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(12) United States Patent

Hirano

(10) **Patent No.: US 6,222,600 B1**

(45) **Date of Patent: Apr. 24, 2001**

(54) **REFLECTIVE LIQUID CRYSTAL DISPLAY APPARATUS WITH LOW MANUFACTURING COST**

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(73) Assignee: **NEC Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/626,890**

(22) Filed: **Jul. 27, 2000**

Related U.S. Application Data

(62) Division of application No. 08/906,256, filed on Aug. 5, 1997.

(30) **Foreign Application Priority Data**

Aug. 5, 1996 (JP) 8-205712

(51) **Int. Cl.**^{7} **G02F 1/1335**

(52) **U.S. Cl.** **349/113**; 340/47

(58) **Field of Search** 349/47, 113

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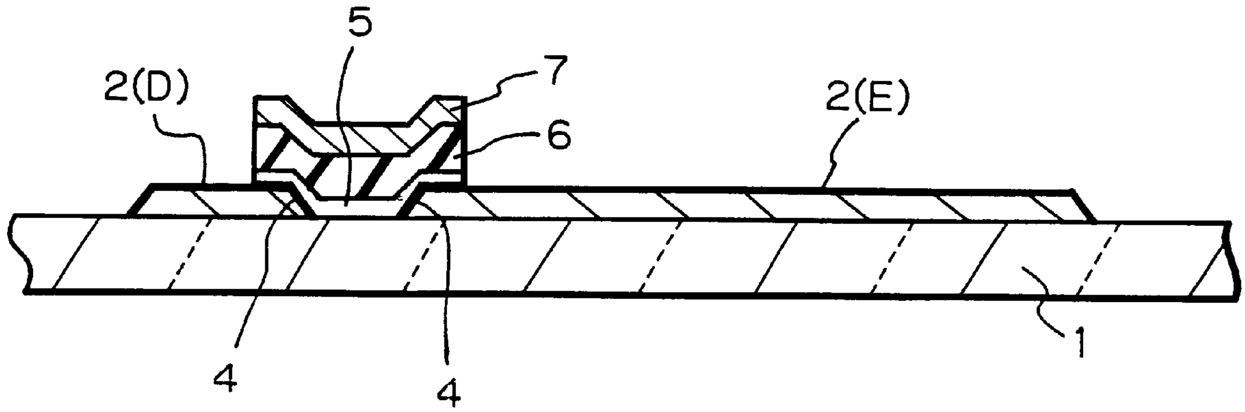
Primary Examiner—James A. Dudek

(74) *Attorney, Agent, or Firm*—Sughrue, Mion, Zinn, Macpeak & Seas, PLLC

(57) **ABSTRACT**

In a reflective liquid crystal apparatus, a drain electrode and a source electrode are formed on a insulating substrate and are formed by an aluminum alloy layer. The source electrode serves as a light reflecting pixel electrode. Also, a non-doped semiconductor layer is formed on a part of the drain electrode and a part of the source electrode, and impurity-doped semiconductor layers are formed between the drain and source electrodes and the non-doped semiconductor layer. Further, a gate electrode is formed via a gate insulating layer on the non-doped semiconductor layer. Additionally, a counter common electrode is formed on a transparent insulating substrate, and a liquid crystal layer is interposed between the insulating substrate and the transparent insulating substrate.

19 Claims, 51 Drawing Sheets



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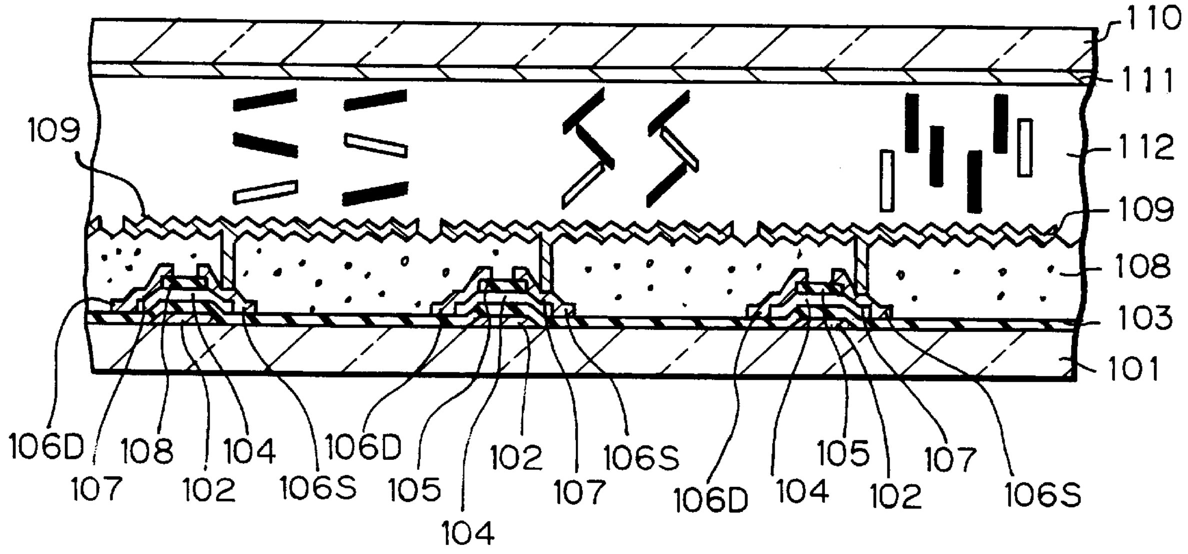

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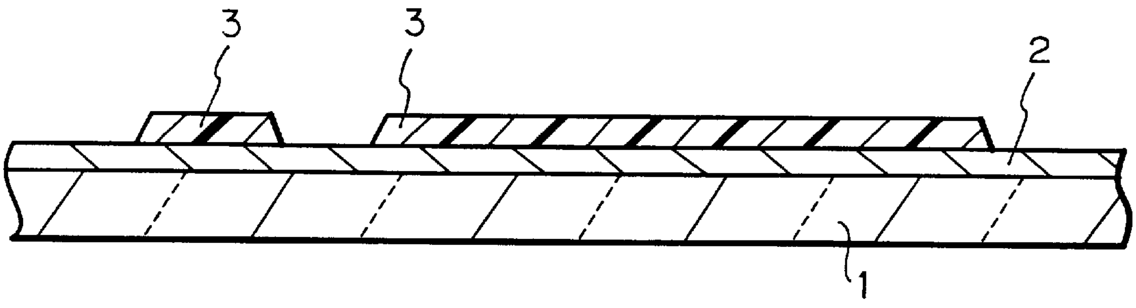

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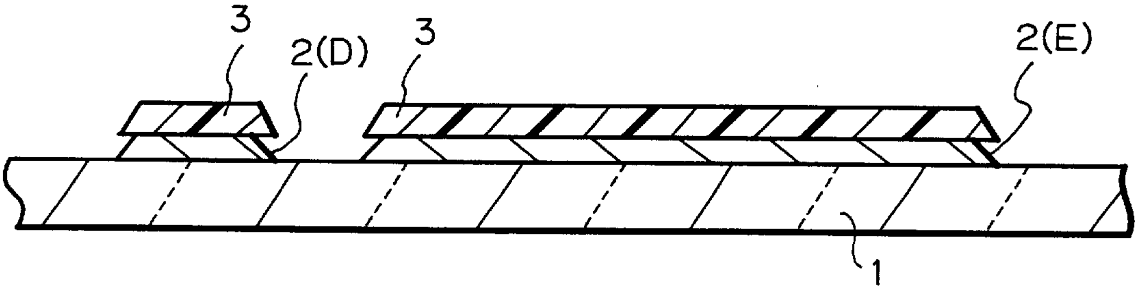
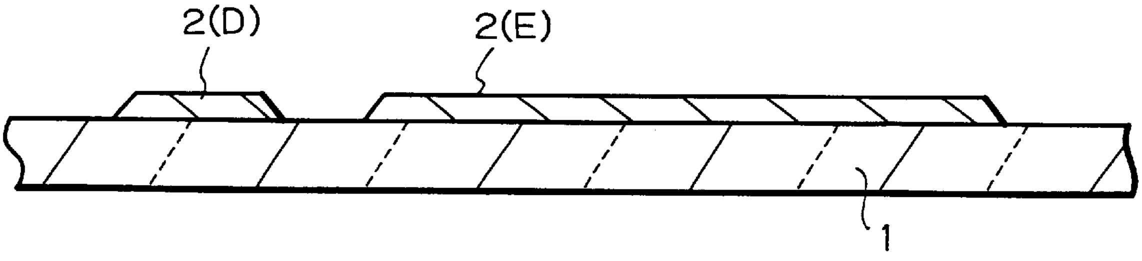


Fig. 2C



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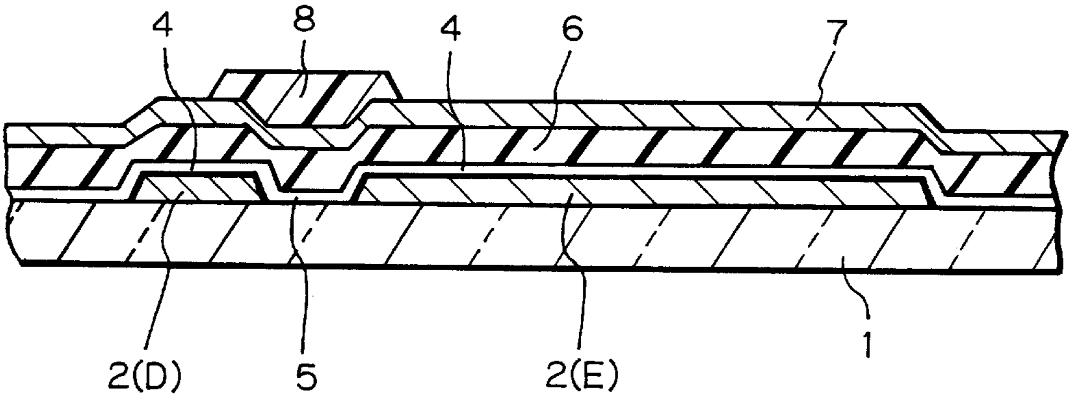

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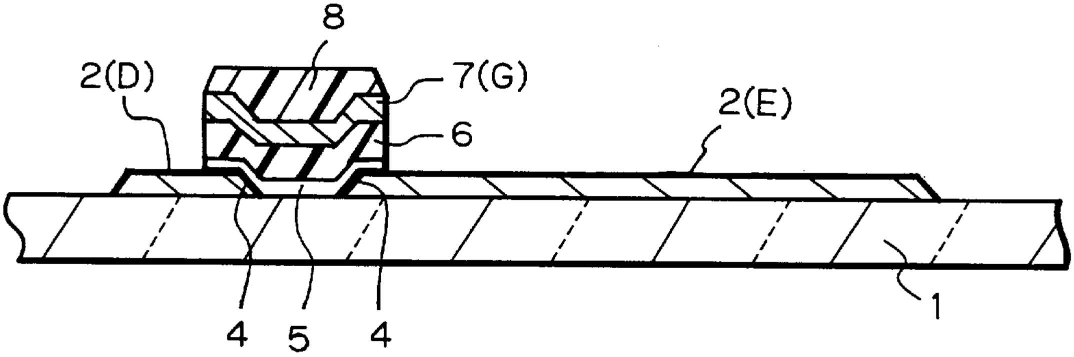

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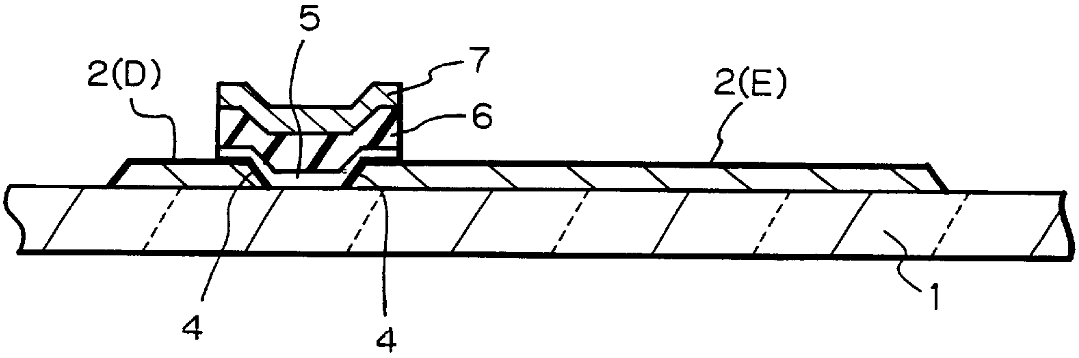

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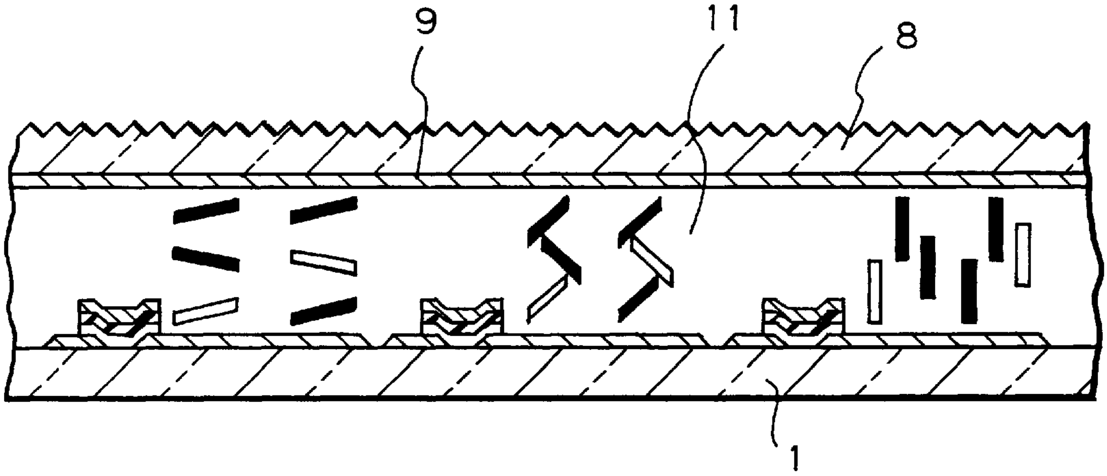

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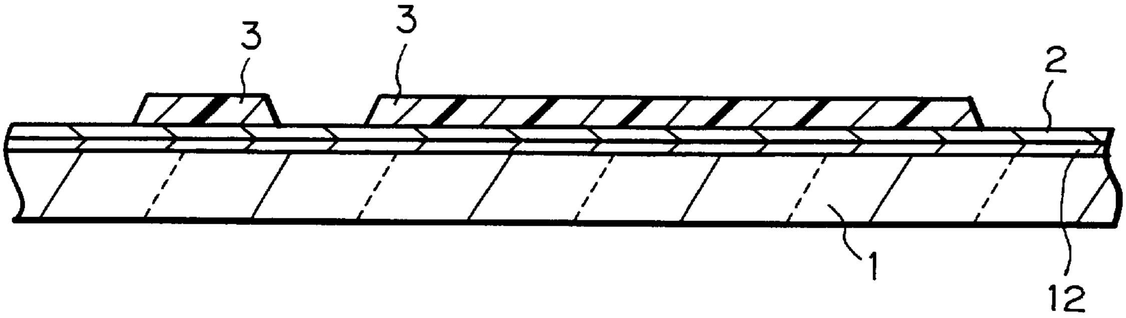

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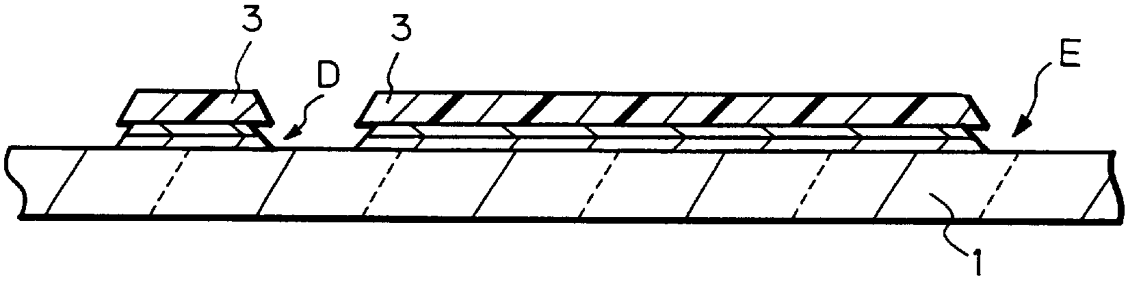

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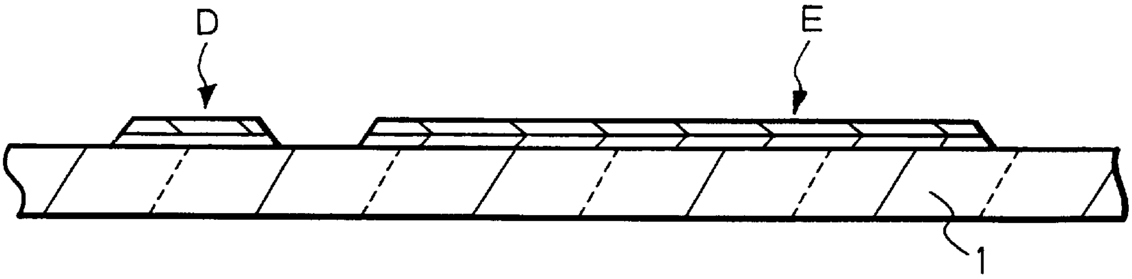

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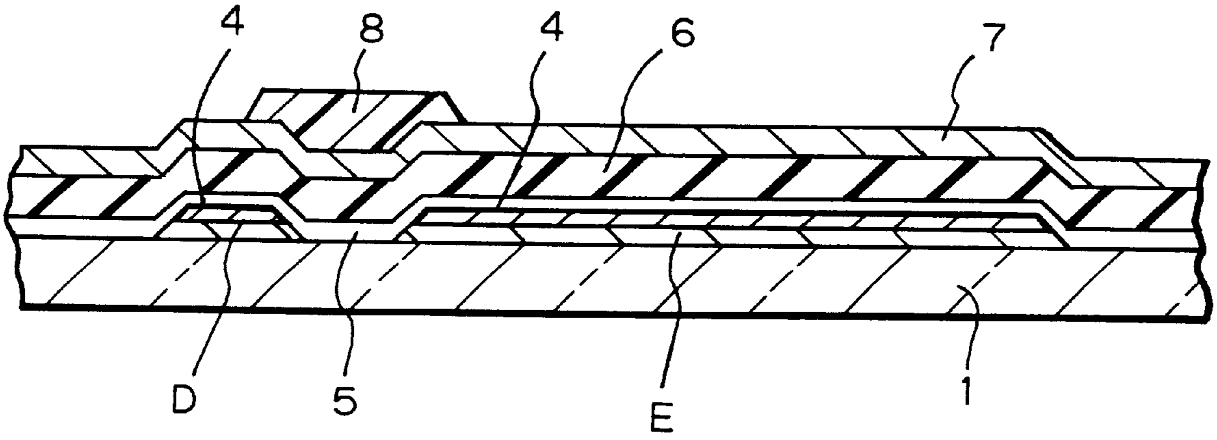

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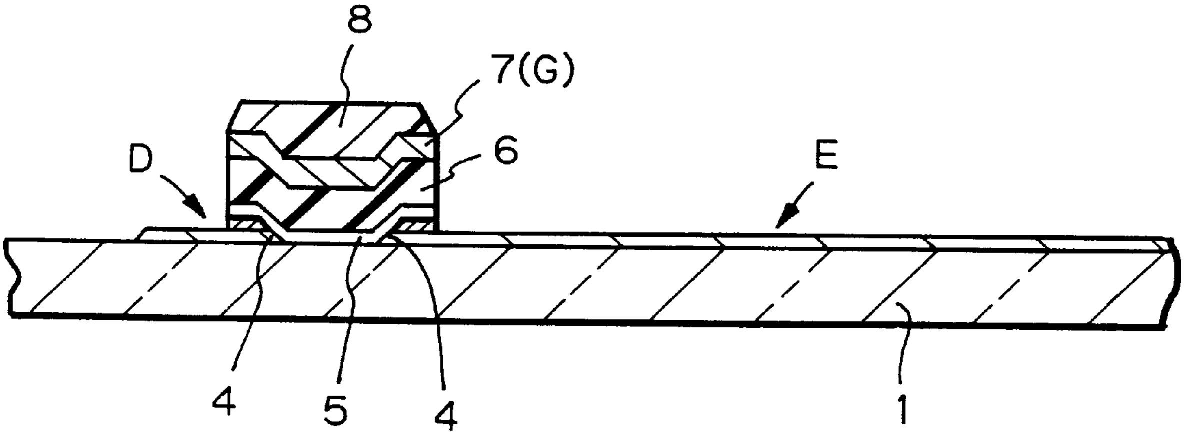

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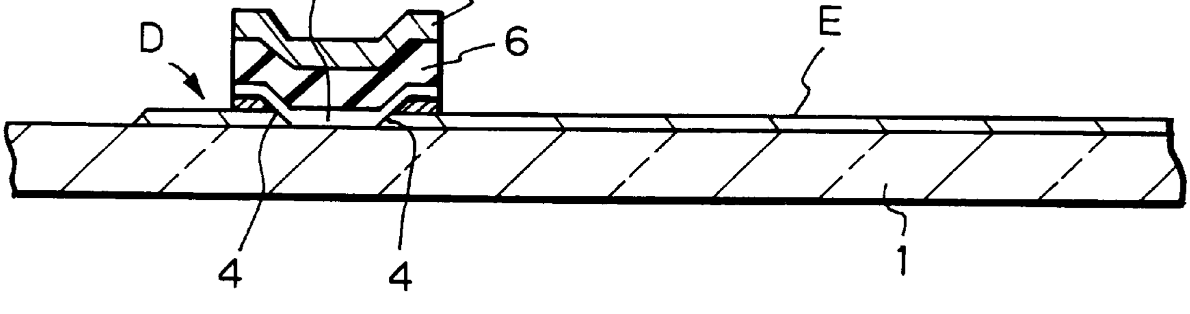

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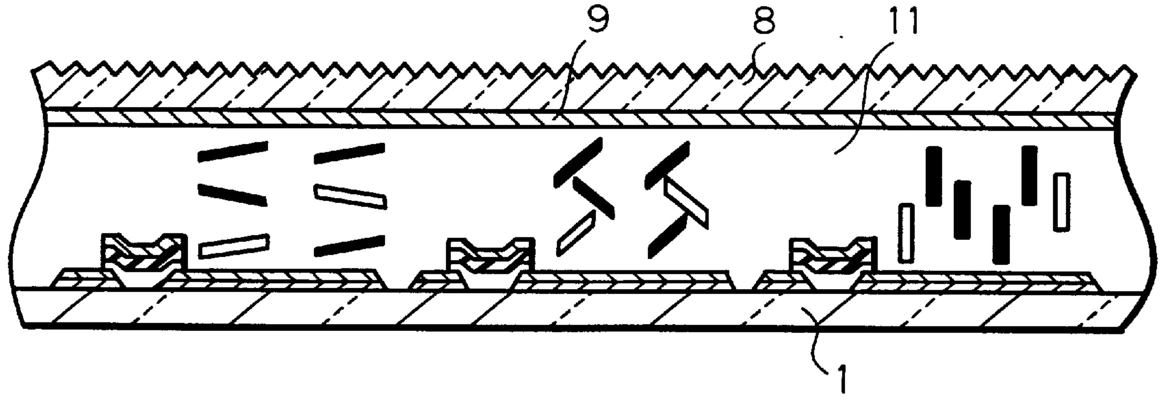

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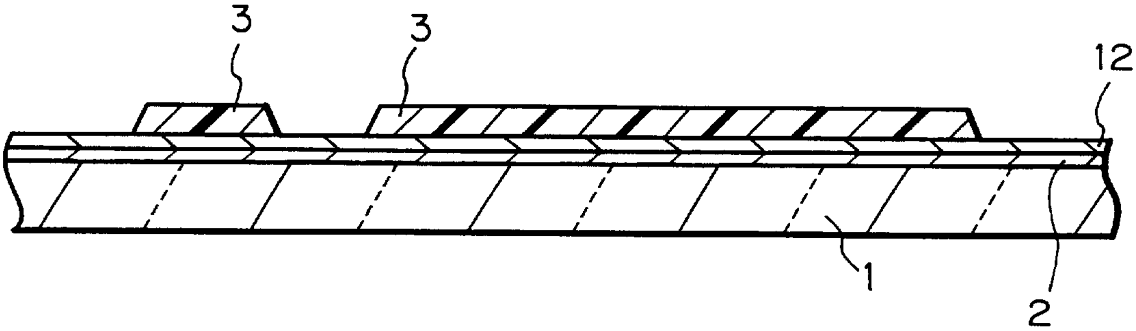

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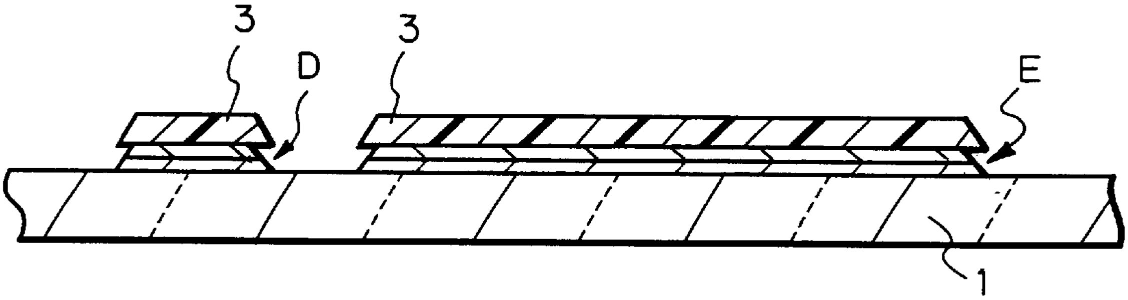

