
0.1
0.4
0.6
0.8
1.0
1.2
1.4
1.7
ELECTRIC
POTENTIAL
(V)
W
50
100
150
200
250
300
X COORDINATE
(μm)
Vg=1V

FIG. 5

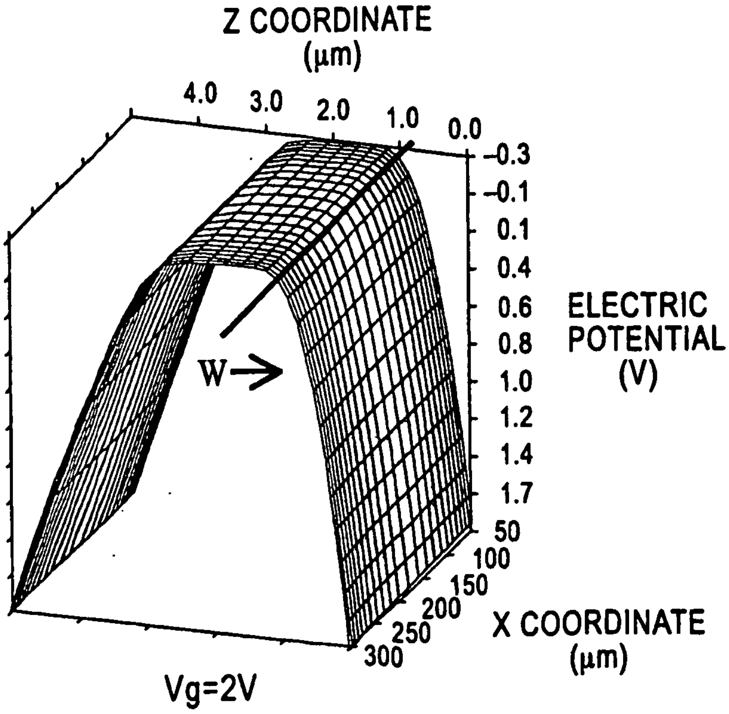
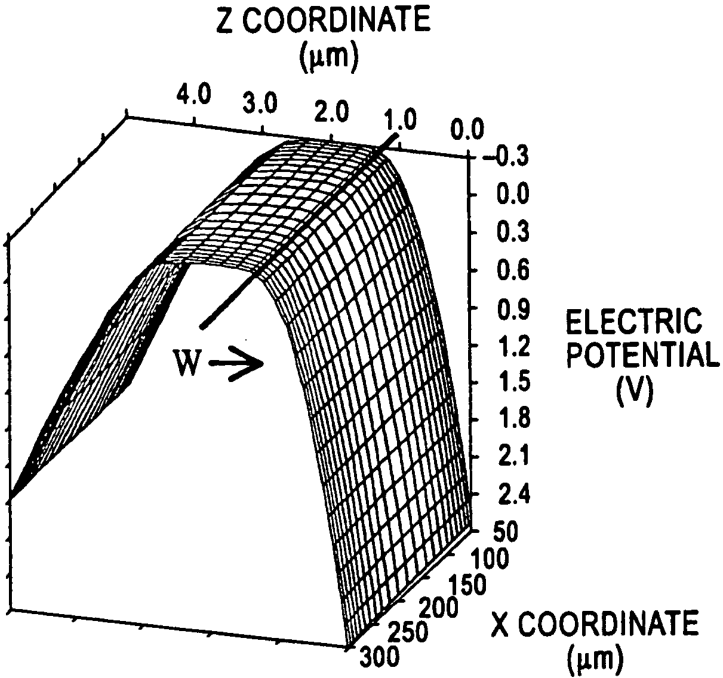
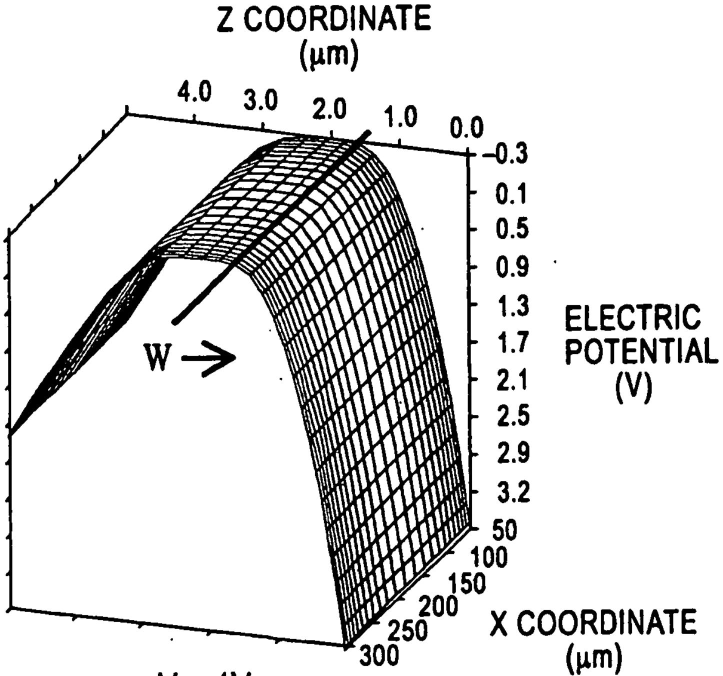