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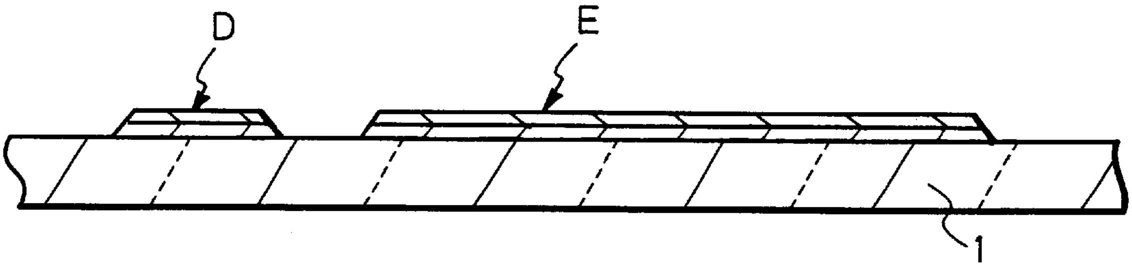

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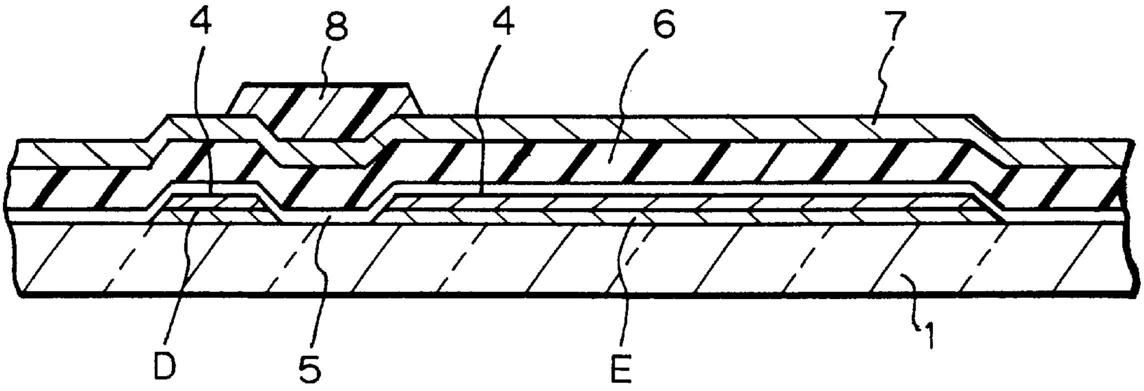

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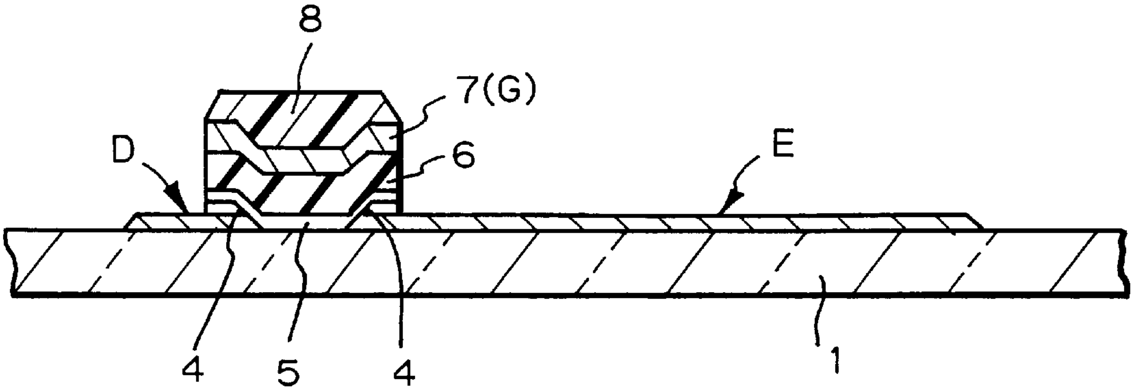

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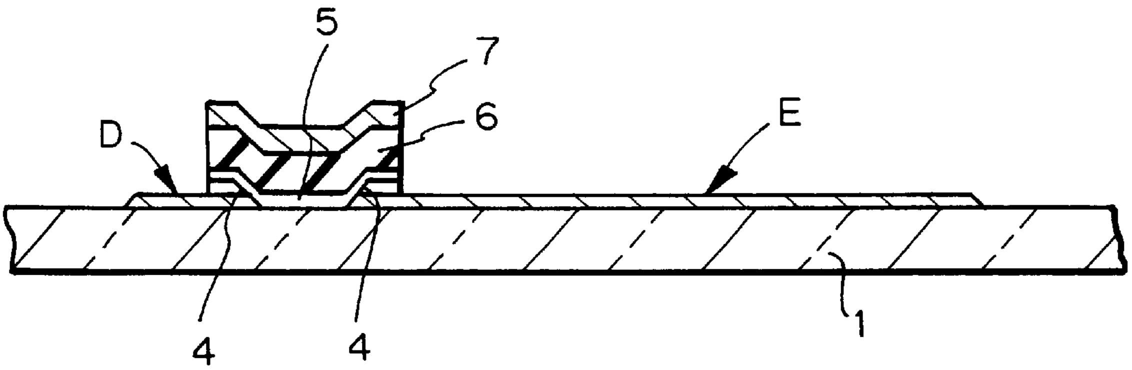

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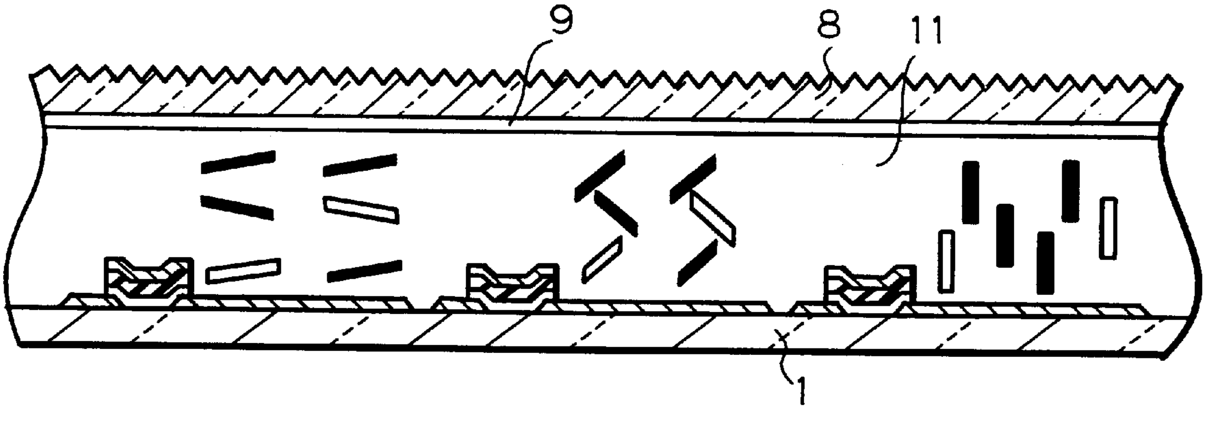

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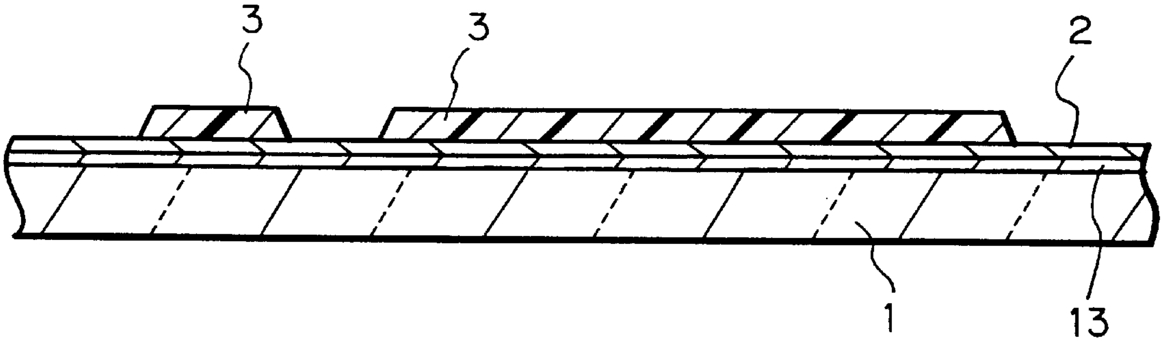

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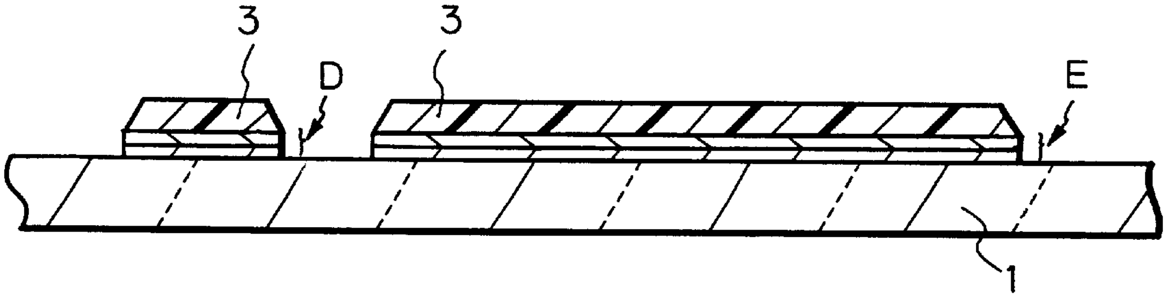

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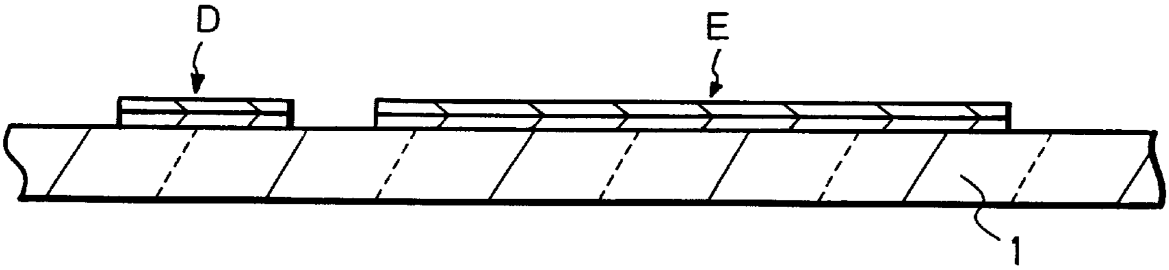

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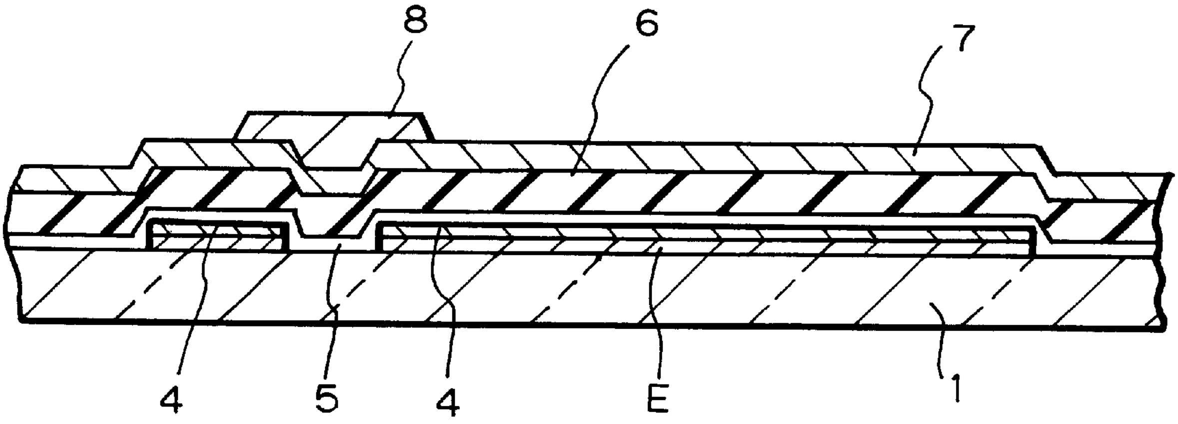

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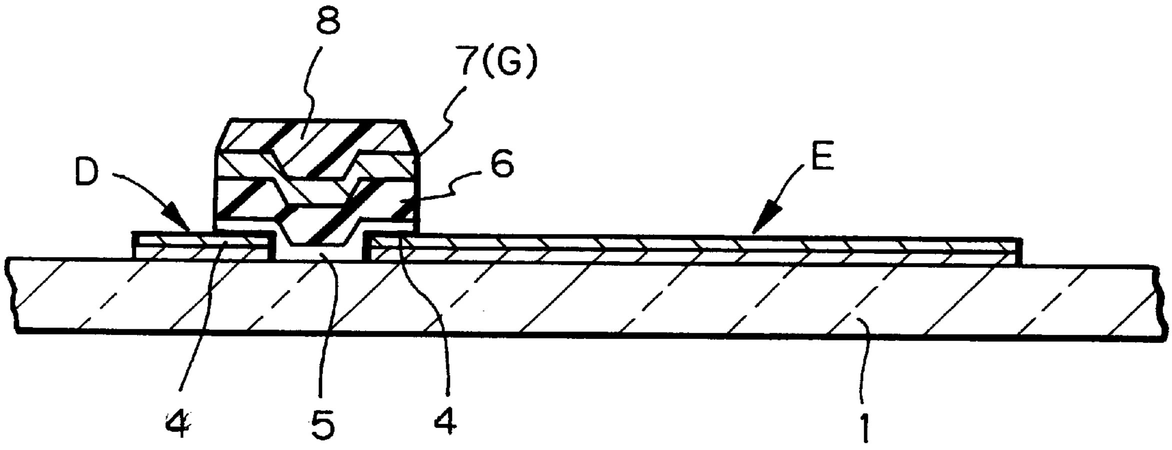

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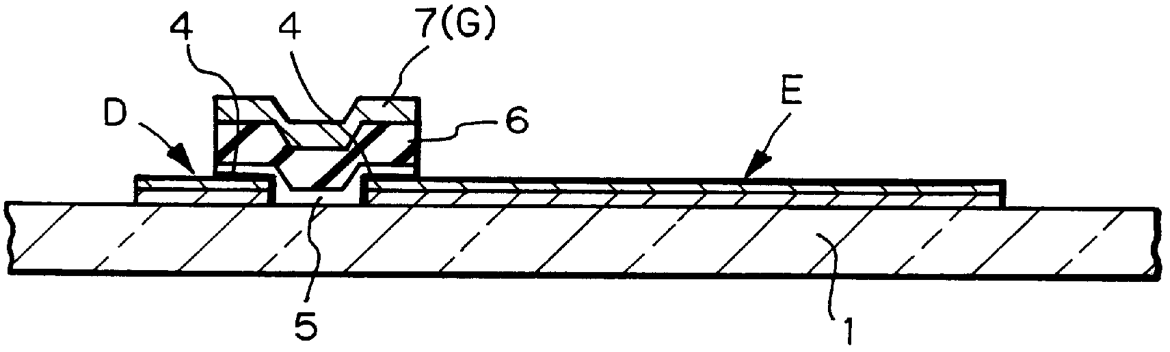

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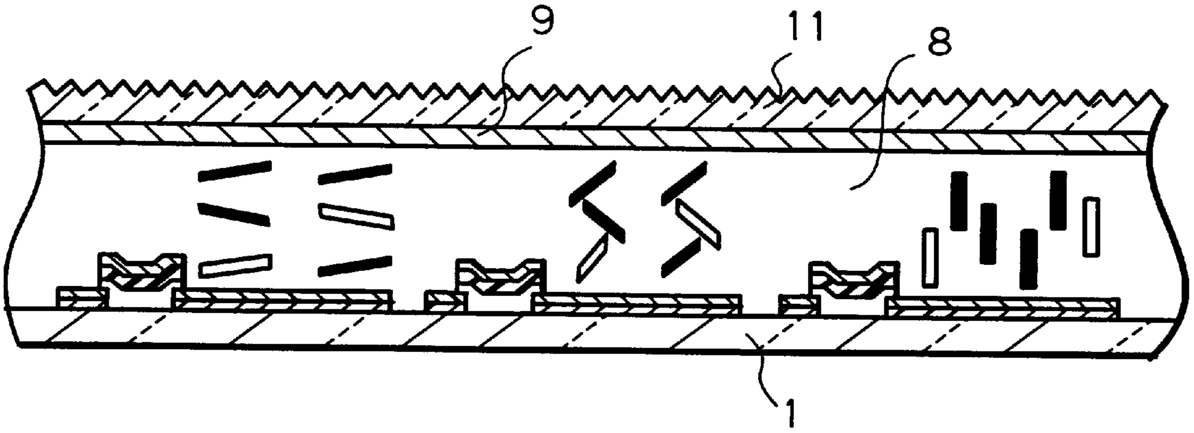

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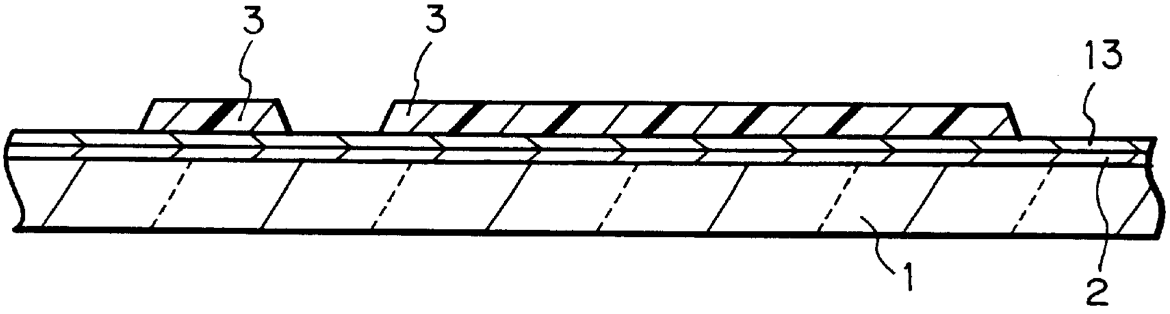

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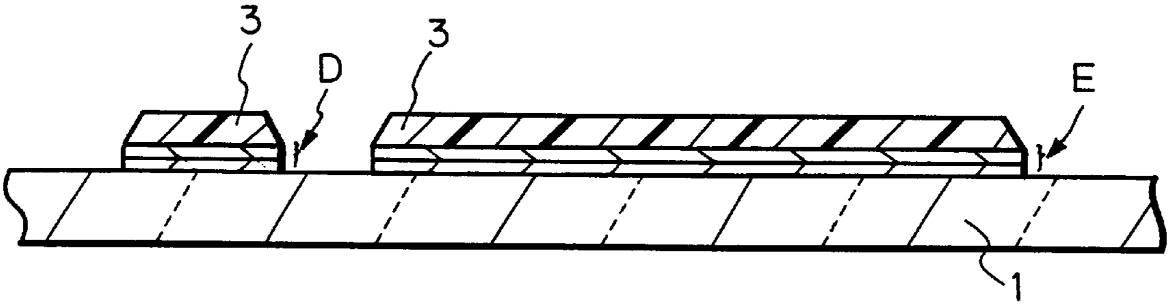

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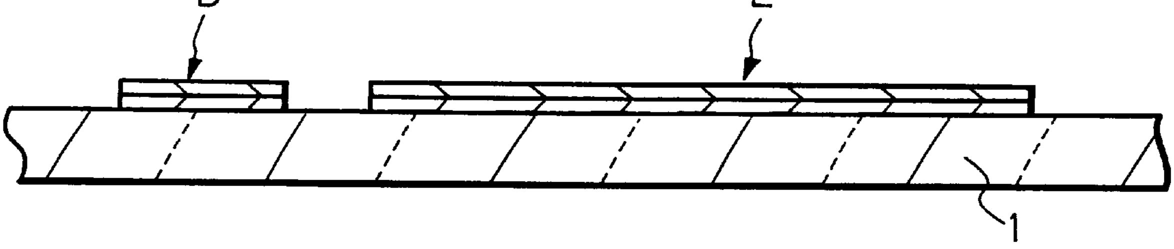

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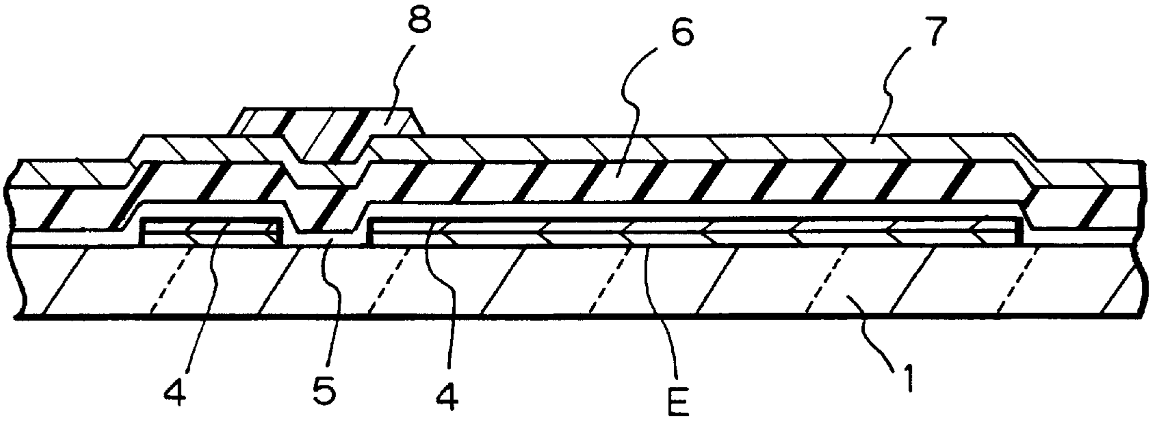

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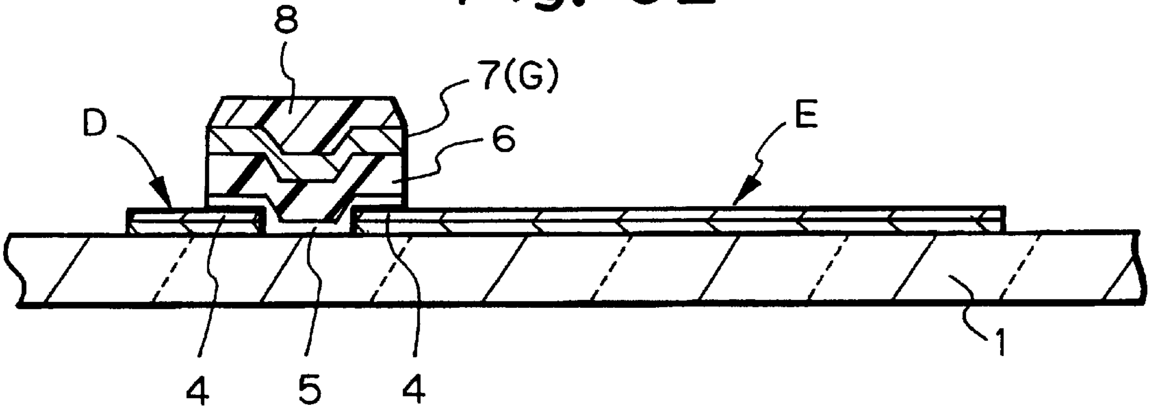

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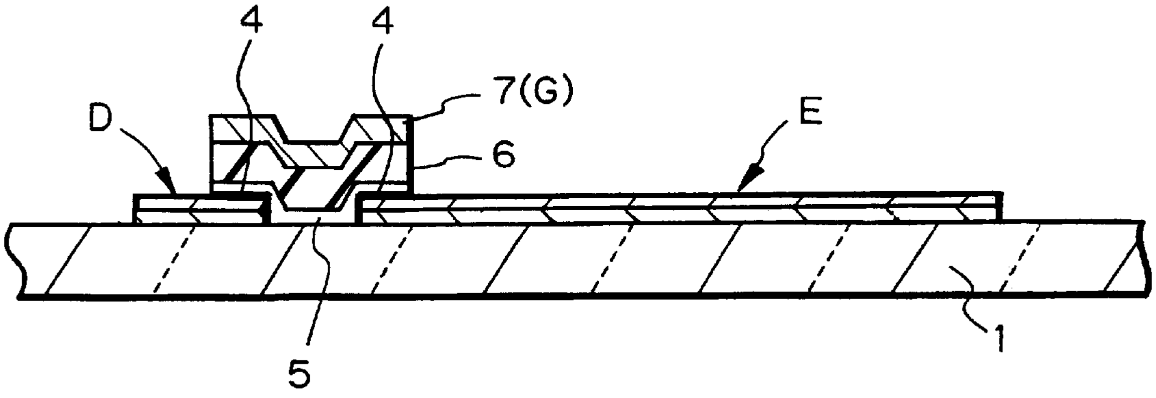

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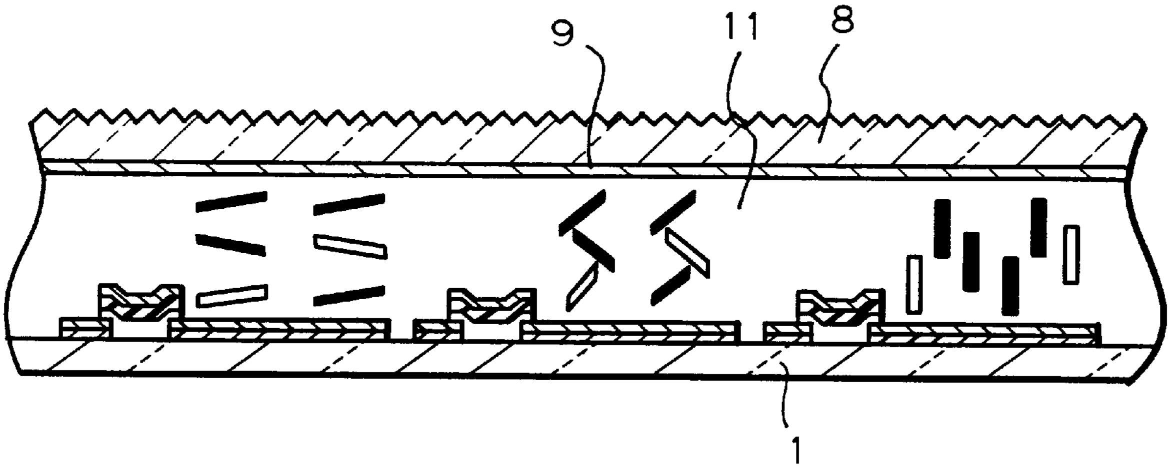