Z COORDINATE
(μm)
4.0
3.0
2.0
1.0
0.0
-0.3
-0.1
0.1
0.4
0.6
0.8
1.0
1.2
1.4
1.7
ELECTRIC
POTENTIAL
(V)
W
50
100
150
200
250
300
X COORDINATE
(μm)
Vg=2V

FIG. 6



Vg=3V

FIG. 7



Vg=4V

FIG. 8

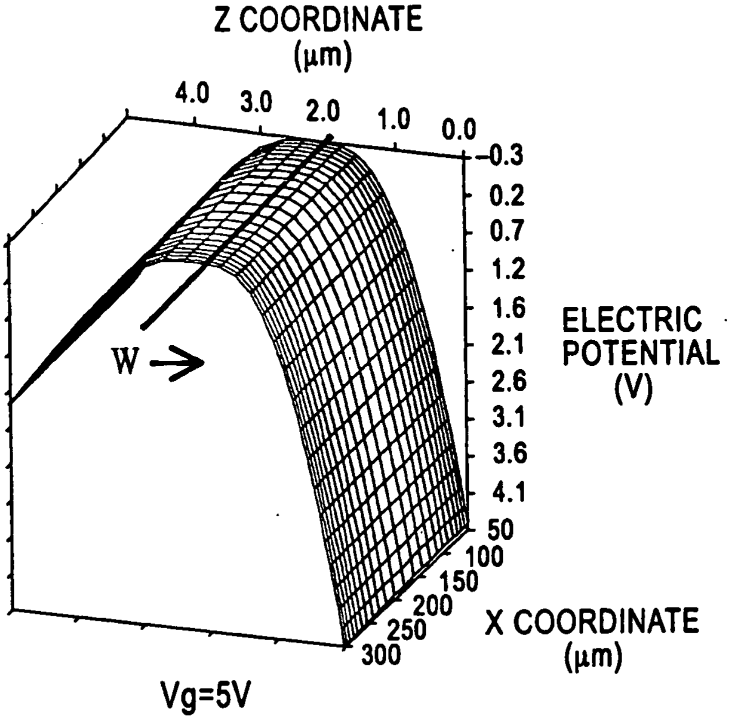

Z COORDINATE
(µm)
4.0
3.0
2.0
1.0
0.0
-0.3
0.2
0.7
1.2
1.6
2.1
2.6
3.1
3.6
4.1
50
100
150
200
250
300
ELECTRIC
POTENTIAL
(V)
W
X COORDINATE
(µm)
Vg=5V