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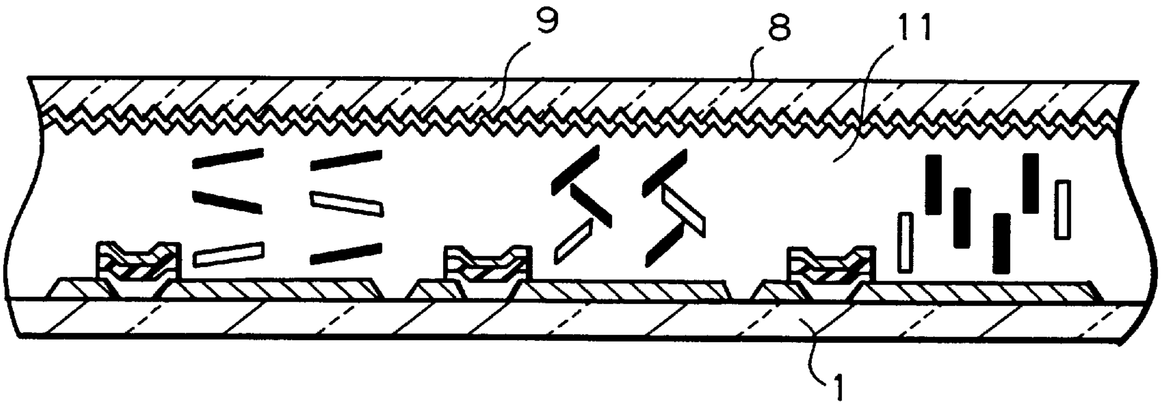

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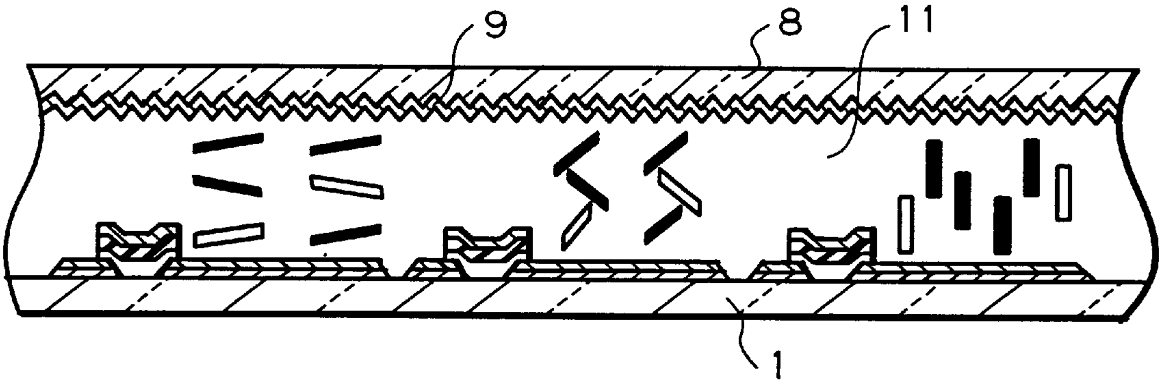

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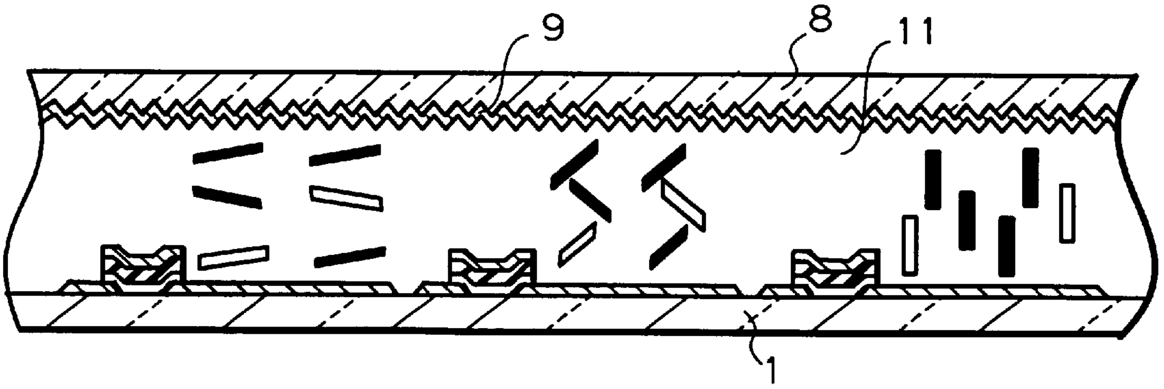

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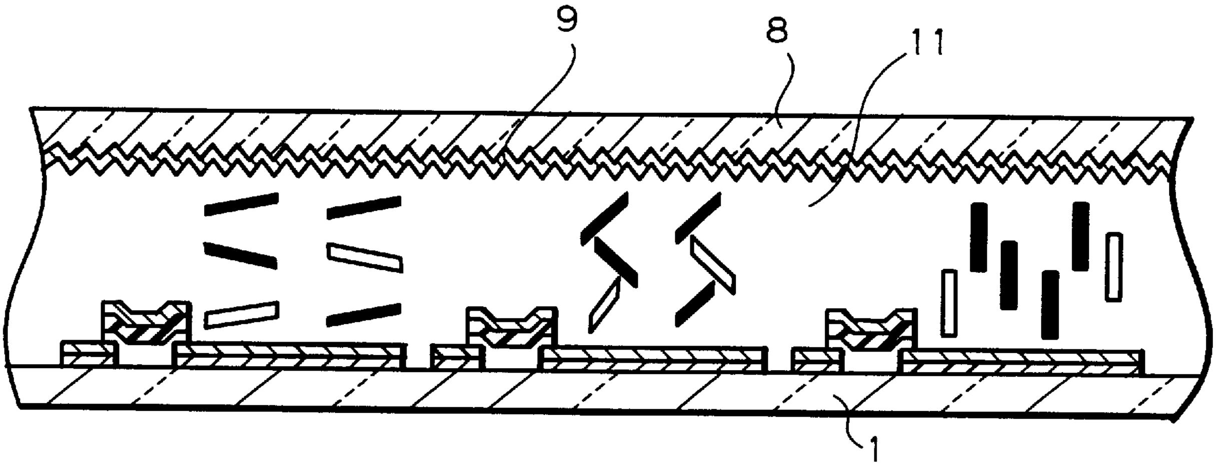

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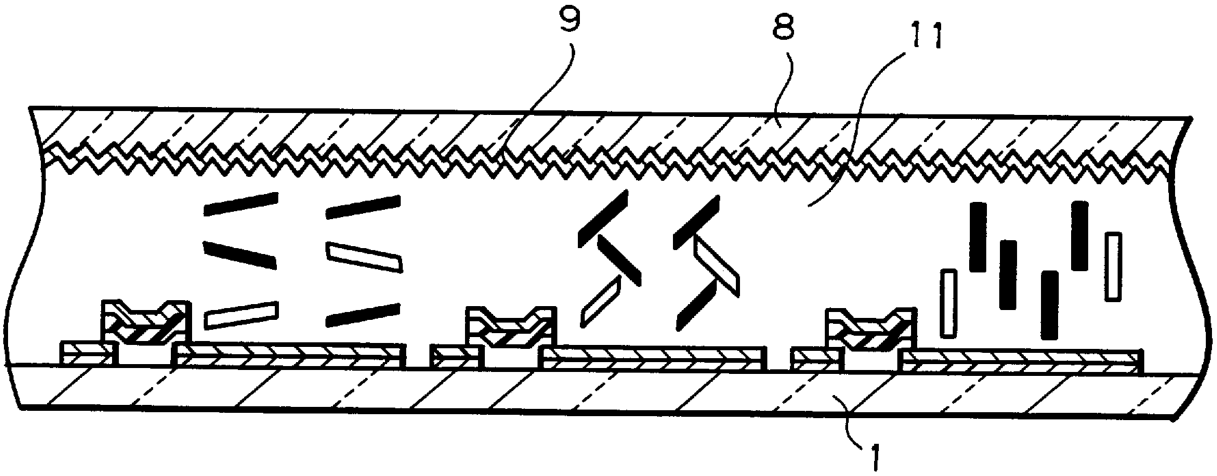

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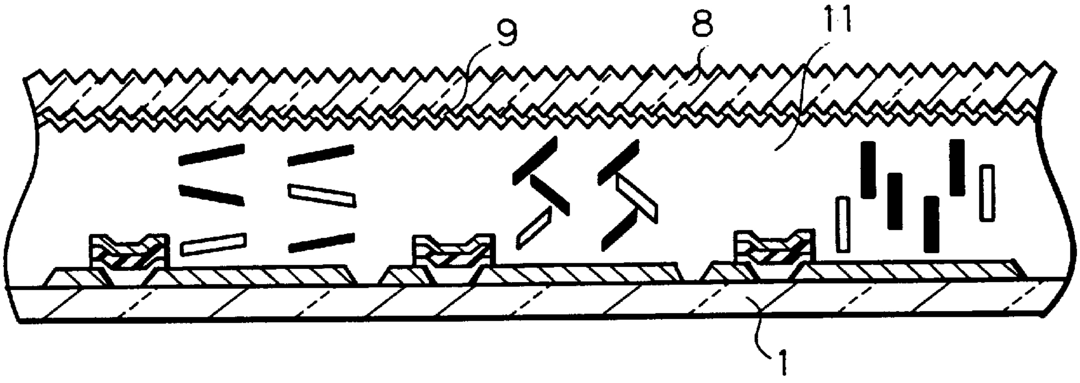

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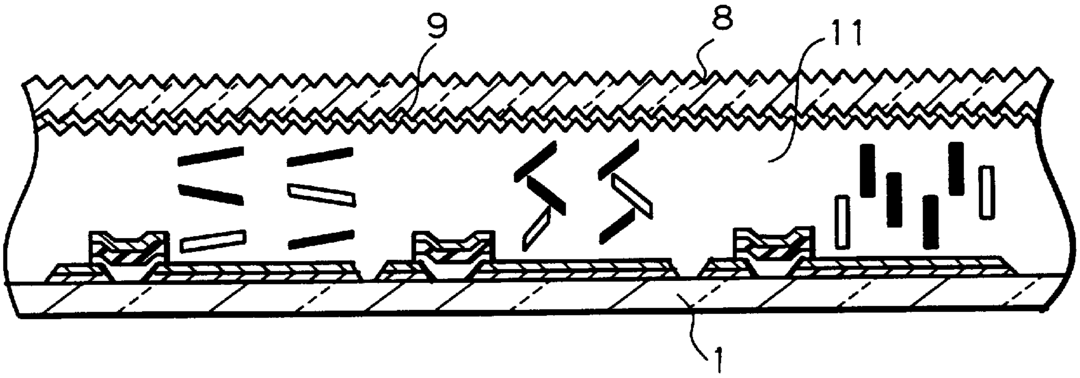

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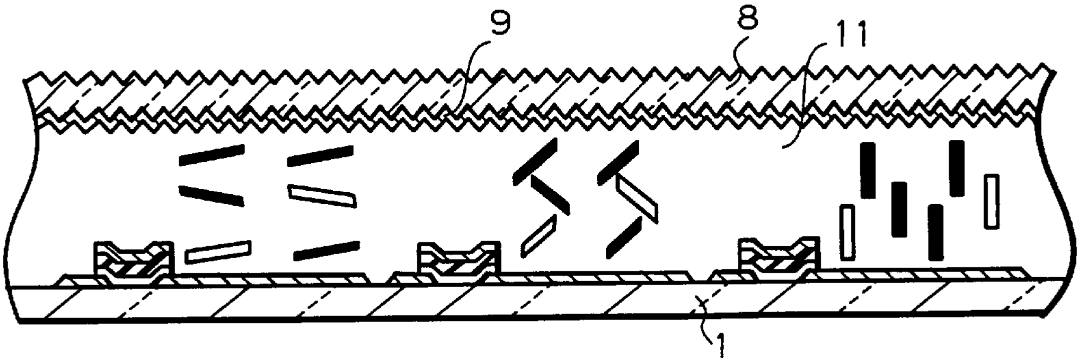

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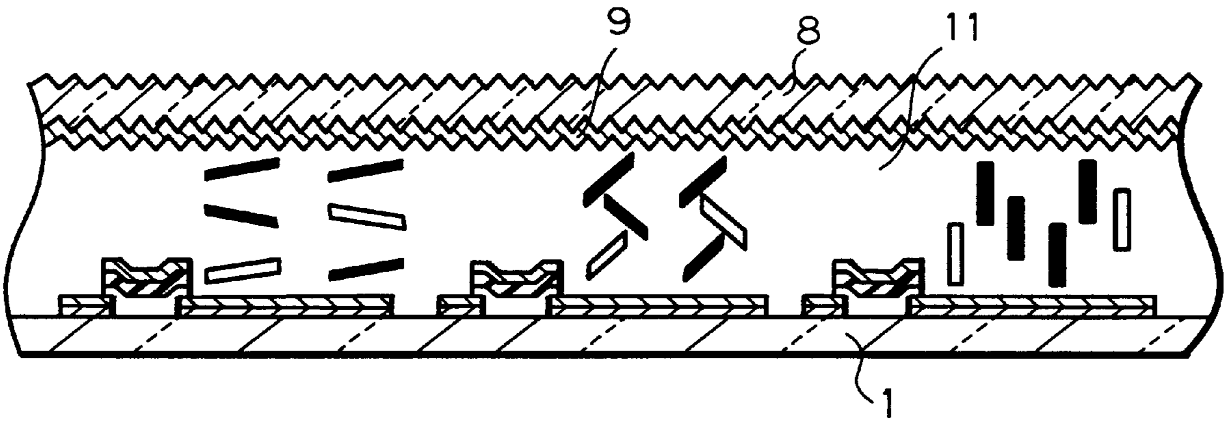

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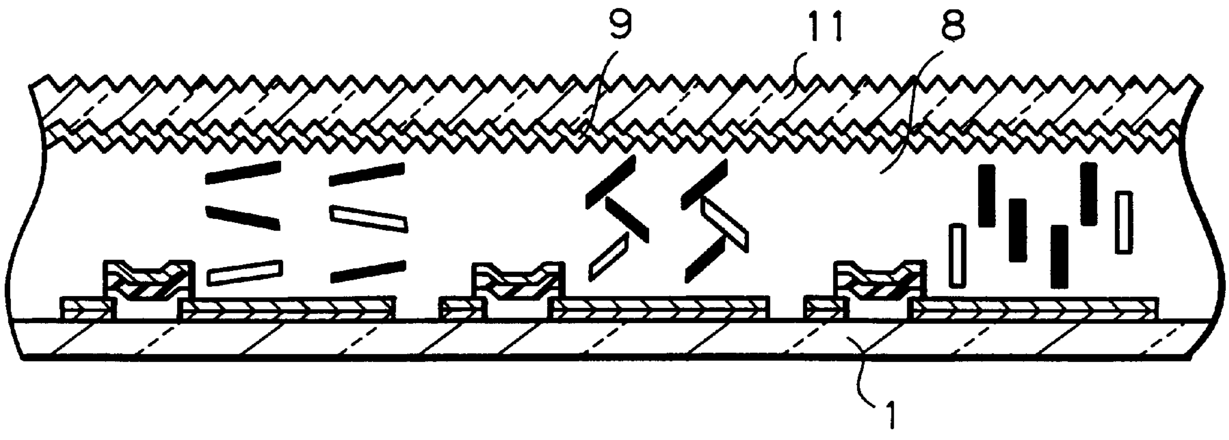

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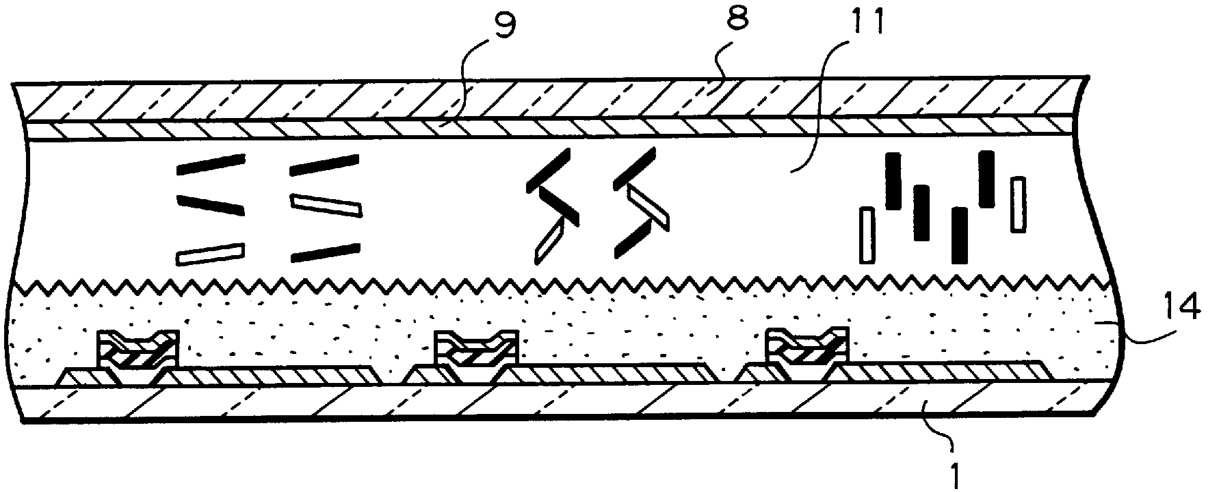

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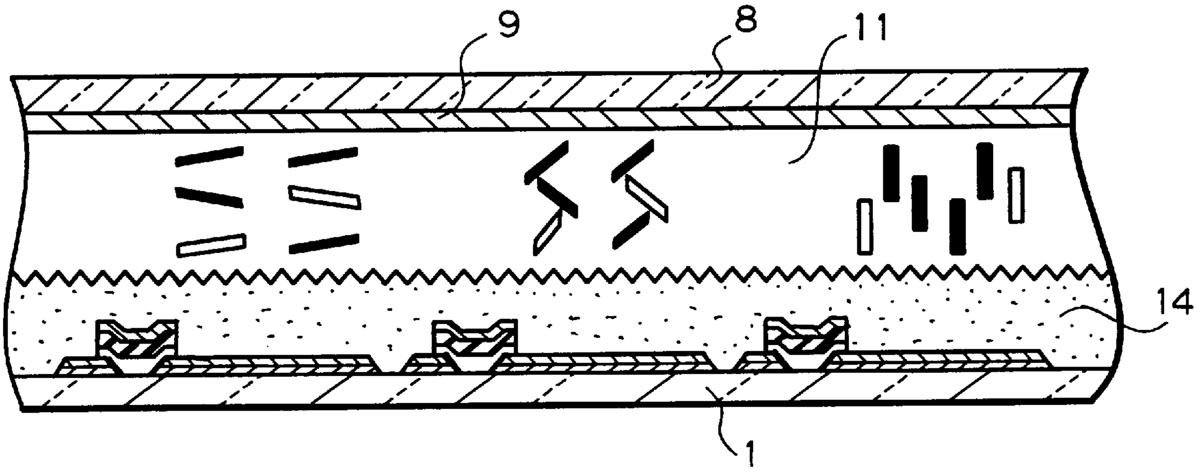

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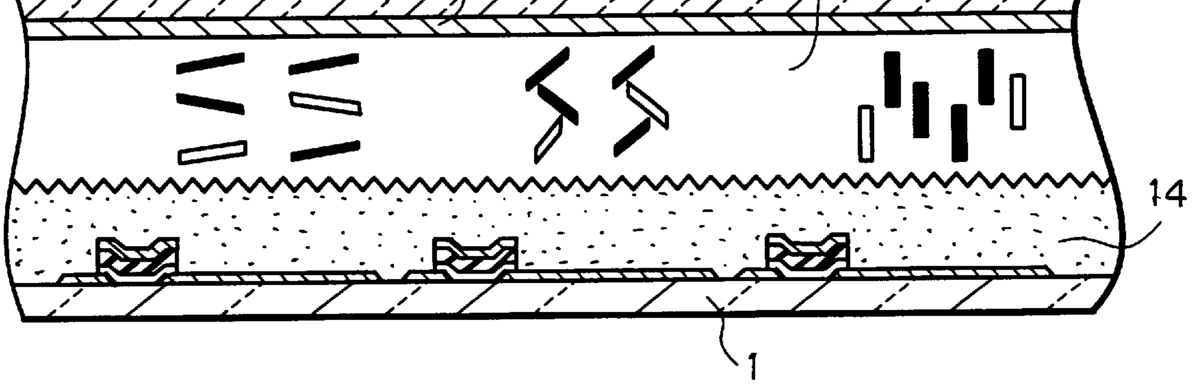

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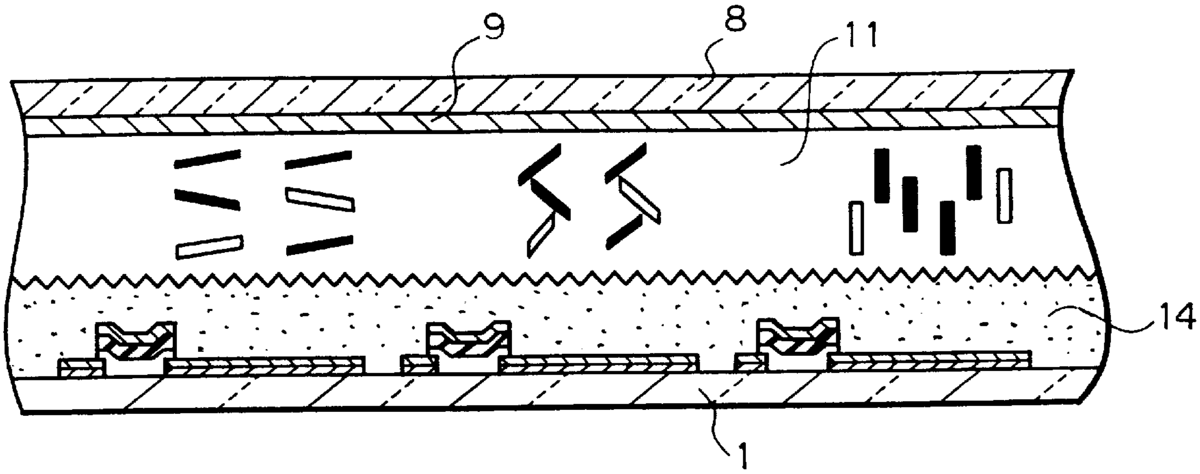

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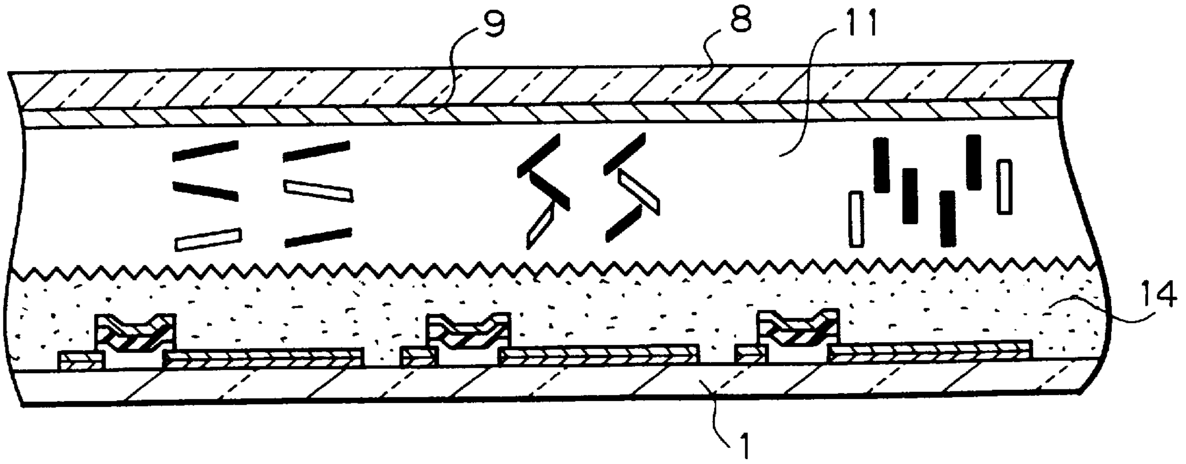

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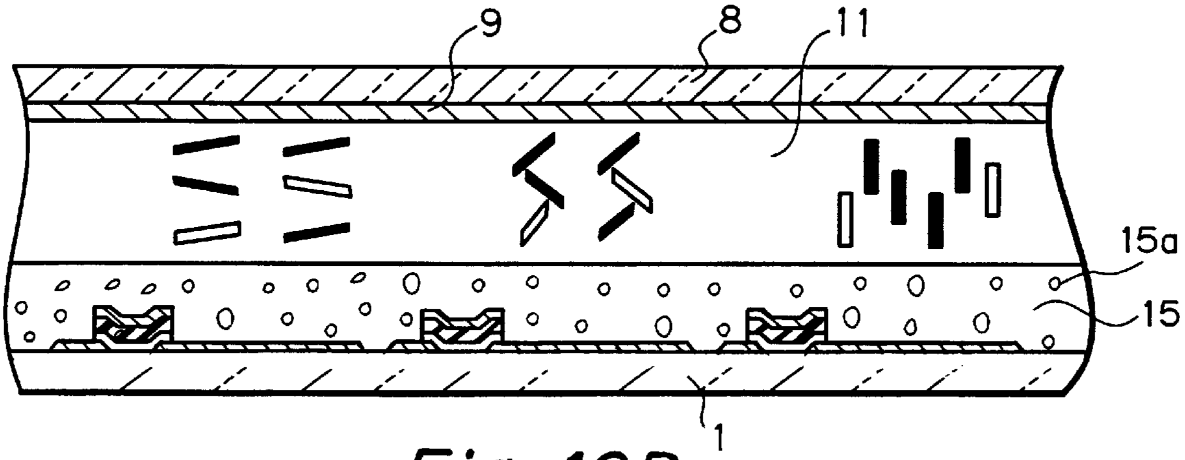

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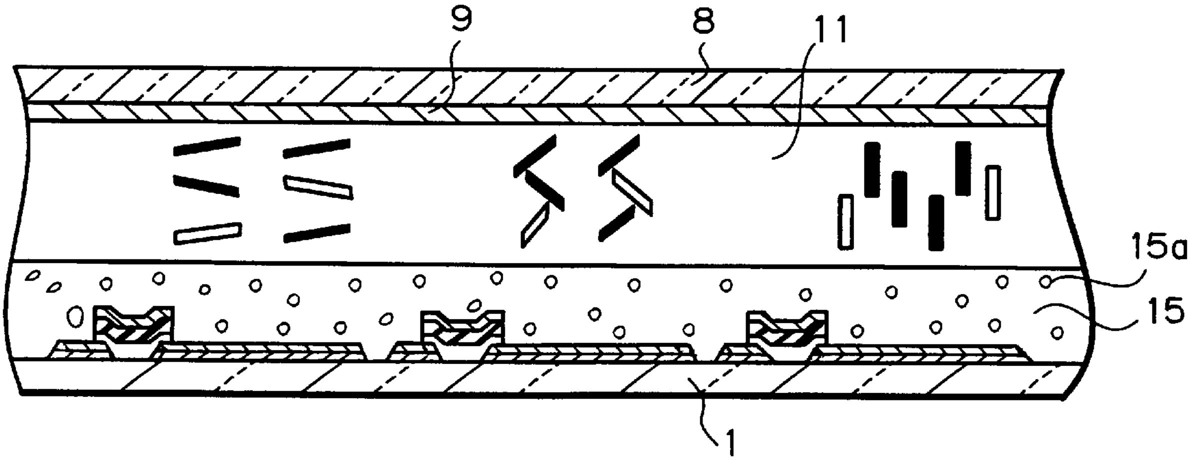

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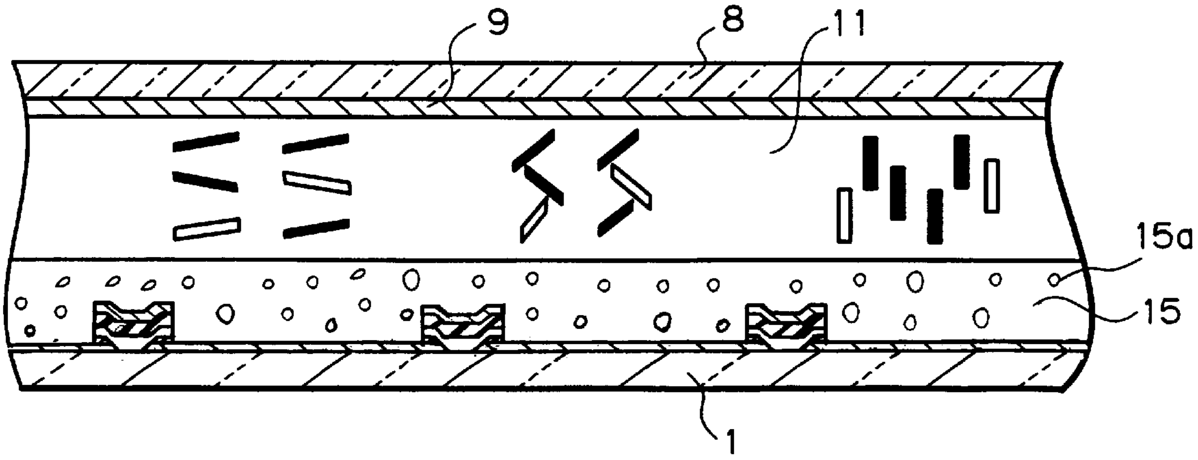

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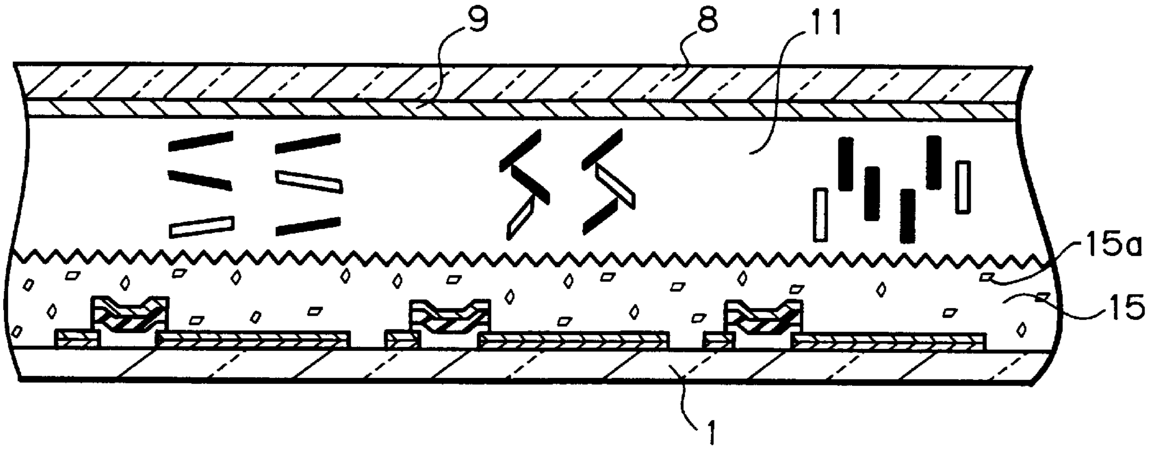

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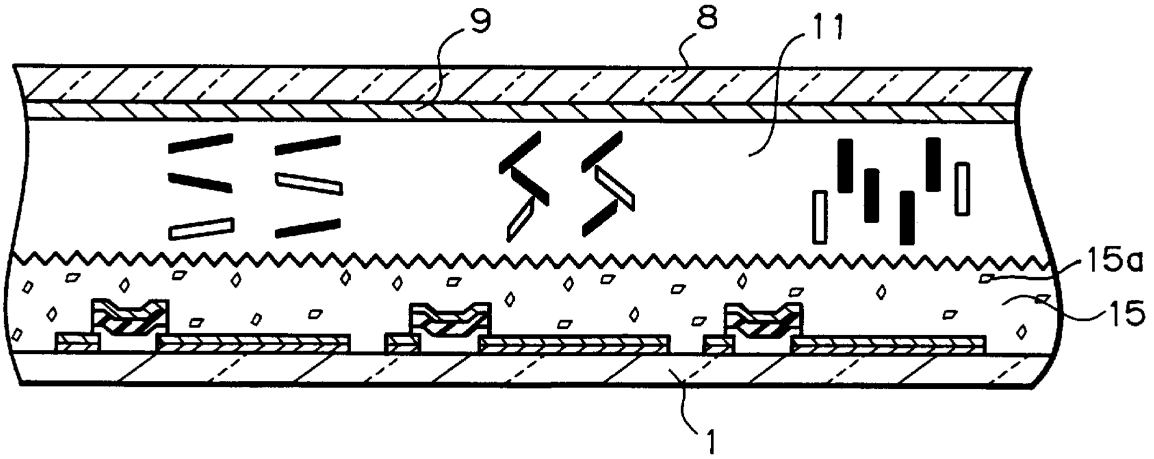

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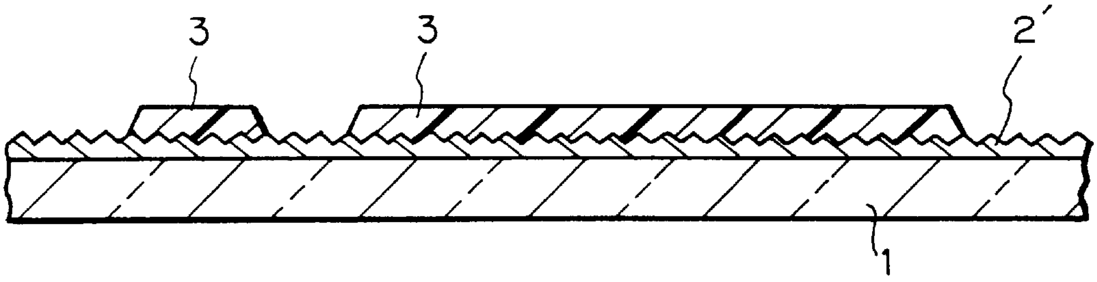

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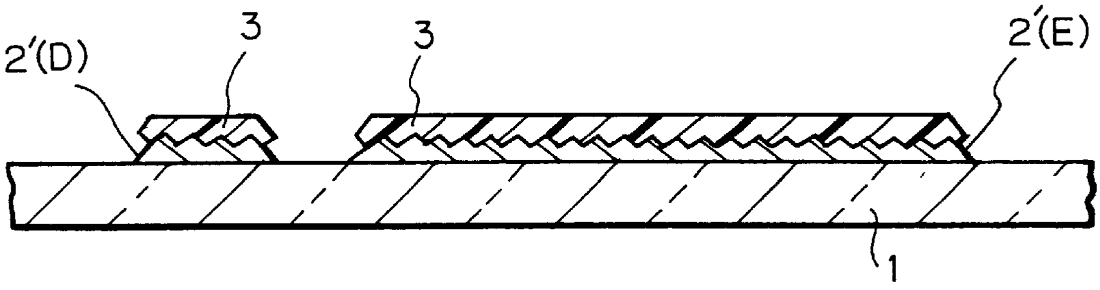

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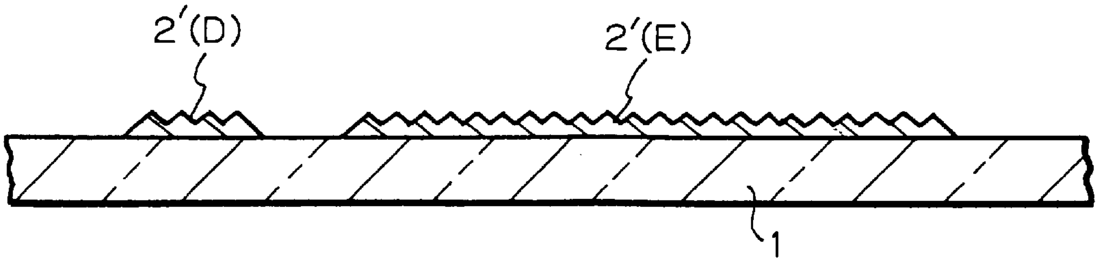

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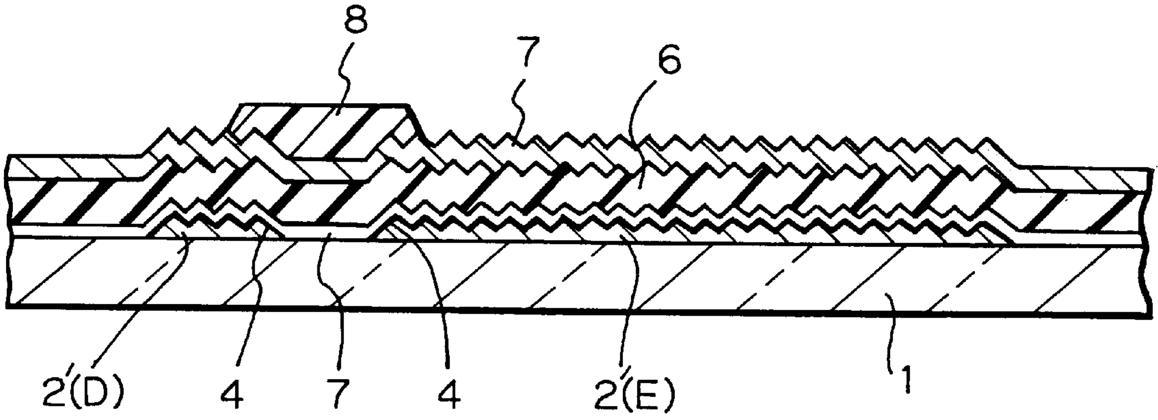

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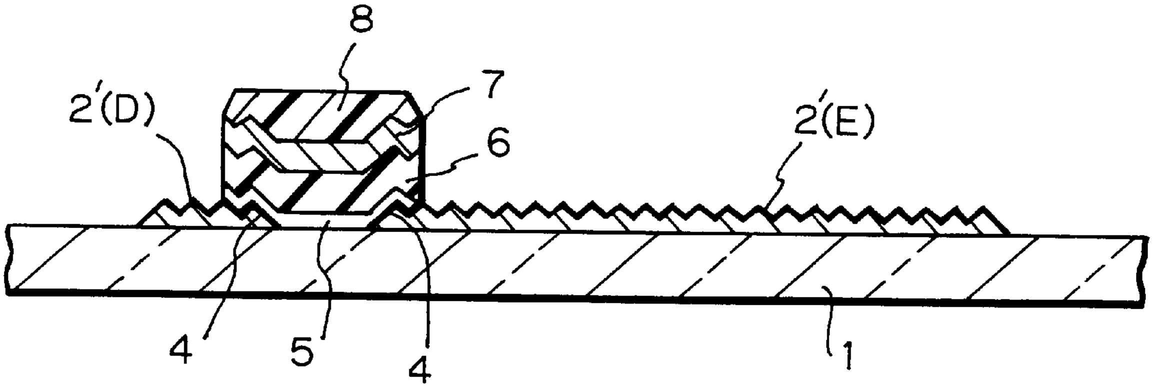

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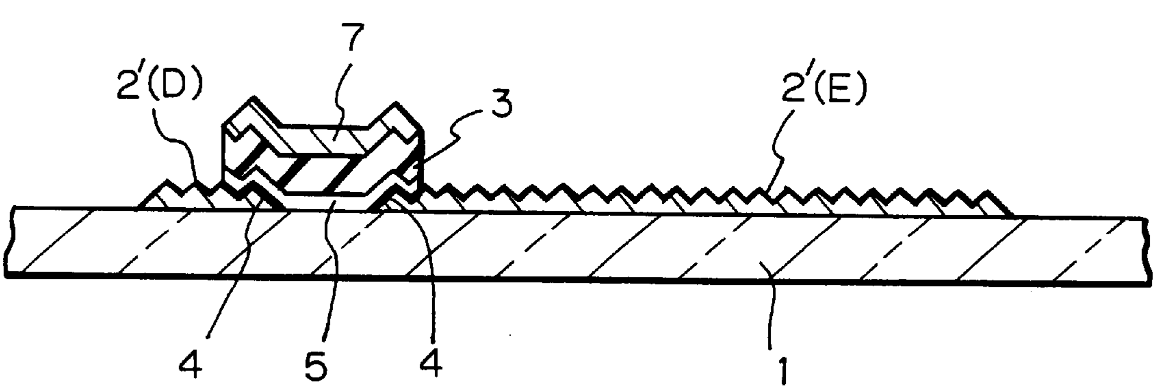

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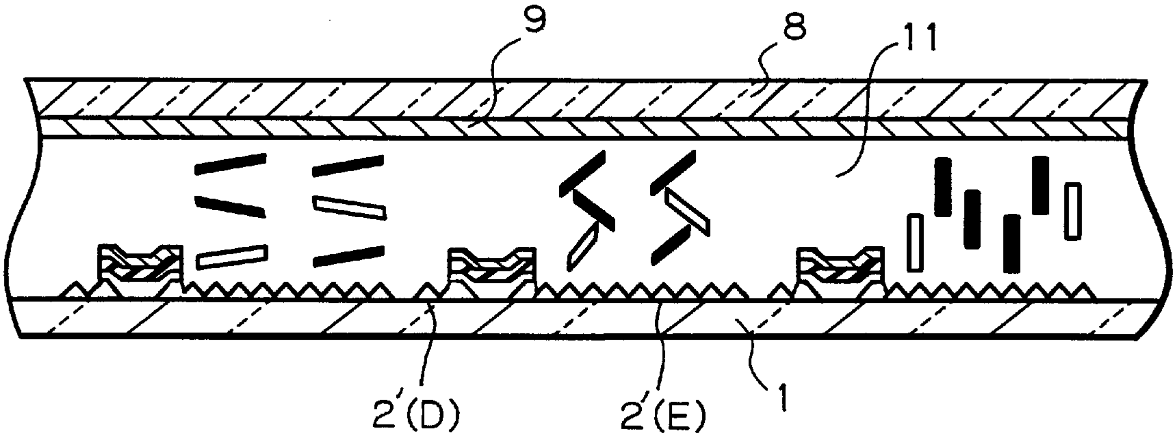

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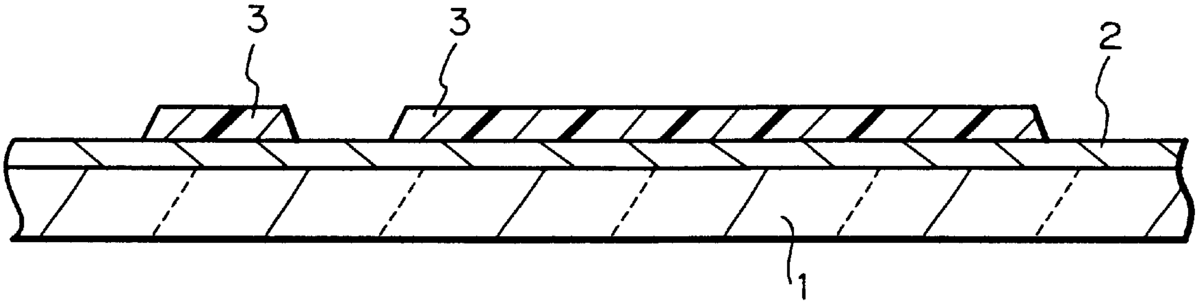