FIG. 9

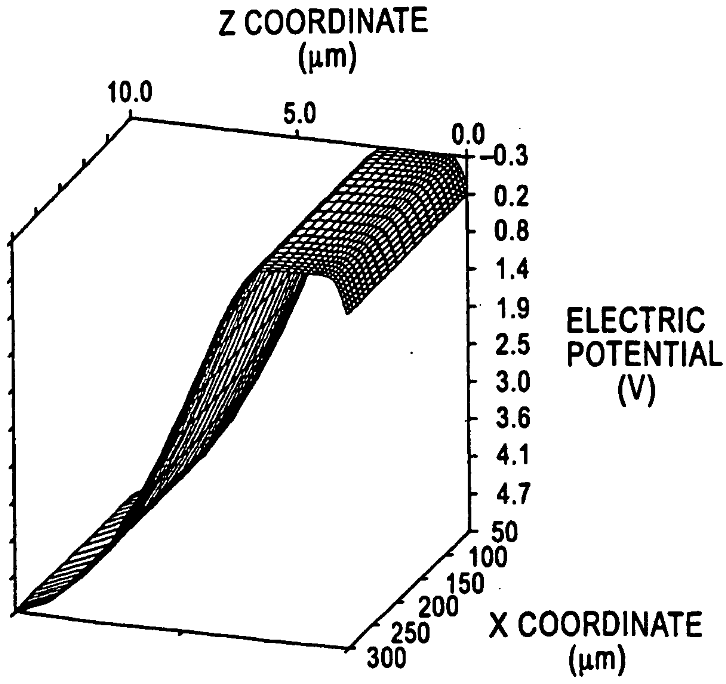

Z COORDINATE
(µm)
10.0
5.0
0.0
-0.3
0.2
0.8
1.4
1.9
2.5
3.0
3.6
4.1
4.7
50
100
150
200
250
300
ELECTRIC
POTENTIAL
(V)
X COORDINATE
(µm)

FIG. 10

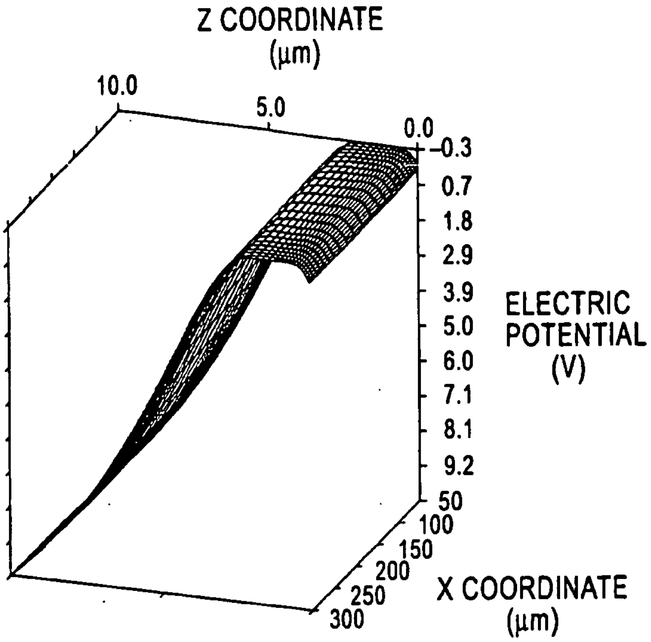

Z COORDINATE
(μm)
10.0
5.0
0.0
-0.3
0.7
1.8
2.9
3.9
5.0
6.0
7.1
8.1
9.2
ELECTRIC
POTENTIAL
(V)
50
100
150
200
250
300
X COORDINATE
(μm)