Fig. 12B

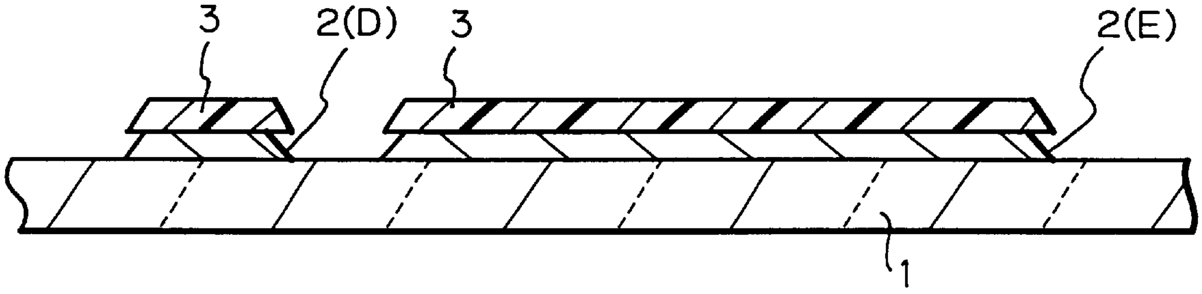


Fig. 12C

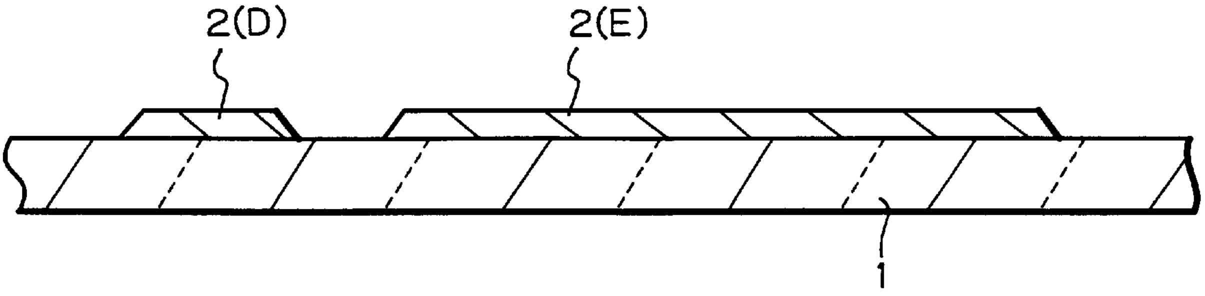


Fig. 12D

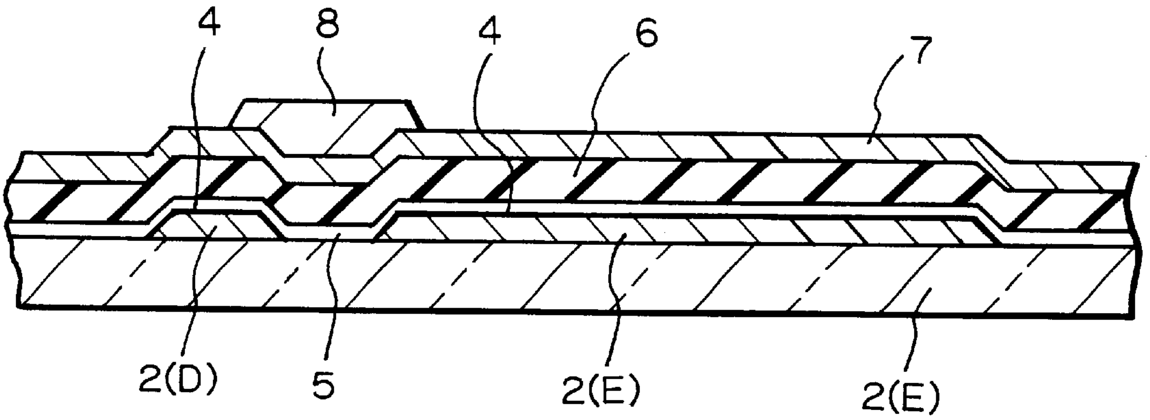


Fig. 12E

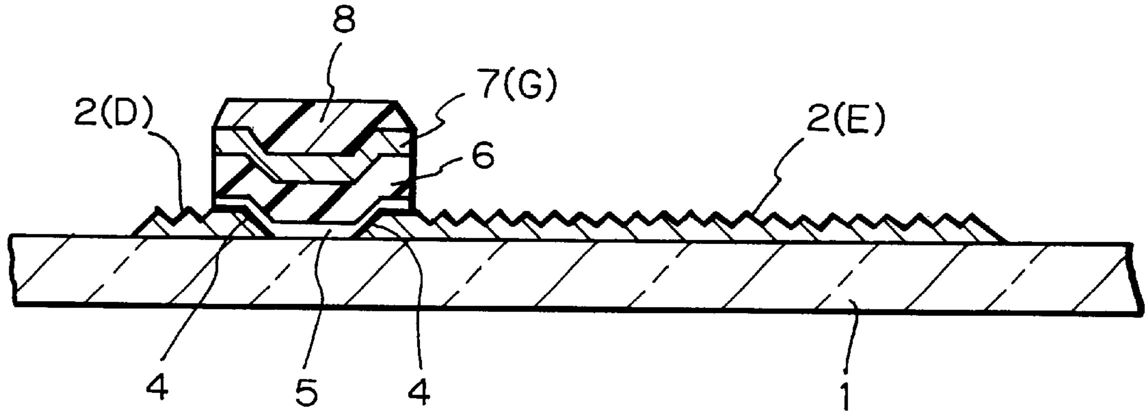


Fig. 12F

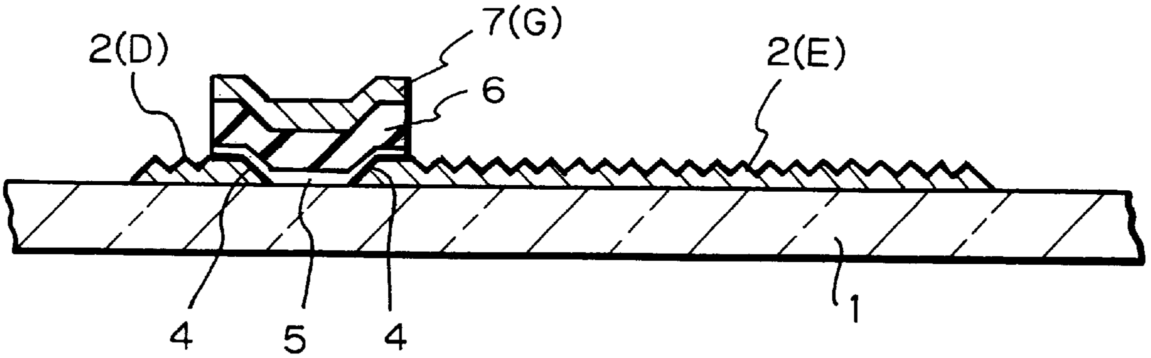


Fig. 12G

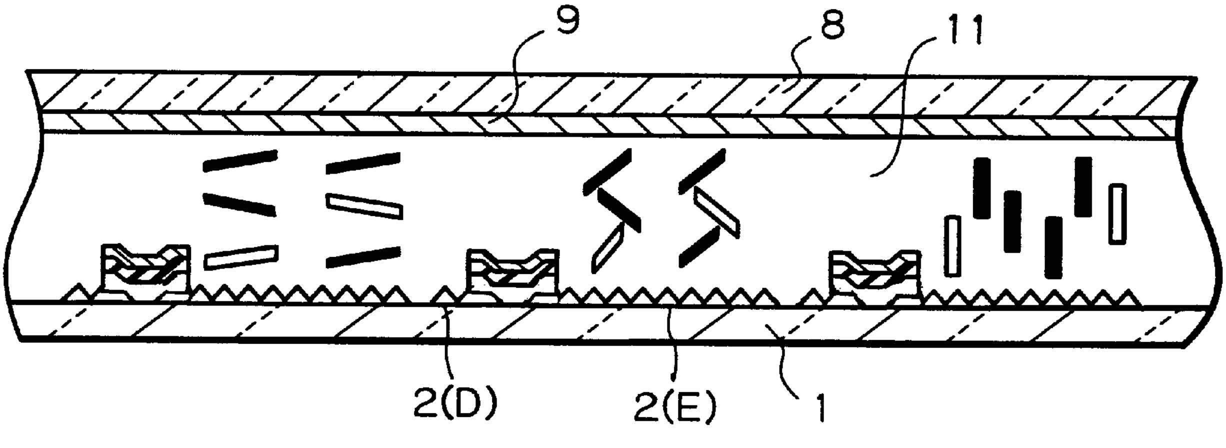


Fig. 13A

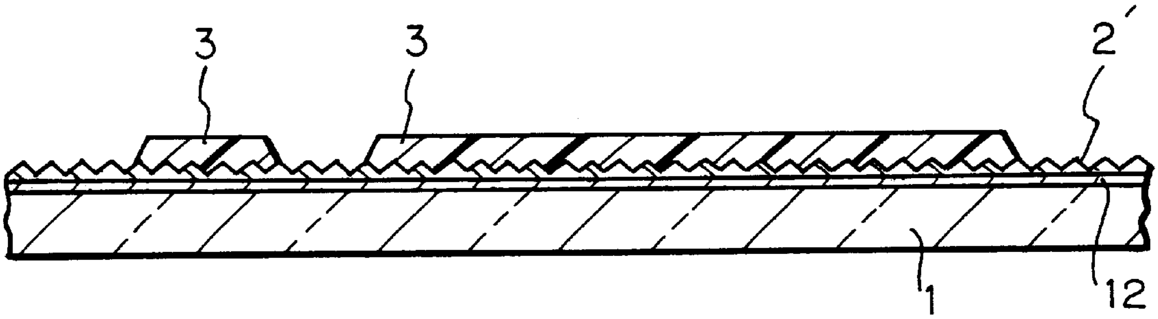


Fig. 13B

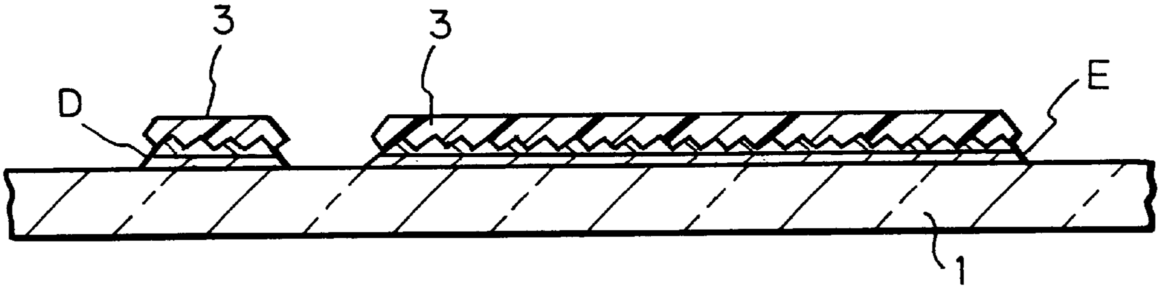


Fig. 13C

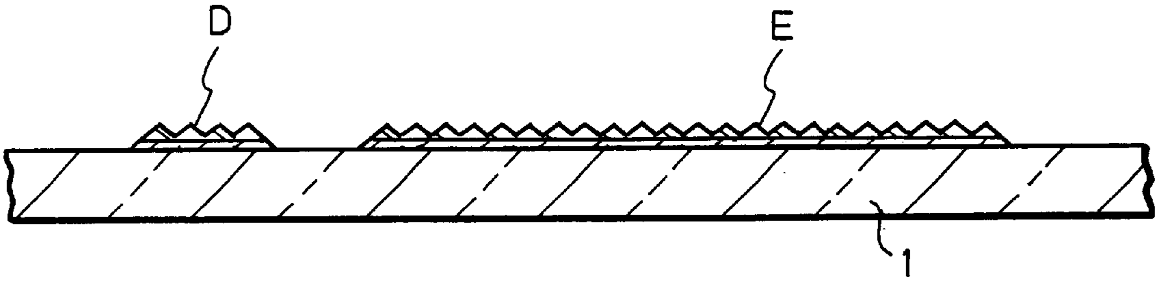


Fig. 13D

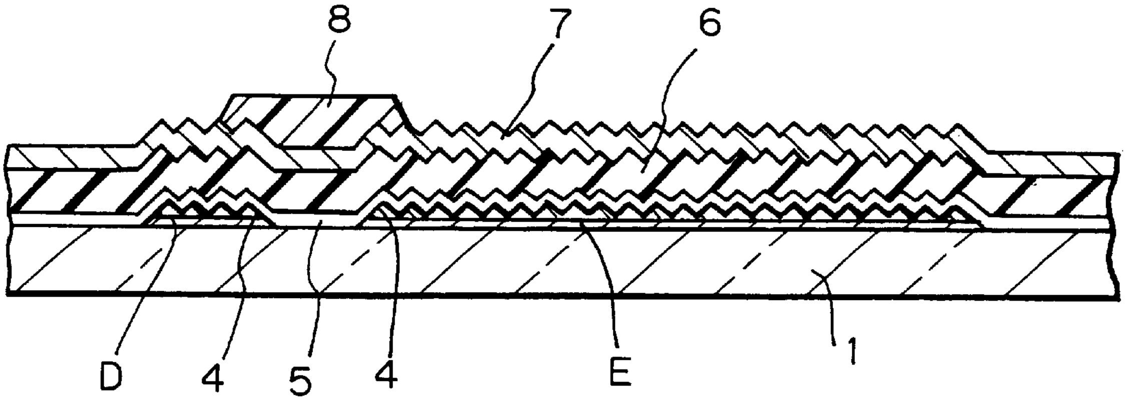


Fig. 13E

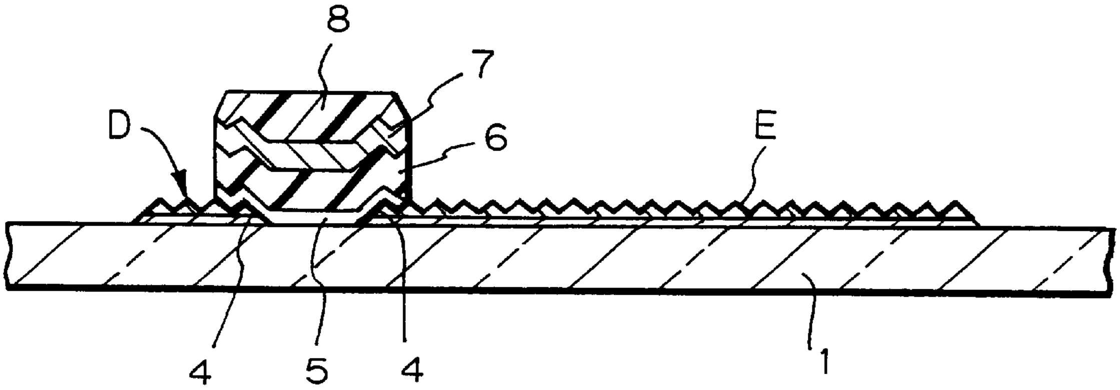


Fig. 13F

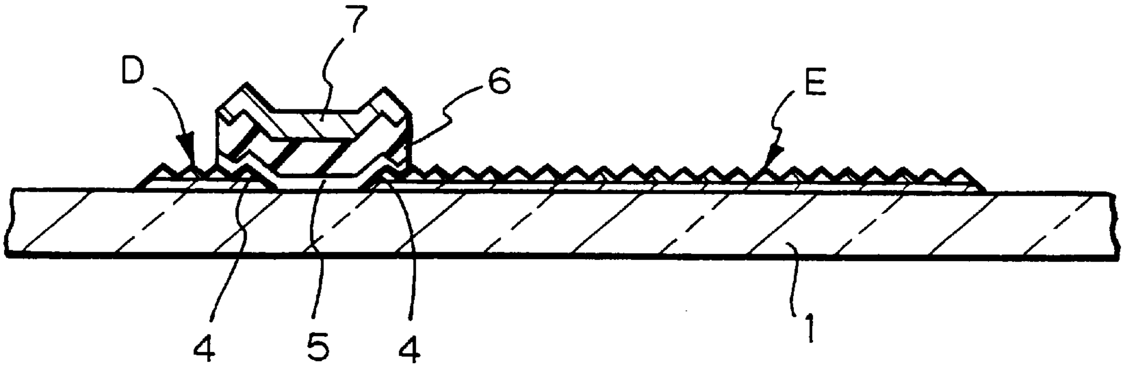
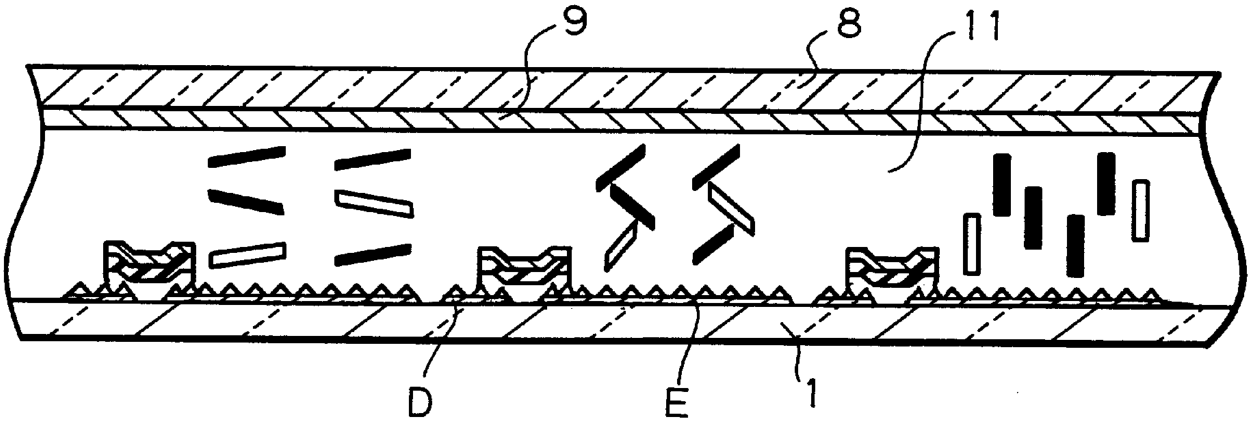


Fig. 13G



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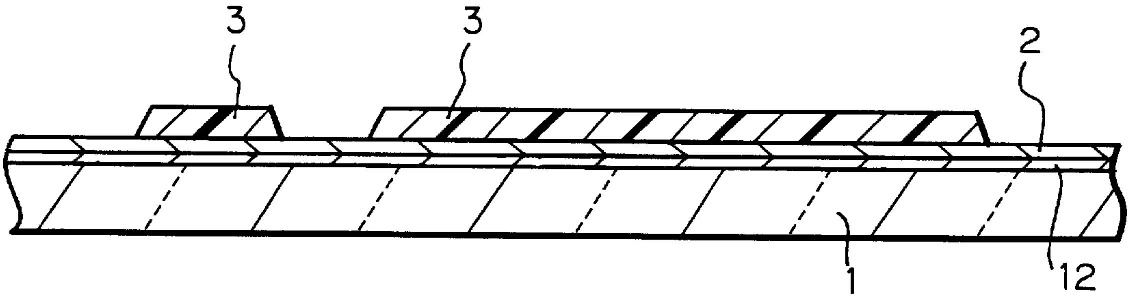


Fig. 14B

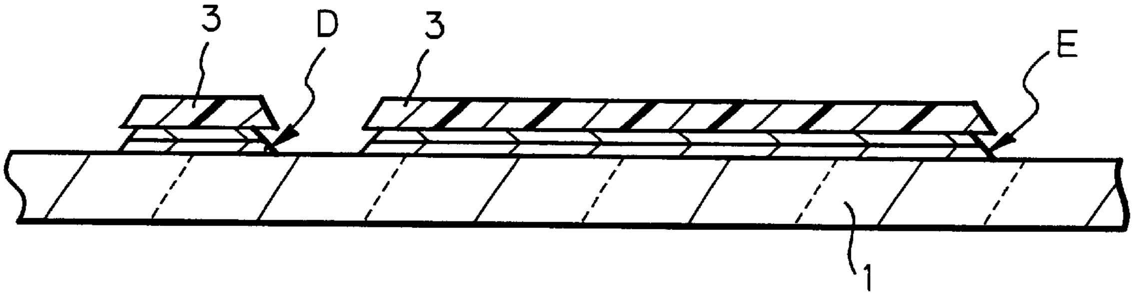


Fig. 14C

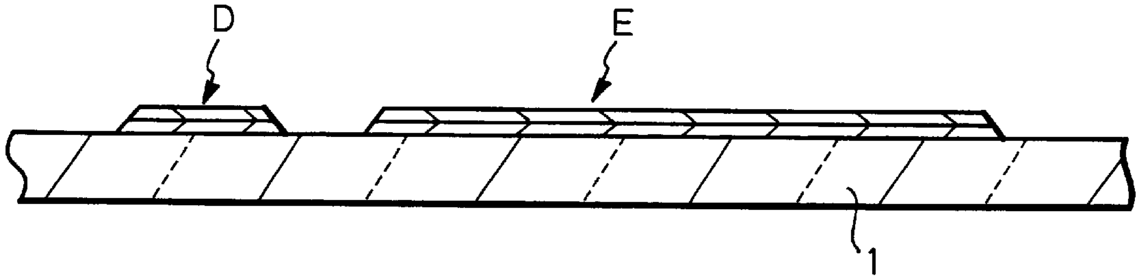


Fig. 14D

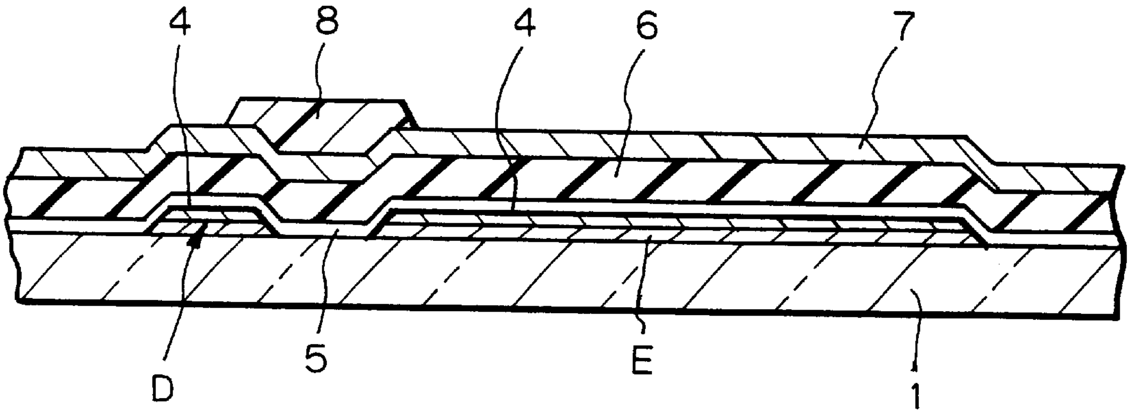


Fig. 14E

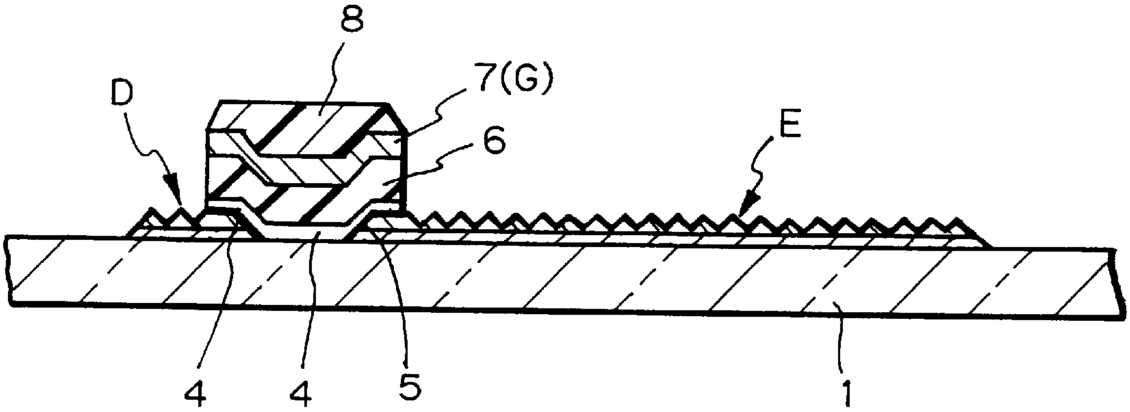


Fig. 14F

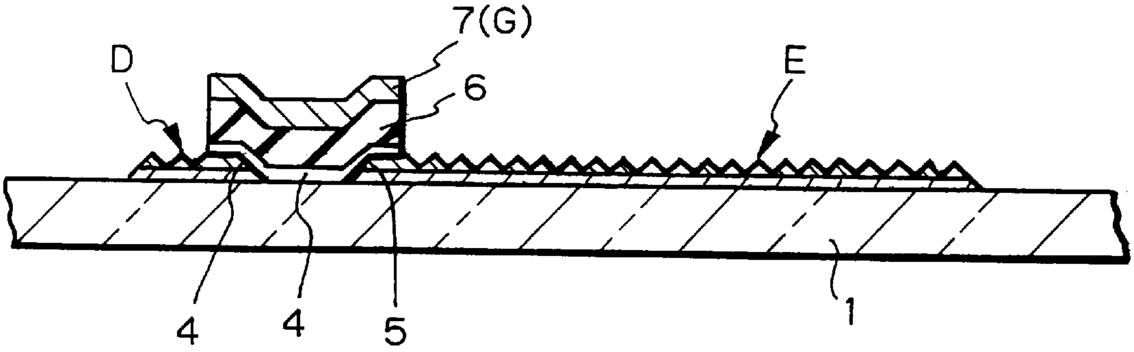


Fig. 14G

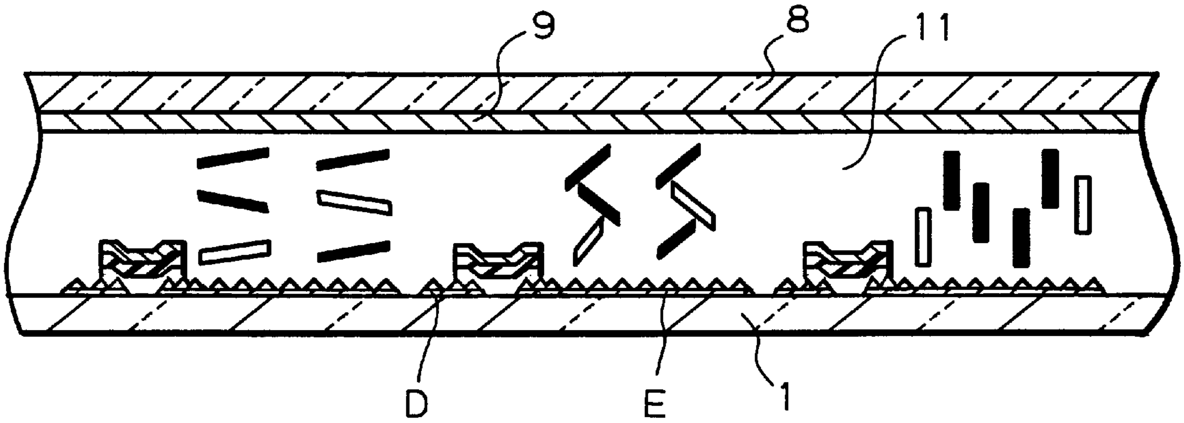


Fig. 15A

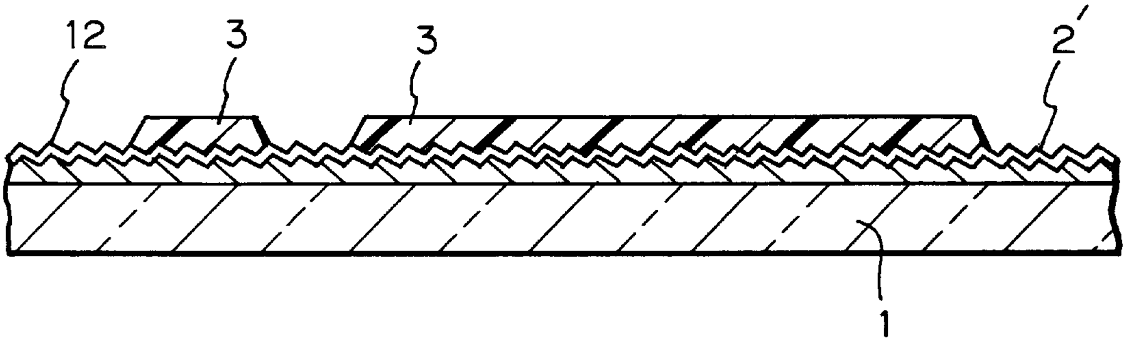


Fig. 15B

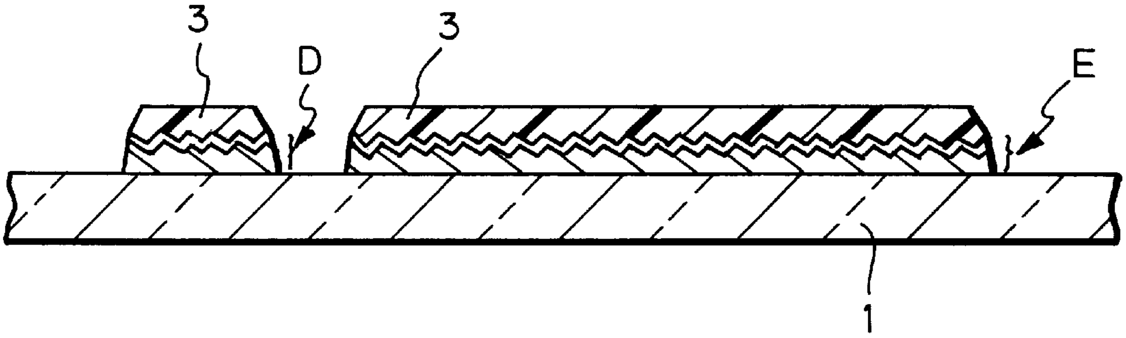


Fig. 15C

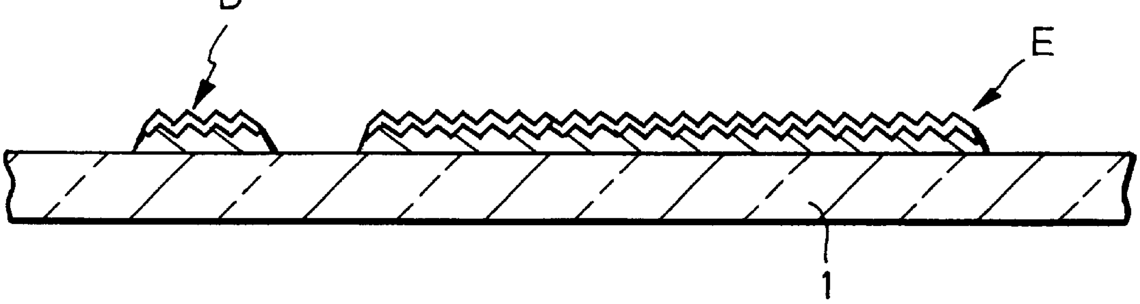


Fig. 15D

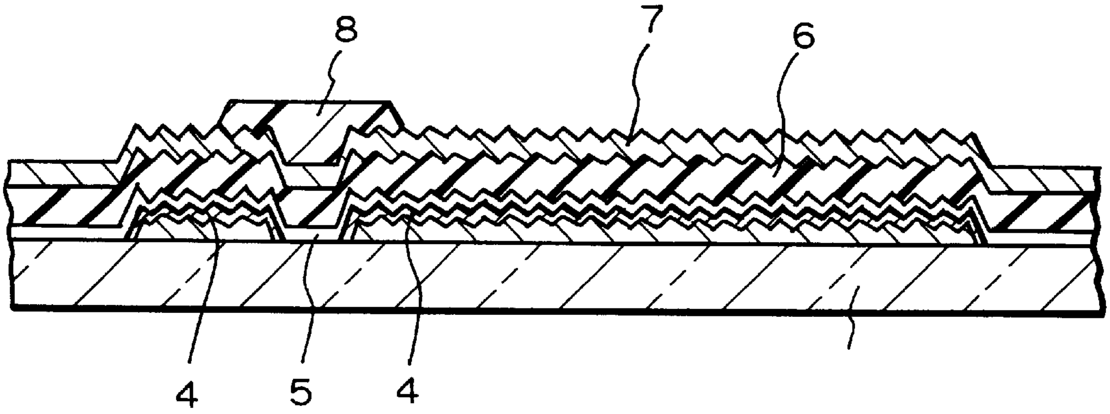


Fig. 15E

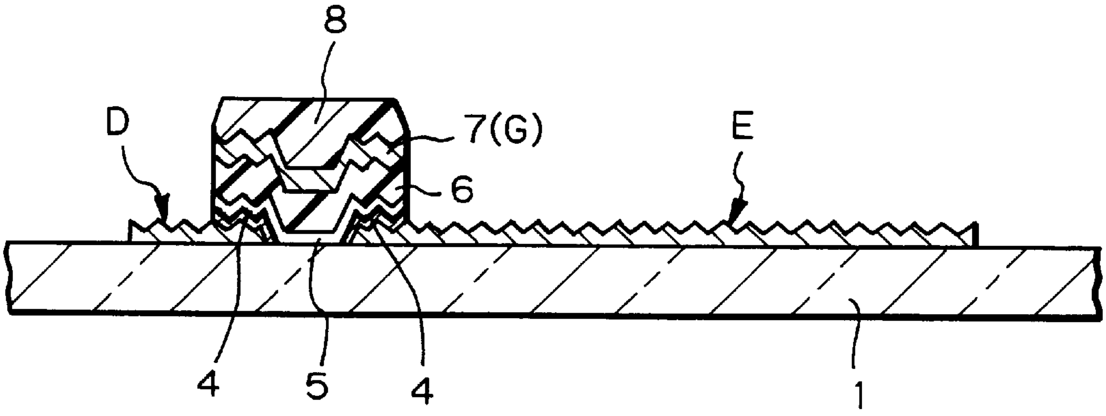


Fig. 15F

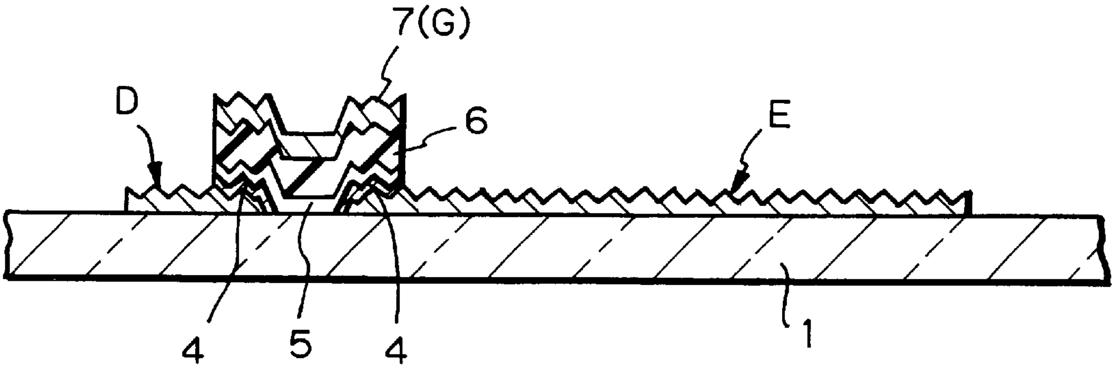


Fig. 15G

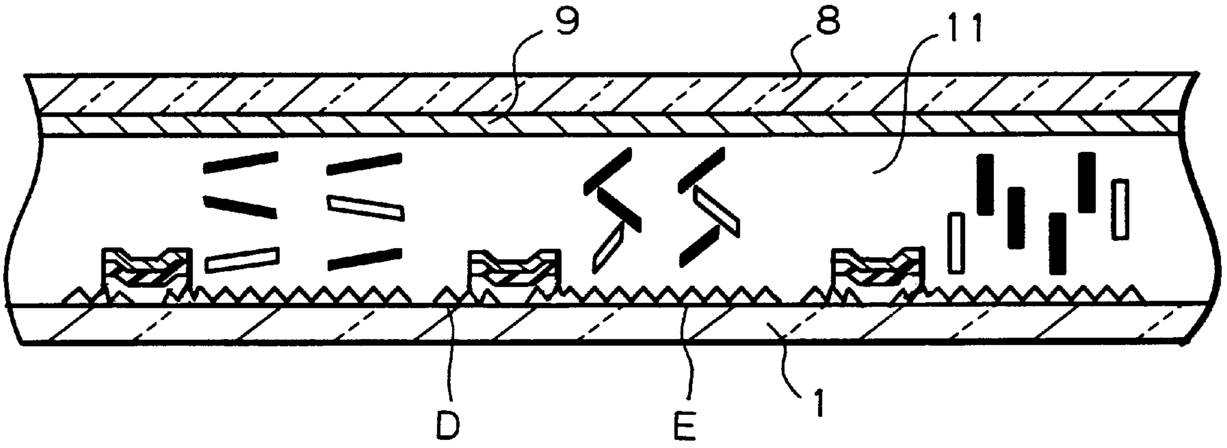


Fig. 16A

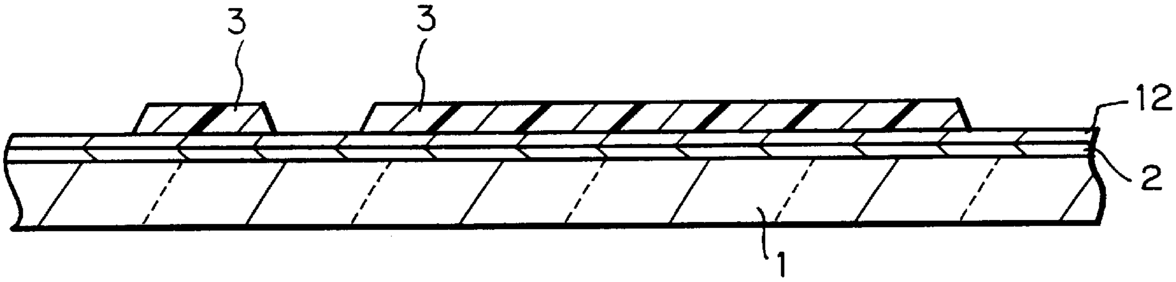


Fig. 16B

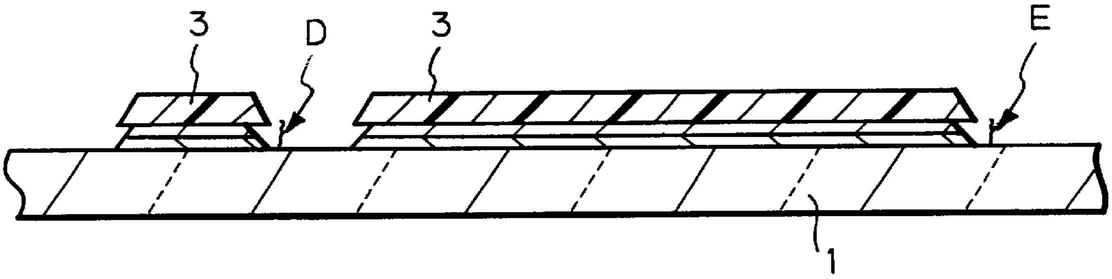


Fig. 16C

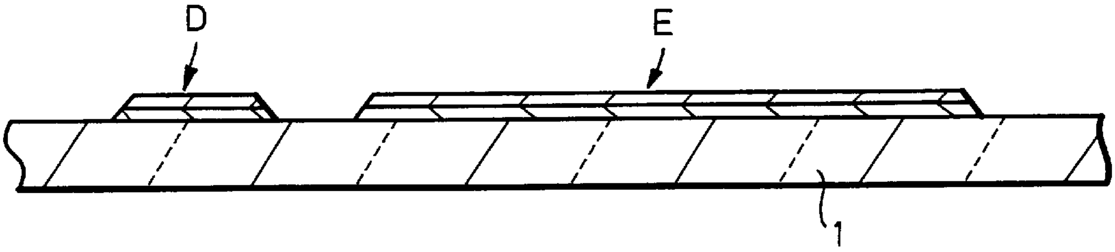


Fig. 16D

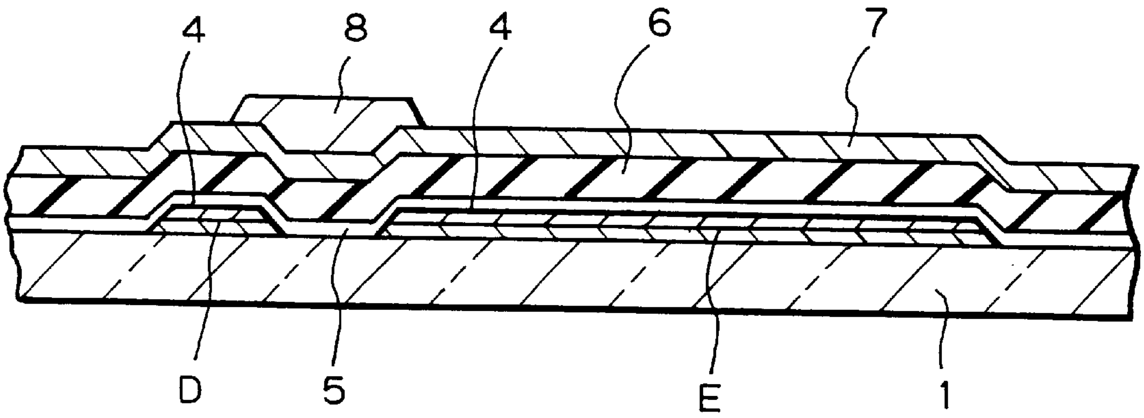


Fig. 16E

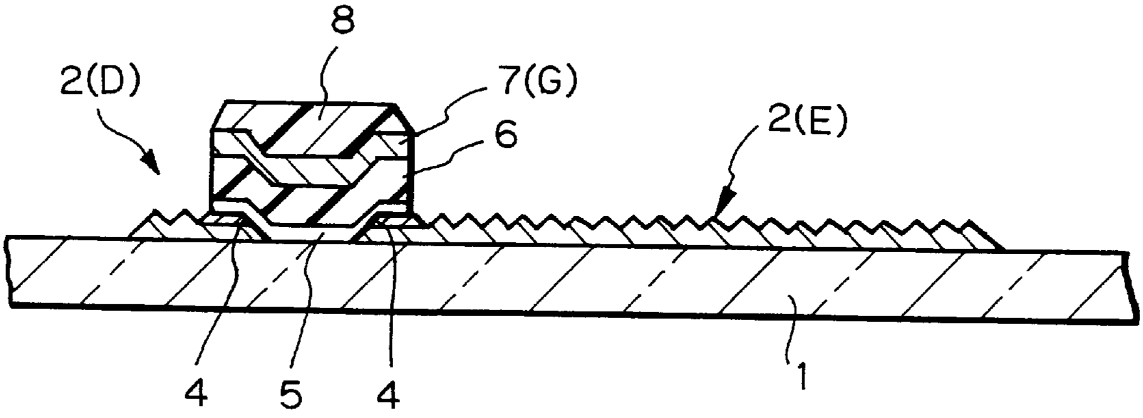


Fig. 16F

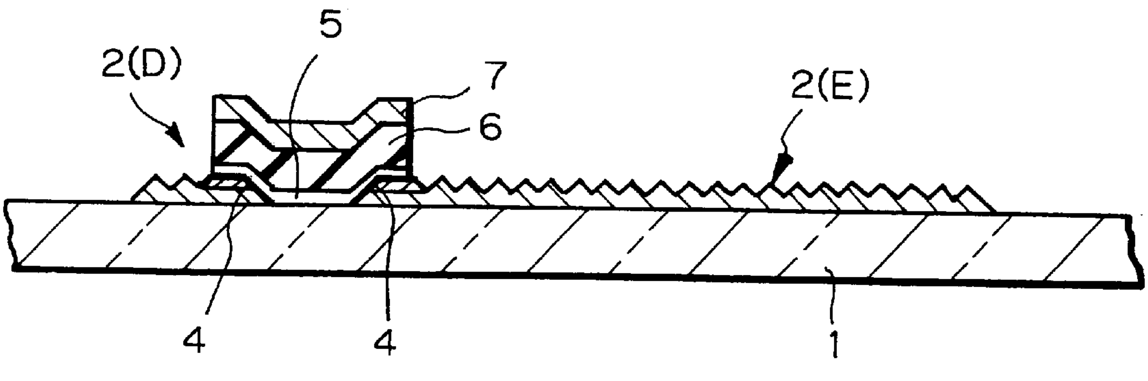


Fig. 16G

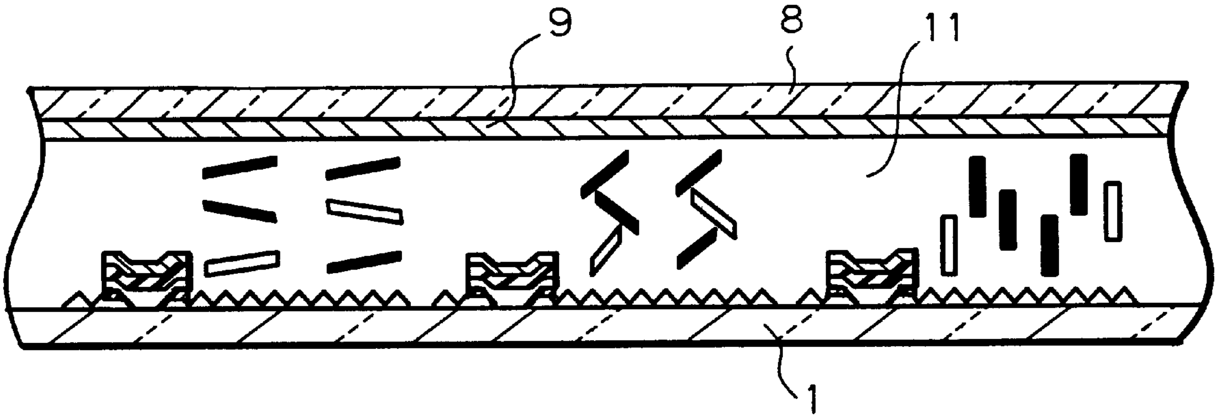


Fig. 17A

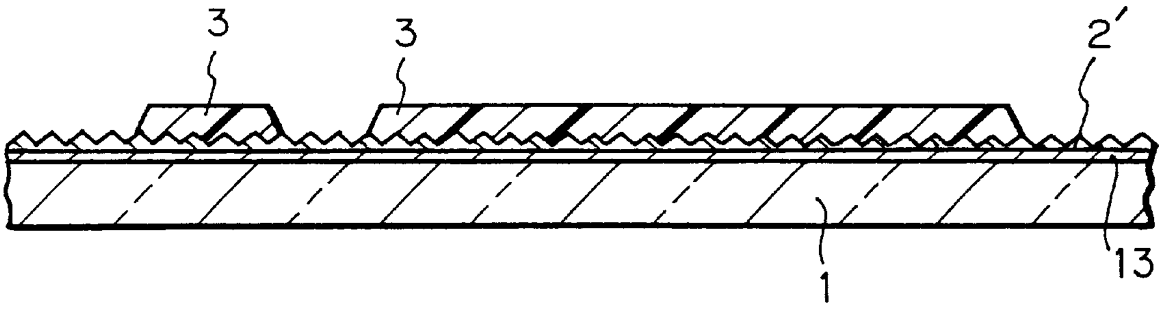


Fig. 17B

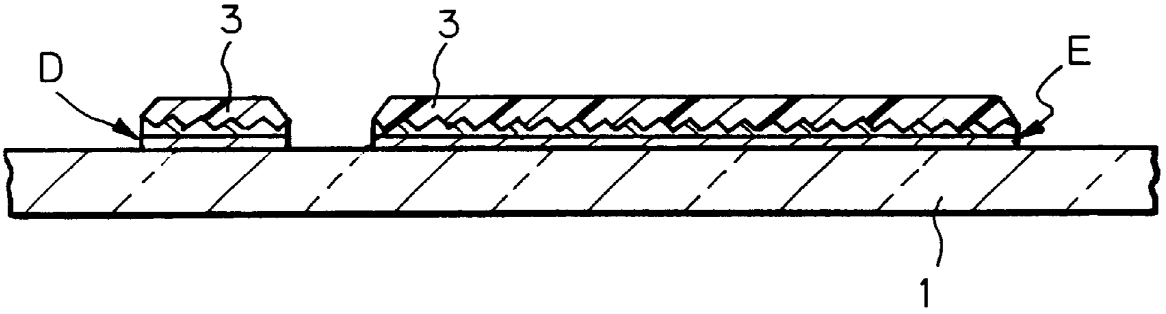


Fig. 17C

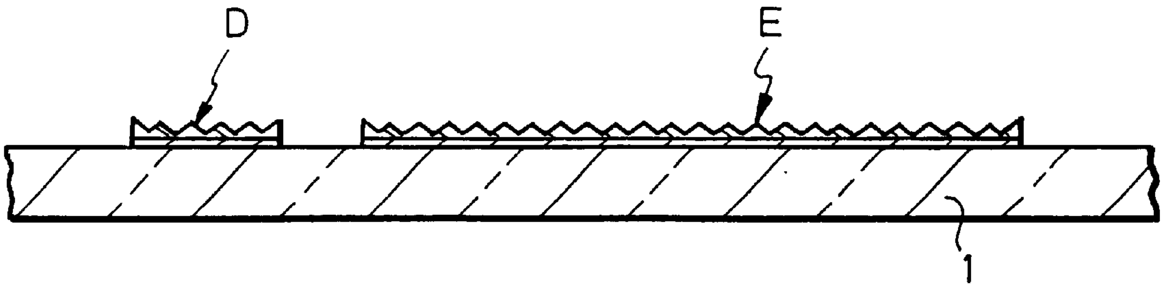


Fig. 17D

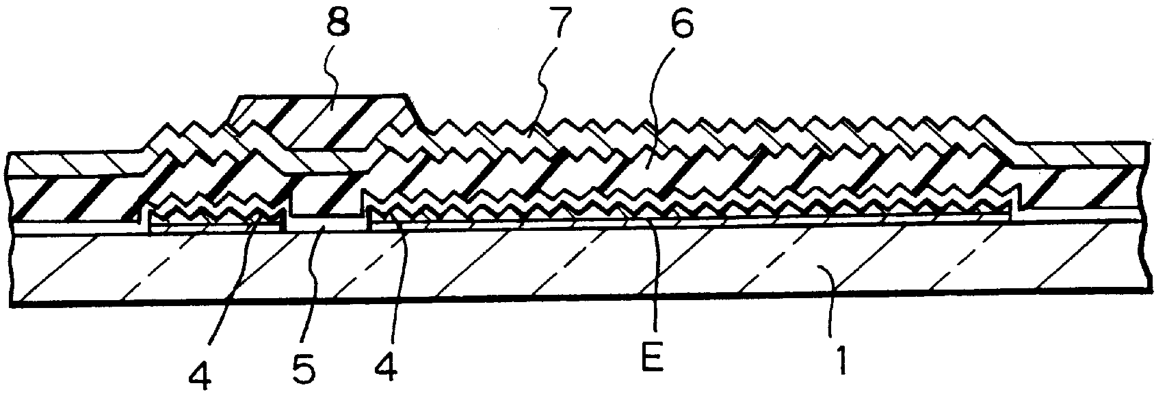


Fig. 17E

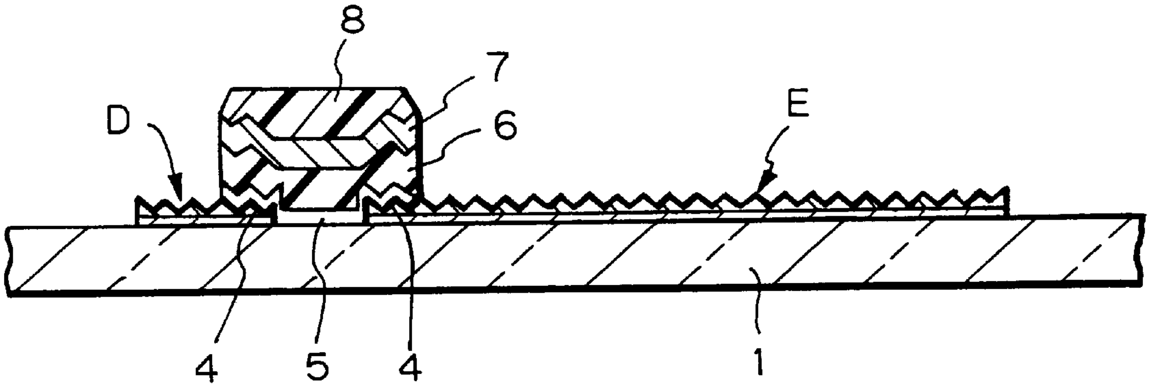


Fig. 17F

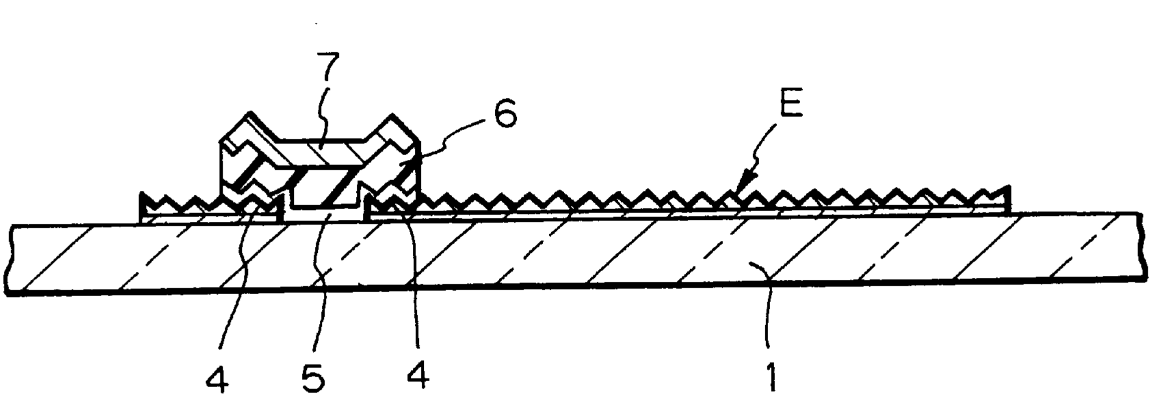


Fig. 17G

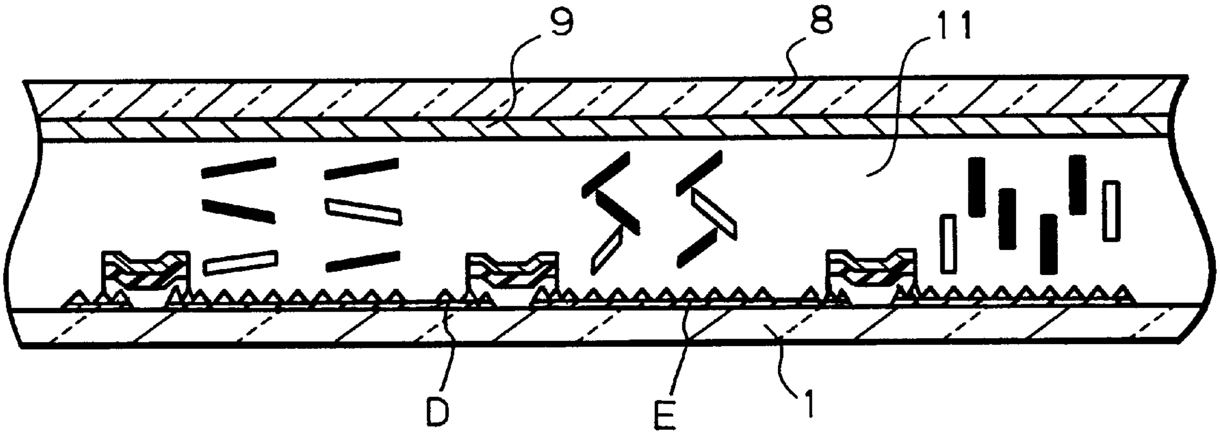


Fig. 18A

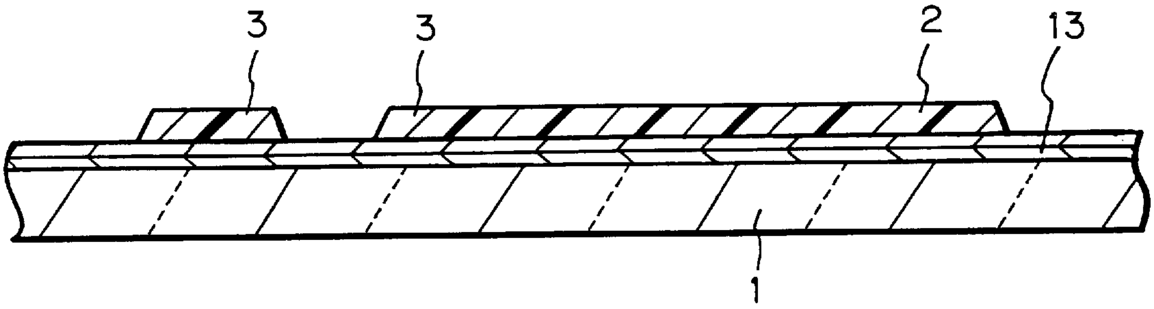


Fig. 18B

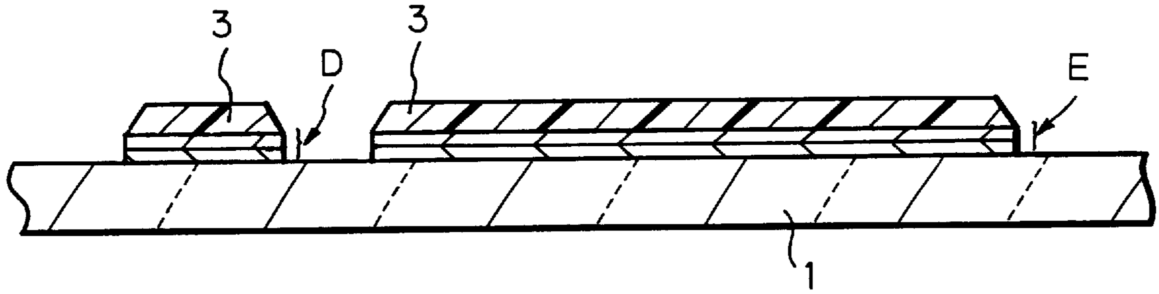


Fig. 18C

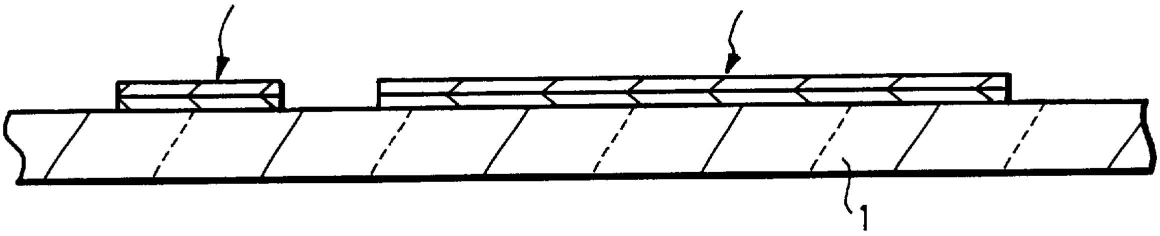


Fig. 18D

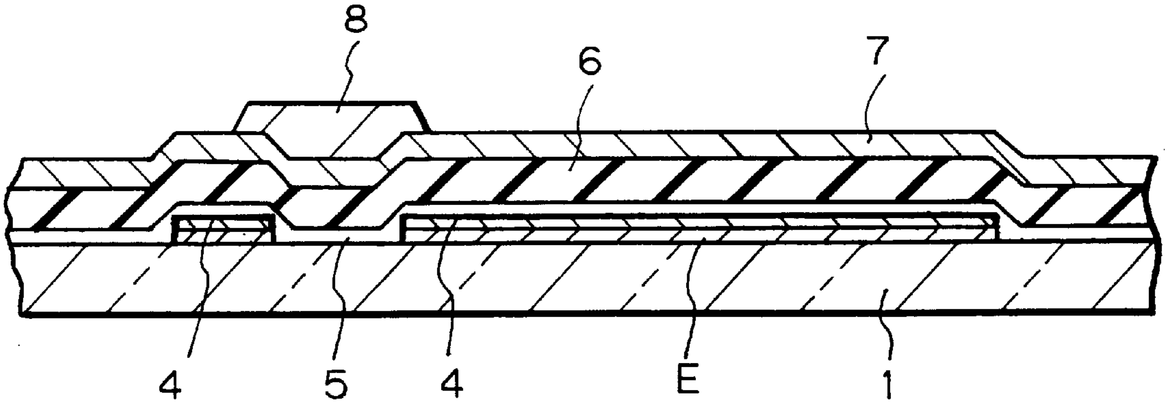


Fig. 18E

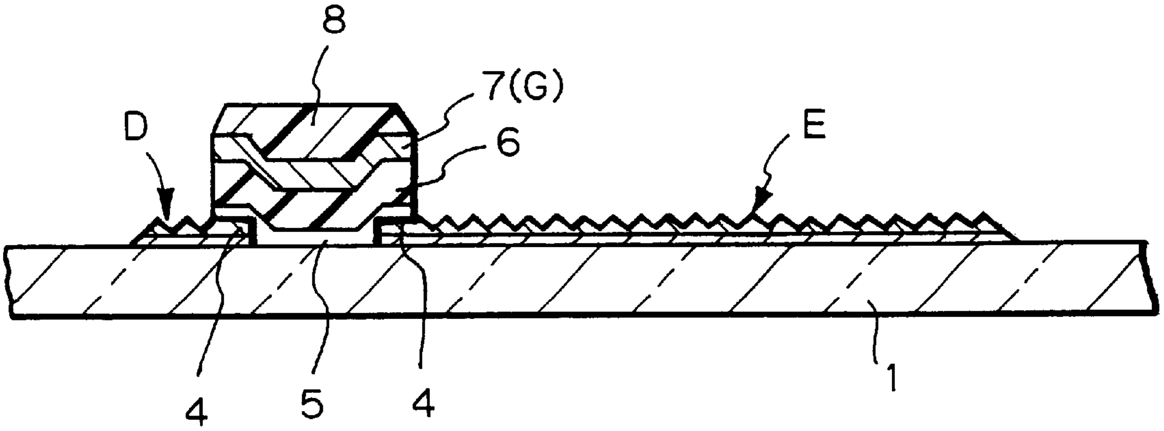


Fig. 18F

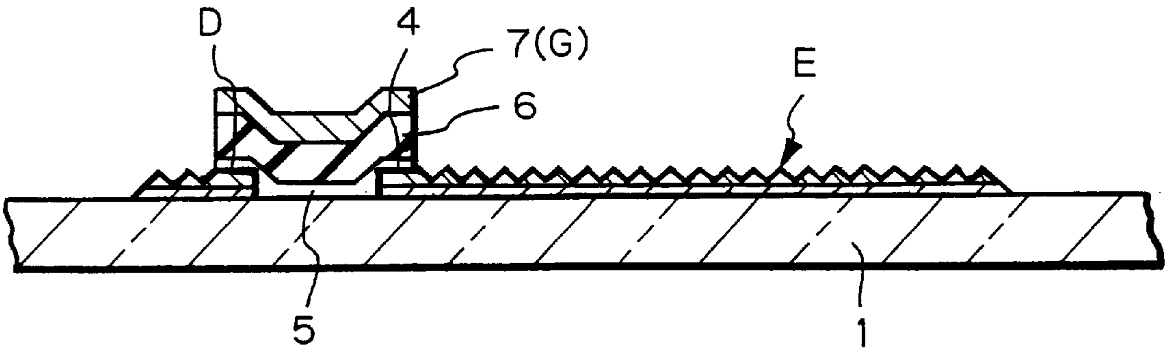


Fig. 18G

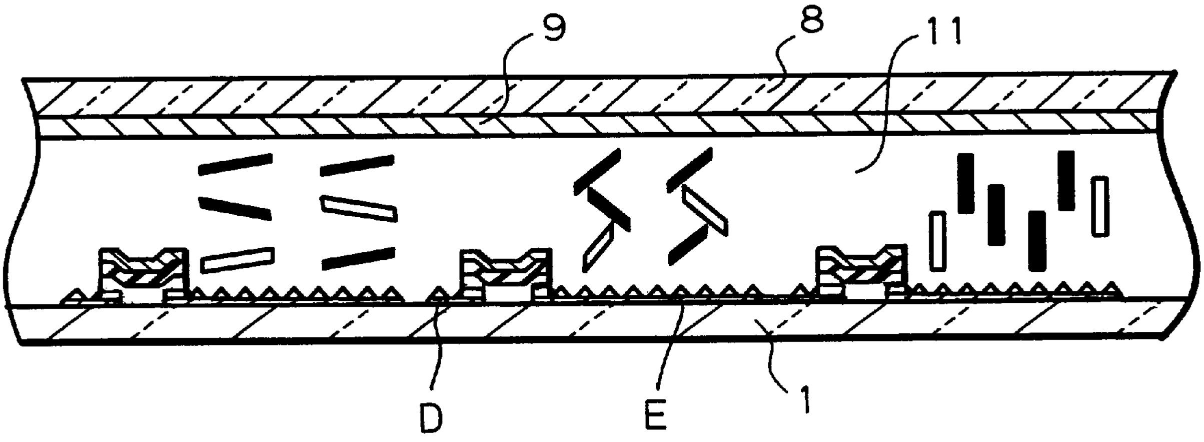


Fig. 19A

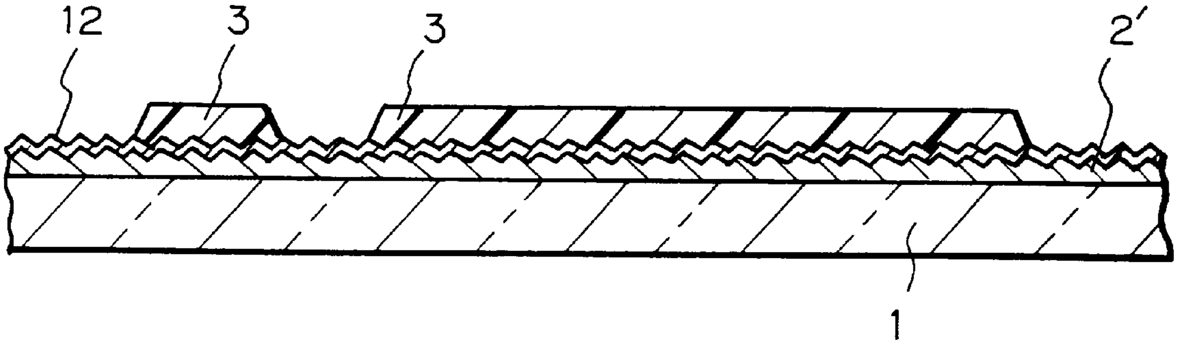


Fig. 19B

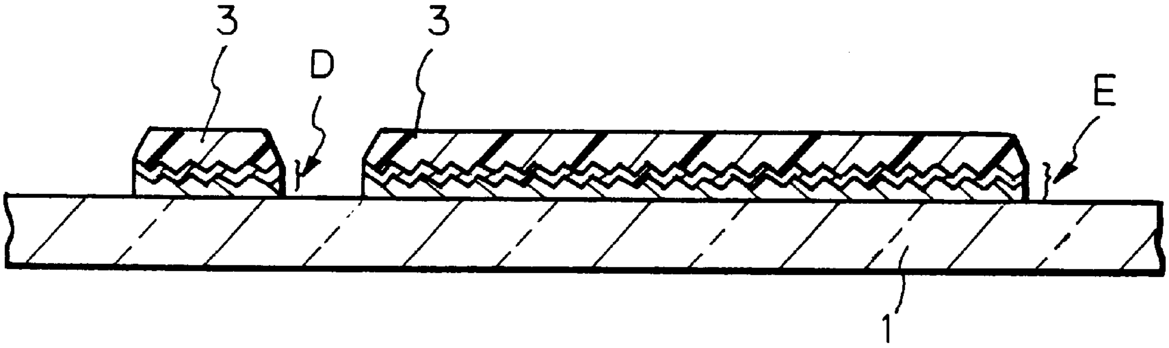


Fig. 19C

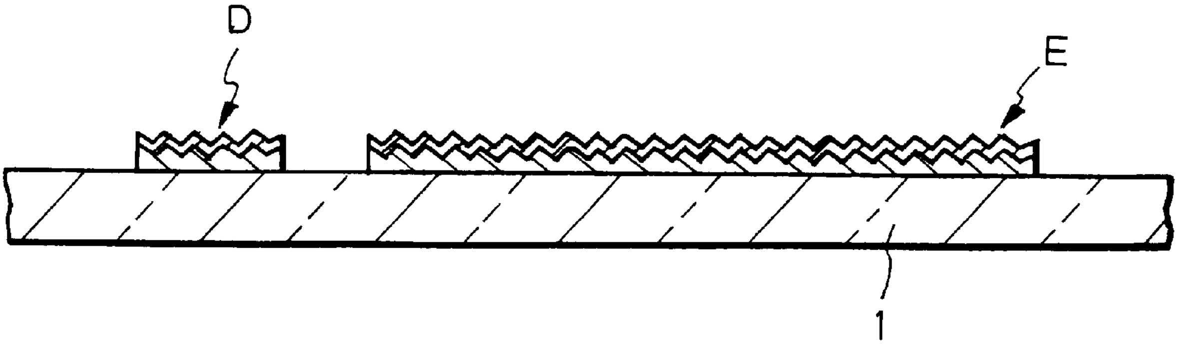


Fig. 19D

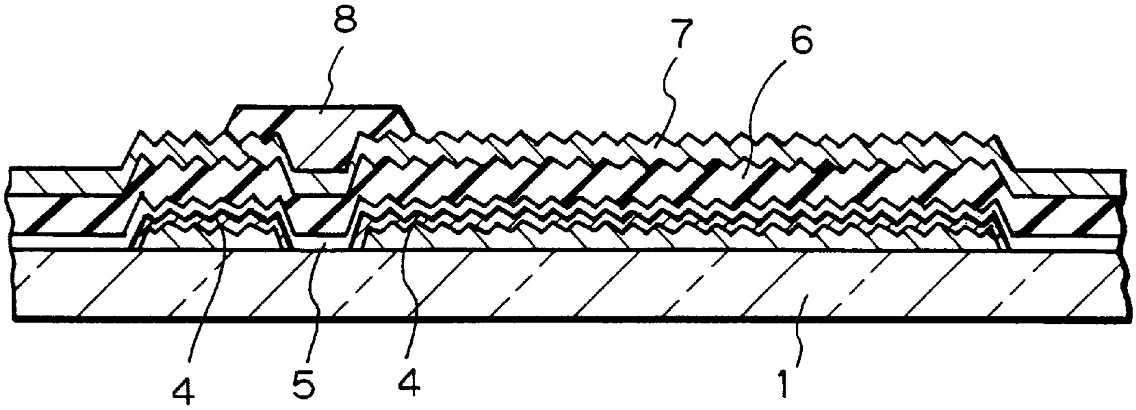


Fig. 19E

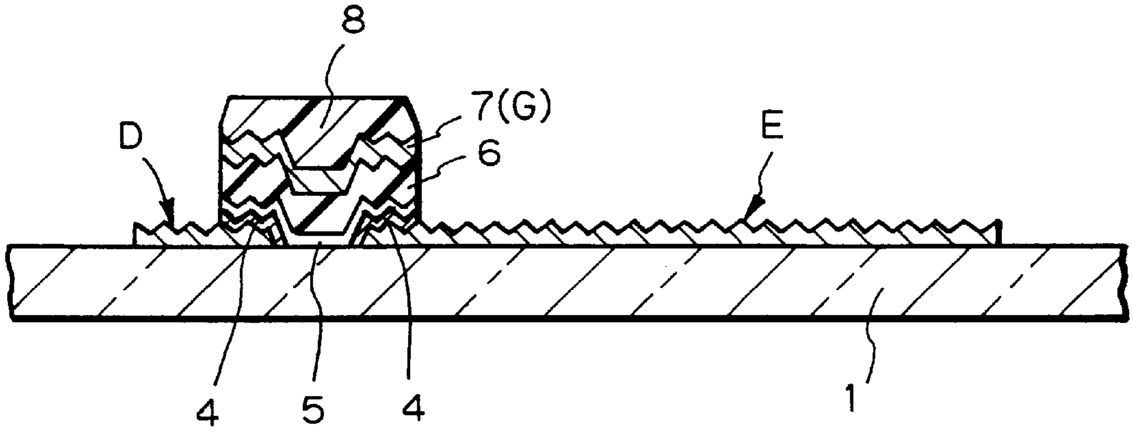


Fig. 19F

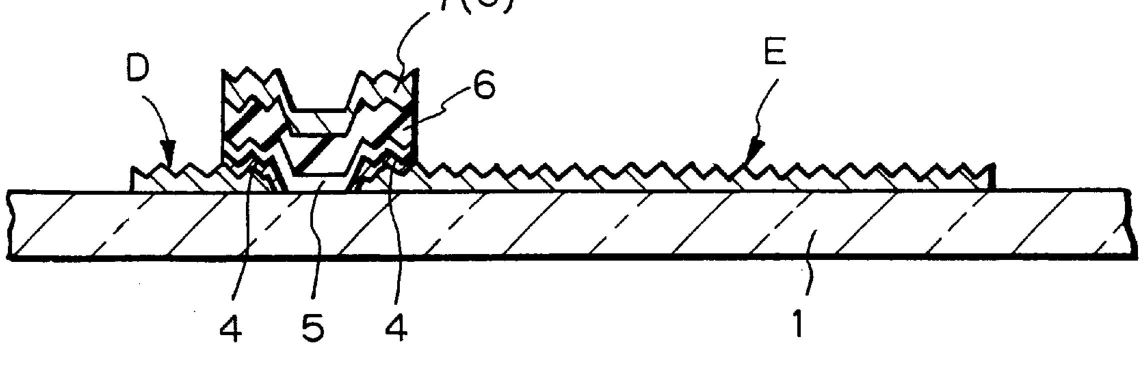
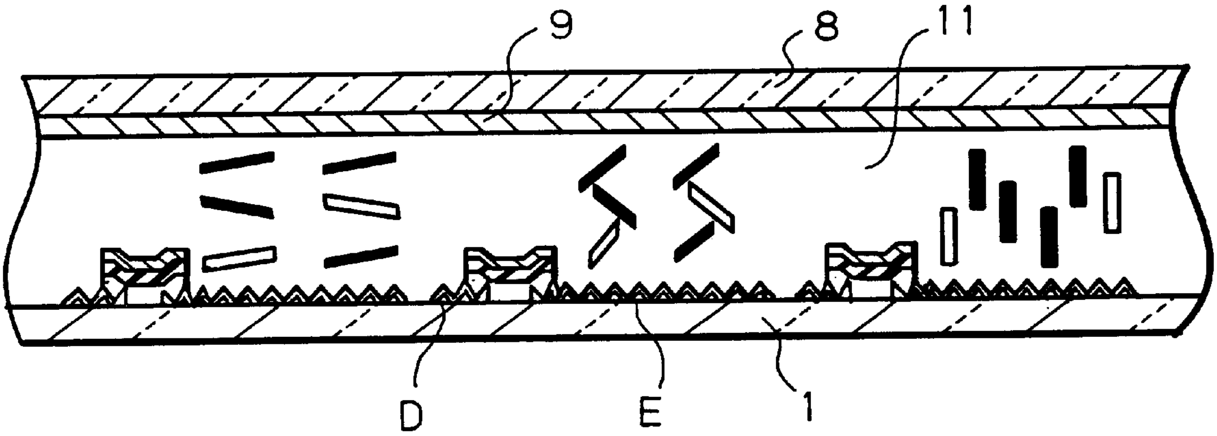


Fig. 19G



REFLECTIVE LIQUID CRYSTAL DISPLAY APPARATUS WITH LOW MANUFACTURING COST

This is a divisional of application Ser. No. 08/906,256 filed Aug. 5, 1997, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a reflective liquid crystal display (LCD) apparatus.

2. Description of the Related Art

LCD apparatuses are divided into light penetration type LCD apparatuses requiring backlights and reflective LCD apparatuses reflecting environmental light.

In the reflective LCD apparatuses, in order to obtain high display quality, the efficiency of reflecting and scattering environmental light is important. Also, since available environmental light is limited, the loss of light has to be reduced. Particularly, in a colored LCD apparatus using color filters, the loss of light is large.

In a prior art reflective LCD apparatus (see Naohito Kimura, "Colored Reflection type LCD", Semiconductor World, pp. 108–112, Feb. 1995), inverted staggered thin film transistors (TFTs) where gate electrodes are beneath amorphous silicon layers are formed on a glass substrate. Further, a photosensitive acrylic resin layer having an uneven surface is formed on the TFTs. Also, pixel electrodes made of aluminum are formed on the photosensitive acrylic resin layer and each of the pixel electrodes is connected to one of the source electrodes. A counter glass substrate is prepared, and a transparent common electrode is formed on the glass substrate.

After orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates, the two substrates are adhered to each other with a predetermined spacing therebetween, and a liquid crystal layer is then inserted into this spacing. This will be explained later in detail.

In the prior art reflective LCD apparatus, since the photosensitive acrylic resin layer has an uneven surface, the pixel electrodes also have uneven surfaces, so that the pixel electrodes serve as optical reflecting means as well as optical scattering means. Therefore, the scattering characteristics of reflected light can be improved to make the brightness of reflected light uniform over a broad visual angle. In addition, since the pixel electrodes are formed over the TFTs, effective use can be made of reflected light, thus increasing the numerical aperture. Further, if guest-host (G-H) liquid crystal which does not require polarization plates is used, a brighter display can be obtained.

In order to manufacture the prior art reflective LCD apparatus, however, a large number of photolithography and etching processes are required due to the complex configuration of the pixel electrodes, thus increasing the manufacturing cost.

SUMMARY OF THE INVENTION

It is an object of the present invention to reduce the manufacturing cost of a reflective LCD apparatus.

According to the present invention, in a reflective liquid crystal apparatus, a drain electrode and a source electrode are formed on a insulating substrate and are formed by an aluminum alloy layer. The source electrode serves as a light

reflecting pixel electrode. Also, a non-doped semiconductor layer is formed on a part of the drain electrode and a part of the source electrode, and impurity-doped semiconductor layers are formed between the drain and source electrodes and the non-doped semiconductor layer. Further, a gate electrode is formed via a gate insulating layer on the non-doped semiconductor layer. In addition, a counter common electrode is formed on a transparent insulating substrate, and a liquid crystal layer is interposed between the insulating substrate and the transparent insulating substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more clearly understood from the description as set forth below, as compared with the prior art, with reference to the accompanying drawings, wherein:

FIG. **1** is a cross-sectional view illustrating a prior art reflective LCD apparatus;

FIGS. **2**A through **2**G are cross-sectional views illustrating a first embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **3**A through **3**G are cross-sectional views illustrating a second embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **4**A through **4**G are cross-sectional views illustrating a third embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **5**A through **5**G are cross-sectional views illustrating a fourth embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **6**A through **6**G are cross-sectional views illustrating a fifth embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **7**A, **7**B, **7**C, **7**D and **7**E are cross-sectional views illustrating modifications of the apparatuses of FIGS. **2**G, **3**G, **4**G, **5**G and **6**G, respectively;