FIG. 11

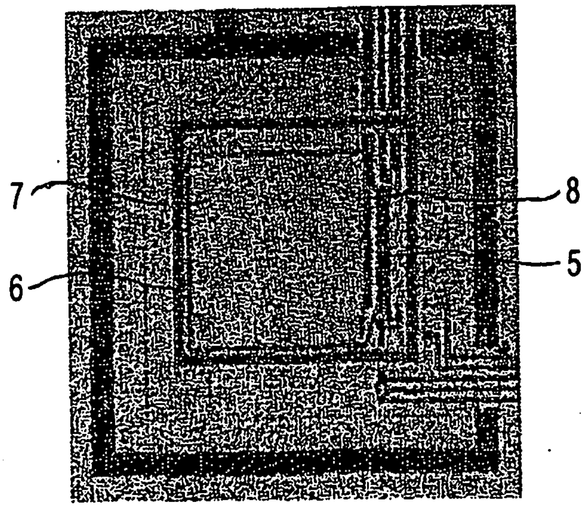

7
6
8
5

FIG. 12

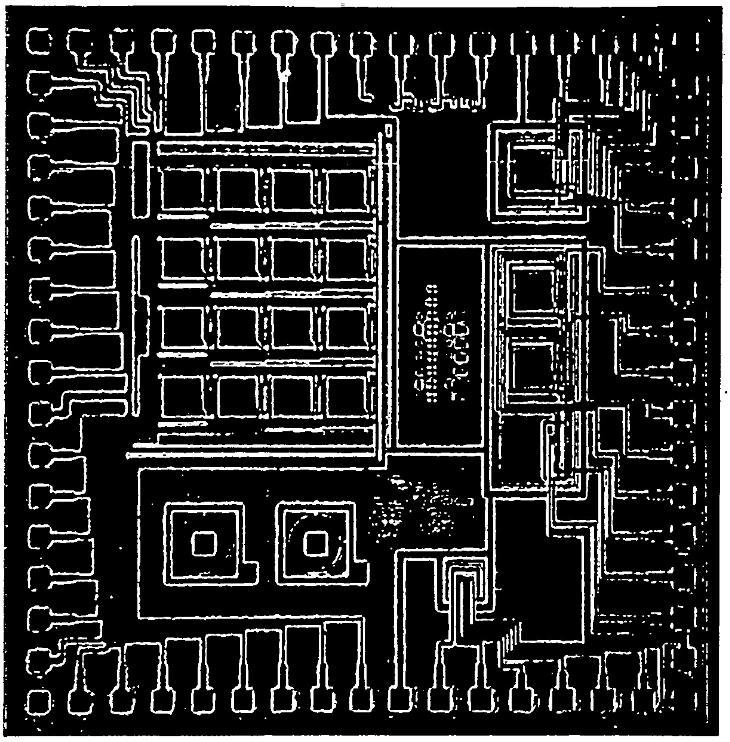
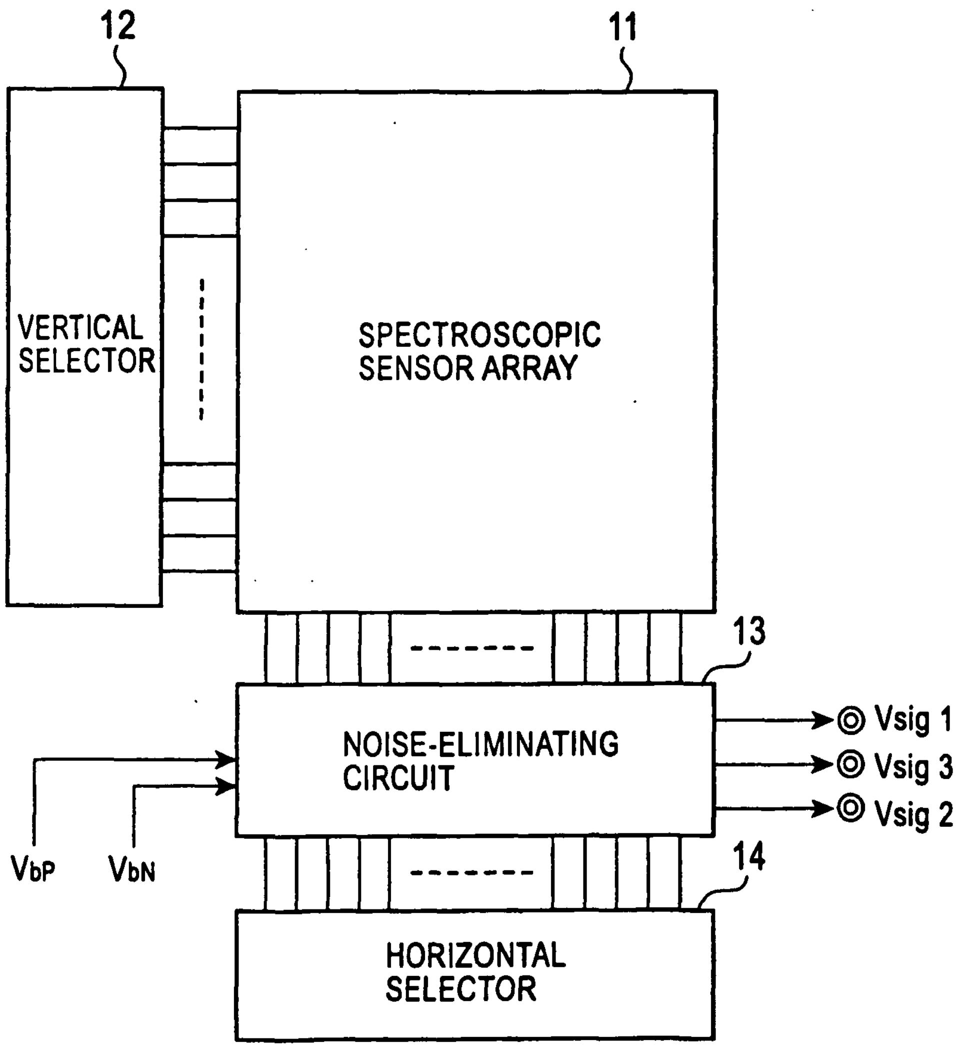


FIG. 13


12
11
VERTICAL SELECTOR
SPECTROSCOPIC SENSOR ARRAY
13
NOISE-ELIMINATING CIRCUIT
Vsig 1
Vsig 3
Vsig 2
VbP
VbN
14
HORIZONTAL SELECTOR

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 5965875 A **[0005] [0009]**
- US 3459944 A **[0011]**
- US 4057819 A **[0012]**