FIGS. **8**A, **8**B, **8**C, **8**D and **8**E are cross-sectional views illustrating modifications of the apparatuses of FIGS. **2**G, **3**G, **4**G, **5**G and **6**G, respectively;

FIGS. **9**A, **9**B, **9**C, **9**D and **9**E are cross-sectional views illustrating modifications of the apparatuses of FIGS. **2**G, **3**G, **4**G, **5**G and **6**G, respectively;

FIGS. **10**A, **10**B, **10**C, **10**D and **10**E are cross-sectional views illustrating modifications of the apparatuses of FIGS. **2**G, **3**G, **4**G, **5**G and **6**G, respectively;

FIGS. **11**A through **11**G are cross-sectional views illustrating a sixth embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **12**A through **12**G are cross-sectional views illustrating a seventh embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **13**A through **13**G are cross-sectional views illustrating an eighth embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **14**A through **14**G are cross-sectional views illustrating a ninth embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **15**A through **15**G are cross-sectional views illustrating a tenth embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **16**A through **16**G are cross-sectional views illustrating an eleventh embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **17**A through **17**G are cross-sectional views illustrating a twelfth embodiment of the reflective LCD apparatus according to the present invention;

FIGS. **18**A through **18**G are cross-sectional views illustrating a thirteenth embodiment of the reflective LCD apparatus according to the present invention; and

FIGS. **19**A through **19**G are cross-sectional views illustrating a fourteenth embodiment of the reflective LCD apparatus according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Before the description of the preferred embodiments, a prior art reflective LCD apparatus will be explained next with reference to FIG. **1** (see Naohito Kimura, "Colored Reflection type LCD", Semiconductor World, pp. 108–112, Feb. 1995).

In FIG. **1**, a conductive layer **102** made of Cr or the like is formed on a glass substrate **101**, and is patterned to form gate electrodes. Then, a gate insulating layer **103** made of silicon nitride is formed on the gate electrodes **103**. Also, an amorphous silicon layer **104** is formed as a semiconductor layer on the gate insulating layer **103**, and a passivation layer **105** is formed on the amorphous silicon layer **104**. Further, a conductive layer is formed thereon and is patterned to form drain electrodes **106**D and source electrodes **106**S. Also, N+-type regions **107** are formed between the amorphous silicon layer **104** and the drain electrodes **106**D (the source electrodes **106**S). Thus, inverted staggered TETs where the gate electrodes **102** are beneath the amorphous silicon layer **104** are formed.

Further, a photosensitive acrylic resin layer **108** having an uneven surface is formed on the TFTs. Also, pixel electrodes **109** made of aluminum are formed on the photosensitive acrylic resin layer **108** and each of the pixel electrodes **109** is connected to one of the source electrodes **106**S.

In addition, a counter glass substrate **110** is prepared, and a transparent common electrode **111** is formed on the glass substrate **110**.

After orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **101** and **110**, the two substrates **101** and **110** are adhered to each other with a predetermined spacing therebetween and then, a liquid crystal layer **112** is inserted into this spacing.

In FIG. **1**, since the photosensitive acrylic resin layer **108** has an uneven surface, the pixel electrodes **109** also have uneven surfaces, so that the pixel electrodes **109** serve as optical reflecting means as well as optical scattering means. Therefore, the scattering characteristics of reflected light can be improved to make the brightness of reflected light uniform over a broad visual angle. In addition, since the pixel electrodes **109** are formed over the TETs, effective use can be made of reflected light, thus increasing the numerical aperture. Further, if guest-host (G-H) liquid crystal which does not require polarization plates is used, a brighter display can be obtained.

In order to manufacture the reflective LCD apparatus of FIG. **1**, however, a large number of photolithography and etching processes, i.e., five processes in this case, are required due to the complex configuration of the pixel electrodes **109**, thus increasing the manufacturing cost.

A first embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **2**A through **2**G.

First, referring to FIG. **2**A, an about 100 nm thick Al—Nd—Si alloy layer **2** is deposited by a sputtering process on a glass substrate **1**. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIG. **2**B, the aluminum alloy layer **2** is etched by a wet etching process using a phosphoric acid/nitric acid solution with a mask of the photoresist pattern **3**. As a result, a drain electrode **2**(D) and a pixel electrode **2**(E) are formed by the aluminum layer **2**. In this case, the side edges of the drain electrode **2**(D) and the pixel electrode **2**(E) are tapered. Note that, if a dry etching process using Cl_2 gas is performed upon the aluminum alloy layer **2**, the side edges of the drain electrode **2**(D) and the pixel electrode **2**(E) are not tapered.

Next, referring to FIG. **2**C, the photoresist pattern **3** is removed.

Next, referring to FIG. **2**D, a thin natural oxide layer (not shown) formed on the drain electrode **2**(D), and the pixel electrode **2**(E), and then, the natural oxide layer is etched by a sputtering process using inert gas or by a chemical etching process using halogen gas. Immediately after that, a phosphor rich amorphous silicon layer, i.e., an about **5** nm thick N+-type amorphous silicon layer **4** is deposited by a PCVD process using pH_3 (phosphin) gas added by a very small amount of SiH_4 (monosilane) gas only on the drain electrode **2**(D) and the pixel electrode **2**(E). Note that the N+-type amorphous silicon layer **4** can be formed by a PH_3 plasma-doping process.

Subsequently, an about 50 nm thick I-type (non-doped) amorphous silicon layer **5** is deposited by a PCVD process using SiH_4 gas and H_2 gas on the entire surface. In addition, an about 300 nm thick silicon nitride layer **6** serving as a gate insulating layer is deposited by a PCVD process using SiH_4 gas, NH_3 gas and N_2 gas. Note that all the above-mentioned PCVD processes are carried out in the same PCVD apparatus.

Then, an about 100 nm thick Al—Nd—Si alloy layer **7** is deposited by a sputtering process on the silicon nitride layer **6**. Then, a photoresist pattern **3A** corresponding to a gate electrode is formed on the aluminum alloy layer **7**.

Next, referring to FIG. **2**E, the aluminum alloy layer **7** is etched by a wet etching process using phosphoric acid/nitric acid solution with a mask of the photoresist pattern **3A** to form a gate electrode **7**(G). Note that the aluminum alloy layer **7** can be etched by a dry etching process using Cl_2 gas. Then, the silicon nitride layer **6**, the I-type amorphous silicon layer **5**, and the N+-type amorphous silicon layer **4** are sequentially etched by a dry etching process using CF_4 gas and O_2 gas with a mask of the photoresist pattern **3A**. Thus, an island is formed. Also, since the aluminum alloy layer **2** is not etched by the above-mentioned dry etching process using fluorine gas, the drain electrode **2**(D) and the pixel electrode **2**(E) outside of the island are exposed.

Next, referring to FIG. **2**F, the photoresist pattern **3A** is removed. Thus, the island for a staggered TFT where the gate electrode **7**(G) is below the amorphous silicon layer **5** is formed.

Finally, referring to FIG. **2**G, a counter glass substrate **8** having an uneven (rough) surface is prepared. For example, the surface of the glass substrate **8** is made uneven by using a sand blast method. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing. Then, the device is sealed by an ultraviolet-setting resin.

In the first embodiment as illustrated in FIGS. **2**A through **2**G, only two photolithography and etching processes are carried out, thus reducing the manufacturing cost.

Also, in FIGS. **2**A through **2**G, since Si, which is the same component as in the N+-type amorphous silicon layer **4** and the amorphous silicon layer **6**, is included in the aluminum alloy layers **2** and **7**, the diffusion of aluminum atom and silicon atoms can be suppressed, thus avoiding the deterioration of the characteristics of the TFT. In addition, since Nd is included in the aluminum alloy layers **2** and **7**, the high temperature resistance and anti-electromigration characteristics of the aluminum alloy layers **2** and **7** can be improved. Further, incident light is-scattered at the counter glass substrate **8**, and penetrates the liquid crystal layer **11**. Then, the light is reflected by the pixel electrode **2**(E), and is further scattered at the counter glass substrate **8**. In this case, the transmittance of the light through the liquid crystal layer **11** is controlled by the liquid crystal layer **11**. Further, since the liquid crystal layer **11** uses guest-host liquid crystal where a color pigment (guest) is mixed into twisted-neumatic (TN) liquid crystal (host) and the absortion of light by the guest is controlled by the viscosity of the host, the polarization plates are unnecessary and a bright display can be obtained.

A second embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **3**A through **3**G.

First, referring to FIG. **3**A, an about 20 nm thick Mo layer **12** is deposited by a sputtering process on a glass substrate **1**. Then, an about 80 nm thick Al—Nd—Si alloy layer **2** is deposited by a sputtering process on the Mo layer **12**. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIG. **3**B, the aluminum alloy layer **2** and the Mo layer **12** are etched by a wet etching process using phosphoric acid/nitric acid solution with a mask of the photoresist pattern **3**. As a result, a drain electrode D and a pixel electrode E are formed by the aluminum layer **2** and the Mo layer **2**. In this case, the side edges of the drain electrode D and the pixel electrode E are tapered. Note that, if a dry etching process using Cl_2 gas is performed upon the aluminum alloy layer **2** and the Mo layer **12**, the side edges of the drain electrode D and the pixel electrode E are not tapered.

Next, referring to FIG. **3**C, the photoresist pattern **3** is removed.

Next, referring to FIG. **3**D, a phosphor rich amorphous silicon layer, i.e., an about 5 nm thick N+-type amorphous silicon layer **4** is deposited by a PCVD process using PH_3 gas added by a very small amount of SiH_4 gas only on the drain electrode D and the pixel electrode E. Note that the N+-type amorphous silicon layer **4** can be-formed by a PH_3 plasma-doping process.

Subsequently, an about 50 nm thick I-type (non-doped) amorphous silicon layer **5** is deposited by a PCVD process using SiH_4 gas and H_2 gas on the entire surface. In addition, an about 300 nm thick silicon nitride layer **6** serving as a gate insulating layer is deposited by a PCVD process using SiH_4 gas, NH_3 gas and N_2 gas. Note that all the above-mentioned PCVD processes are carried out in the same PCVD apparatus.

Then, an about 100 nm thick Al—Nd—Si alloy layer **7** is deposited by a sputtering process on the silicon nitride layer **6**. Then, a photoresist pattern **3**A corresponding to a gate electrode is formed on the aluminum alloy layer **7**.

Next, referring to FIG. **3**E, the aluminum alloy layer **7** is etched by a wet etching process using phosphoric acid/nitric acid solution with a mask of the photoresist pattern **3**A to form a gate electrode **7**(G). Note that the aluminum alloy layer **7** can be etched by a dry etching process using Cl_2 gas. Then, the silicon nitride layer **6**, the I-type amorphous silicon layer **5**, and the N+-type amorphous silicon layer **4** are sequentially etched by a dry etching process using CF_4 gas and O_2 gas with a mask of the photoresist pattern **8**. Thus, an island is formed. Also, since the aluminum alloy layer **2** is not etched by the above-mentioned dry etching process using fluorine gas, the drain electrode D and the pixel electrode E outside of the island are exposed.

Next, referring to FIG. **3**F, the photoresist pattern **3**A is removed. Thus, the island for a staggered TFT where the gate electrode **7**(G) is below the amorphous silicon layer **5** is formed.

Finally, referring to FIG. **3**G, a counter glass substrate **8** having an uneven surface is prepared. For example, the surface of the glass substrate **8** is made uneven by using a sand blast method. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing, and the device is sealed by an ultraviolet-setting resin.

Also, in the first embodiment, the aluminum alloy layer **2** has a bad ohmic contact characteristic to the N+-type amorphous silicon layer **4**, while in the second embodiment, the Mo layer **12** has good ohmic contact characteristics to the aluminum alloy layer **2** and the N+-type amorphous silicon layer **4**. Therefore, the aluminum alloy layer **2** can be electrically connected effectively via the Mo layer **12** to the N+-type amorphous silicon layer **4**.

In the second embodiment as illustrated in FIGS. **3**A through **3**G, although a step for forming the Mo layer **12** as an ohmic contact material for th N+-type amorphous silicon layer **4** is added to the first embodiment, only two photolithography and etching processes are carried out. In addition, the Mo layer **12** and the aluminum alloy layer **2** are sequentially formed in the same sputtering apparatus. Therefore, the manufacturing cost can be reduced.

Also, in FIGS. **3**A through **3**G, in the same way as in FIGS. **2**A through **2**G, the diffusion of aluminum atoms and silicon atoms can be suppressed, thus avoiding the deterioration of the characteristics of the TFT. In addition, the high temperature resistance and anti-electromigration characteristics of the aluminum alloy layers **2** and **7** can be improved. Further, polarization plates are unnecessary and a bright display can be obtained.

A third embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **4**A through **4**G.

First, referring to FIG. **4**A, an about 80 nm thick Al—ND—Si alloy layer **2** is deposited by a sputtering process on a glass substrate **1**. Then, an about 20 nm thick

Mo layer **12** is deposited by a sputtering process on the aluminum alloy layer **2**. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIG. **4**B, the Mo layer **12** and the aluminum alloy layer **2** are etched by a wet etching process using a phosphoric acid/nitric acid solution with a mask of the photoresist pattern **3**. As a result, a drain electrode D and a pixel electrode E are formed by the Mo layer **12** and the aluminum alloy layer **2**. In this case, the side edges of the drain electrode D and the pixel electrode E are tapered. Note that, if a dry etching process using Cl_2 gas is performed upon the Mo layer **12** and the aluminum alloy layer **2**, the side edges of the drain electrode D and the pixel electrode E are not tapered.

Next, referring to FIG. **4**C, the photoresist pattern **3** is removed.

Next, referring to FIG. **4**D, a phosphor rich amorphous silicon layer, i.e., an about 5 nm thick N+-type amorphous silicon layer **4** is deposited by a PCVD process using PH_3 gas added by a very small amount of SiH_4 gas only on the drain electrode D and the pixel electrode E. Note that the N+-type amorphous silicon layer **4** can be formed by a PH_3 plasma-doping process.

Subsequently, an about 50 nm thick I-type (non-doped) amorphous silicon layer **5** is deposited by a PCVD process using SiH_4 gas and H_2 gas on the entire surface. In addition, an about 300 nm thick silicon nitride layer **6** serving as a gate insulating layer is deposited by a PCVD process using SiH_4 gas, NH_3 gas and N_2 gas. Note that all the above-mentioned PCVD processes are carried out in the same PCVD apparatus.

Then, an about 100 nm thick Al—Nd—Si alloy layer **7** is deposited by a sputtering process on the silicon nitride layer **6**. Then, a photoresist pattern **3**A corresponding to a gate electrode is formed on the aluminum alloy layer **7**.

Next, referring to FIG. **4**E, the aluminum alloy layer **7** is etched by a wet etching process using a phosphoric acid/nitric acid solution with a mask of the photoresist pattern **3**A to form a gate electrode **7**(G). Note that the aluminum alloy layer **7** can be etched by a dry etching process using Cl_2 gas. Then, the silicon nitride layer **6**, the I-type amorphous silicon layer **5**, the N+-type amorphous silicon layer **4** and the Mo layer **12** are sequentially etched by a dry etching process using CF_4 gas and O_2 gas with a mask of the photoresist pattern **3**A. Thus, an island is formed. Also, since the Mo layer **12** is etched but the aluminum alloy layer **2** is not etched by the above-mentioned dry etching process using fluorine gas, the drain electrode D and the pixel electrode E outside of the island are exposed.

Next, referring to FIG. **4**F, the photoresist pattern **3**A is removed. Thus, the island for a staggered TFT where the gate electrode **7**(G) is below the amorphous silicon layer **5** is formed.

Finally, referring to FIG. **4**G, a counter glass substrate **8** having an uneven surface is prepared. For example, the surface of the glass substrate **8** is made uneven by using a sand blast method. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing, and the device is sealed by an ultraviolet-setting resin.

Even in the third embodiment as illustrated in FIGS. **4**A through **4**G, although a step for forming the Mo layer **12** as an ohmic contact material for th N+-type amorphous silicon layer **4** is added to the first embodiment, only two photolithography and etching processes are carried out. In addition, the aluminum alloy layer **2** and the Mo layer **12** are sequentially formed in the same sputtering apparatus. Therefore, the manufacturing cost can be reduced.

Also, in the third embodiment, the Mo layer **12** has good ohmic contact characteristics to the aluminum alloy layer **2** and the N+-type amorphous silicon layer **4**. Therefore, the aluminum alloy layer **2** can be electrically connected effectively via the Mo layer **12** to the N+-type amorphous silicon layer **4**.

Note that, since the Mo layer **12** on the aluminum alloy layer **2** outside of the island is etched, the aluminum alloy layer **2** completely serves as reflecting means.

Also, in FIGS. **4**A through **4**G, in the same way as in FIGS. **2**A through **2**G, the diffusion of aluminum atoms and silicon atoms can be suppressed, thus avoiding the deterioration of the characteristics of the TFT. In addition, the high temperature resistance and anti-electromigration characteristics of the aluminum alloy layers **2** and **7** can be improved. Further, polarization plates are unnecessary and a bright display can be obtained.

A fourth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **5**A through **5**G. In FIGS. **5**A through **5**G, an indium tin oxide (ITO) layer is used instead of the Mo layer **12** of FIGS. **3**A through **3**G.

First, referring to FIG. **5**A, an about 20 nm thick ITO layer **13** is deposited by a sputtering process on a glass substrate **1**. Then, an about 80 nm thick Al—Nd—Si alloy layer **2** is deposited by a sputtering process on the ITO layer **13**. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIG. **5**B, the aluminum alloy layer **2** and the ITO layer **13** are etched by a dry etching process using Cl_2 gas, CF_4 gas and H_2 gas with a mask of the photoresist pattern **3**. As a result, a drain electrode D and a pixel electrode E are formed by the aluminum alloy layer **2** and the ITO layer **13**. In this case, the side edges of the drain electrode D and the pixel electrode E are not tapered.

Next, referring to FIG. **5**C, the photoresist pattern **3** is removed.

Next, referring to FIG. **5**D, a phosphor rich amorphous silicon layer, i.e., an about 5 nm thick N+-type amorphous silicon layer **4** is deposited by a PCVD process using PH_3 gas added by a very small amount of SiH_4 gas only the drain electrode D and the pixel electrode E. Note that the N+-type amorphous silicon layer **4** can be formed by a PH_3 plasma-doping process.

Subsequently, an about 50 nm thick I-type (non-doped) amorphous silicon layer **5** is deposited by a PCVD process using SiH_4 gas and H_2 gas on the entire surface. In addition, an about 300 nm thick silicon nitride layer **6** serving as a gate insulating layer is deposited by a PCVD process using SiH_4 gas, NH_3 gas and N_2 gas. Note that all the above-mentioned PCVD processes are carried out in the same PCVD apparatus.

Then, an about 100 nm thick Al—Nd—Si alloy layer **7** is deposited by a sputtering process on the silicon nitride layer

6. Then, a photoresist pattern **3**A corresponding to a gate electrode is formed on the aluminum alloy layer **7**.

Next, referring to FIG. **5**E, the aluminum alloy layer **7** is etched by a wet etching process using a phosphoric acid/nitric acid solution with a mask of the photoresist pattern **3**A to form a gate electrode **7**(G). Note that the aluminum alloy layer **7** can be etched by a dry etching process using Cl_2 gas. Then, the silicon nitride layer **6**, the I-type amorphous silicon layer **5**, and the N+-type amorphous silicon layer **4** are sequentially etched by a dry etching process using CF_4 gas and O_2 gas with a mask of the photoresist pattern **3**A. Thus, an island is formed. Also, since the aluminum alloy layer **2** is not etched by the above-mentioned dry etching process using fluorine gas, the drain electrode D and the pixel electrode E outside of the island are exposed.

Next, referring to FIG. **5**F, the photoresist pattern **3**A is removed. Thus, the island for a staggered TFT **20** where the gate electrode **7**(G) is below the amorphous silicon layer **5** is formed.

Finally, referring to FIG. **5**G, a counter glass substrate **8** having an uneven surface is prepared. For example, the surface of the glass substrate **8** is made uneven by using a sand blast method. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing, and the device is sealed by an ultraviolet-setting resin.

In the fourth embodiment as illustrated in FIGS. **5**A through **5**G, although a step for forming the ITO layer **13** as an ohmic contact material for the N+-type amorphous silicon layer **4** is added to the first embodiment, only two photolithography and etching processes are carried out. In addition, the ITO layer **13** and the aluminum alloy layer **2** are sequentially formed in the same sputtering apparatus. Therefore, the manufacturing cost can be reduced.

Also, in the fourth embodiment, the ITO layer **13** has good ohmic contact characteristics to the N+-type amorphous silicon layer **4**. Therefore, the aluminum alloy layer **2** can be electrically connected effectively via the ITO layer **13** to the N+-type amorphous silicon layer **4**.

Also, in FIGS. **5**A through **5**G, in the same way as in FIGS. **2**A through **2**G, the diffusion of aluminum atoms and silicon atoms can be suppressed, thus avoiding the deterioration of the characteristics of the TET. In addition, the high temperature resistance and anti-electromigration characteristics of the aluminum alloy layers **2** and **7** can be improved. Further, polarization plates are unnecessary and a bright display can be obtained.

A fifth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **6**A through **6**G. In FIGS. **6**A through **6**G, an ITO layer is used instead of the Mo layer **12** of FIGS. **4**A through **4**G.

First, referring to FIG. **6**A, an about 80 nm thick Al—Nd—Si alloy layer **2** is deposited by a sputtering process on a glass substrate **1**. Then, an about 20 nm thick ITO layer **13** is deposited by a sputtering process on the aluminum alloy layer **2**. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIG. **6**B, the ITO layer **13** and the aluminum alloy layer **2** are etched by a dry etching process using Cl_2 gas, CF_4 gas and H_2 gas with a mask of the photoresist pattern **3**. As a result, a drain electrode D and a pixel electrode E are formed by the ITO layer **13** and the aluminum alloy layer **2**. In this case, the side edges of the drain electrode D and the pixel electrode E are not tapered.

Next, referring to FIG. **6**C, the photoresist pattern **3** is removed.

Next, referring to FIG. **6**D, a phosphor rich amorphous silicon layer, i.e., an about 5 nm thick N+-type amorphous silicon layer **4** is deposited by a PCVD process using PH_3 gas added by a very small amount of SiH_4 gas only the drain electrode D and the pixel electrode E. Note that the N^4-type amorphous silicon layer **4** can be formed by a PH_3 plasma-doping process.

Subsequently, an about 50 nm thick I-type (non-doped) amorphous silicon layer **5** is deposited by a PCVD process using SiH_4 gas and H_2 gas on the entire surface. In addition, an about 300 nm thick silicon nitride layer **6** serving as a gate insulating layer is deposited by a PCVD process using SiH_4 gas, NH_3 gas and N_2 gas. Note that all the-above-mentioned PCVD processes are carried out in the same PCVD apparatus.

Then, an about 100 nm thick Al—Nd—Si alloy layer **7** is deposited by a sputtering process on the silicon nitride layer **6**. Then, a photoresist pattern **3**A corresponding to a gate electrode is formed on the aluminum alloy layer **7**.

Next, referring to FIG. **6**E, the aluminum alloy layer **7** is etched by a wet etching process using a phosphoric acid/nitric acid solution with a mask of the photoresist pattern **3**A to form a gate electrode **7**(G). Note that the aluminum alloy layer **7** can be etched by a dry etching process using Cl_2 gas. Then, the silicon nitride layer **6**, the I-type amorphous silicon layer **5**, and the N+-type amorphous silicon layer **4** are sequentially etched by a dry etching process using CF_4 gas and O_2 gas with a mask of the photoresist pattern **3**A. Thus, an island is formed. Also, since the ITO layer **13** is not etched by the above-mentioned dry etching process using fluorine gas, the drain electrode D and the pixel electrode E outside of the island are exposed. Note that, since the ITO layer **13** is transparent, even if the ITO layer **13** remains in the drain electrode D and the pixel electrode E, the aluminum alloy layer **2** can completely serve as reflecting means.

Next, referring to FIG. **6**F, the photoresist pattern **3**A is removed. Thus, the island for a staggered TFT where the gate electrode **7**(G) is below the amorphous silicon layer **5** is formed.

Finally, referring to FIG. **6**G, a counter glass substrate **8** having an uneven surface is prepared. For example, the surface of the glass substrate **8** is made uneven by using a sand blast method. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing, and the device is sealed by an ultraviolet-setting resin.

In the fifth embodiment as illustrated in FIGS. **6**A through **6**G, although a step for forming the ITO layer **13** as an ohmic contact material for the N+-type amorphous silicon layer **4** is added to the first embodiment, only two photolithography and etching processes are carried out. In addition, the ITO layer **13** and the aluminum alloy layer **2** are sequentially formed in the same sputtering apparatus. Therefore, the manufacturing cost can be reduced.

Also, in the fifth embodiment, the ITO layer **13** has a good ohmic contact characteristics to the N+-type amorphous silicon layer **4**. Therefore, the aluminum alloy layer **2** can be electrically connected effectively via the ITO layer **13** to the N+-type amorphous silicon layer **4**.

Also, in FIGS. **6**A though **6**G, in the same way as in FIGS. **2**A through **2**G, the diffusion of aluminum atoms and silicon atoms can be suppressed, thus avoiding the deterioration of the characteristics of the TET. In addition, the high temperature resistance and anti-electromigration characteristics of the aluminum alloy layers **2** and **7** can be improved. Further, polarization plates are unnecessary and a bright display can be obtained.

In FIGS. **7**A through **7**E, which are modifications of the apparatuses of FIGS. **2**G, **3**G, **4**G, **5**G and **6**G, respectively, an opposite surface of the counter glass substrate **8** on which the transparent common electrode **9** is formed is made uneven. Even in this case, the same light scattering effect can be expected.

In FIGS. **8**A through **8**E, which are also modifications of the apparatuses of FIGS. **2**G, **3**G, **4**G, **5**G and **6**G, respectively, both surfaces of the counter glass substrate **8** are made uneven. Even in this case, the same light scattering effect can be expected.

In FIGS. **9**A through **9**E, which are further modifications of the apparatuses of FIGS. **2**G, **3**G, **4**G, **5**G and **6**G, respectively, a transparent insulating layer **14** made of photosensitive acrylic resin or polyimide resin having an uneven surface is formed on the TETs instead of providing an uneven surface on the counter glass substrate **8**. Note that a large difference in refractive index between the transparent insulating layer **14** and the liquid crystal layer **11** enhances the light scattering effect. Even in this case, the same light scattering effect can be expected.

In FIGS. **10**A through **10**E, which are still further modifications of the apparatuses of FIGS. **2**G, **3**G, **4**G, **5**G and **6**G, respectively, a transparent insulating layer **15** is formed on the TETs instead of providing an uneven surface on the counter glass substrate **8**. In this case, the transparent insulating layer **15** is formed by spin-coating polyimide resin including light scattering particles (beeds) **15***a*. Even in this case, the same light scattering effect can be expected.

A sixth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **11**A through **11**G. Note that the sixth embodiment is a modification of the first embodiment as illustrated in FIGS. **2**A through **2**G.

First, referring to FIG. **11**A, an about 200 nm thick Al—Si alloy layer **2'** is deposited by a sputtering process at a substrate temperature higher than 150° C. on a glass substrate **1**. As a result, the surface of the aluminum alloy layer **2'** is made uneven and turbid as aluminum crystal grains grow. In this case, the higher the substrate temperature, the larger the aluminum grain size. Also, the thicker the aluminum alloy layer **2'**, the larger the aluminum crystal grain size. However, if the aluminum alloy layer **2'** is too thick, the coverage characteristics of PCVD layers which will be formed thereon become deteriorated. Thus, the aluminum alloy layer **2'** can serve as light scattering means as well as light reflecting means. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIGS. **11**B through **11**F, the same operations as in the steps as illustrated in FIGS. **2**B through **2**F are carried out.

Finally, referring to FIG. **11**G, a counter glass substrate **8** is prepared. In this case, the surfaces of the counter glass substrate **8** are both flat. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing, and the device is sealed by an ultraviolet-setting resin.

In the sixth embodiment the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

A seventh embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **12**A through **12**G. Note that the seventh embodiment is another modification of the first embodiment as illustrated in FIGS. **2**A through **2**G.

Referring to FIGS. **12**A through **12**E, the same operations as in the steps illustrated in FIGS. **2**A through **2**E are carried out.

Also, at a step as illustrated in FIG. **12**E, the aluminum alloy layer **2** is etched by a dry etching process using Cl_2 gas and H_2 gas, to make the surface of the aluminum alloy layer **2** uneven. Note that this dry etching process can be sequentially carried out with the dry etching process for etching the silicon nitride layer **6**, the amorphous silicon layer **5** and the N+-type amorphous silicon layer **4**.

Finally, referring to FIG. **12**G, the same operation as in a step illustrated in FIG. **11**G is carried out.

Even in the seventh embodiment, the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

An eighth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **13**A through **13**G. Note that the eighth embodiment is a modification of the second embodiment as illustrated in FIGS. **3**A through **3**G.

First, referring to FIG. **13**A, an about 200 nm thick Mo layer **12** is deposited by a sputtering process on a glass substrate **1**. Then, an about 80 nm thick Al—Si alloy layer **2'** is deposited by a sputtering process at a substrate temperature higher than 150° C. on the Mo layer **12**. As a result, the surface of the aluminum alloy layer **2'** is made uneven and turbid as aluminum crystal grains grow. Thus, the aluminum alloy layer **2'** can serve as light scattering means as well as light reflecting means. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIGS. **13**B through **13**F, the same operations as in the steps illustrated in FIGS. **3**B through **3**F are carried out.

Finally, referring to FIG. **13**G, a counter glass substrate **8** is prepared. In this case, the surfaces of the counter glass substrate **8** are both flat. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing. Then, the device is sealed by an ultraviolet-setting resin.

In the eighth embodiment the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

A ninth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **14**A through **14**G. Note that the ninth embodiment is another modification of the second embodiment as illustrated in FIGS. **3**A through **3**G.

Referring to FIGS. **14**A through **14**E, the same operations at the steps as illustrated in FIGS. **3**A through **3**E.

Also, at a step as illustrated in FIG. **14**E, the aluminum alloy layer **2** is etched by a dry etching process using Cl_2 gas and H_2 gas, to make the surface of the aluminum alloy layer **2** uneven. Note that this dry etching process can be sequentially carried out with the dry etching process for etching the silicon nitride layer **6**, the amorphous silicon layer **5** and the N+-type amorphous silicon layer **4**.

Finally, referring to FIG. **14**G, the same operation as in a step illustrated in FIG. **13**G is carried out.

Even in the ninth embodiment, the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

A tenth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **15**A through **15**G. Note that the tenth embodiment is a modification of the third embodiment as illustrated in FIGS. **4**A through **4**G.

First, referring to FIG. **15**A, an about 80 nm thick Al—Si alloy layer **2'** is deposited by a sputtering process at a substrate temperature higher than 150° C. on a glass substrate **1**. Then, an about 20 nm thick Mo layer **12** on the aluminum alloy layer **2'**. As a result, the surface of the aluminum alloy layer **2'** is made uneven and turbid as aluminum crystal grains grow. Thus, since the MO layer **12** will be removed at a later stage, the aluminum alloy layer **2'** can serve as light scattering means as well as light reflecting means. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIGS. **15**B through **15**F, the same operations as in the steps illustrated in FIGS. **3**B through **3**F are carried out.

Finally, referring to FIG. **15**G, a counter glass substrate **8** is prepared. In this case, the surfaces of the counter glass substrate **8** are both flat. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing, and the device is sealed by an ultraviolet-setting resin.

Also, in the tenth embodiment the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

An eleventh embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **16**A through **16**G. Note that the eleventh embodiment is another modification of the third embodiment as illustrated in FIGS. **4**A through **4**G.

Referring to FIGS. **16**A through **16**E, the same operations as in the steps illustrated in FIGS. **4**A through **4**E are carried out.

Also, at a step as illustrated in FIG. **16**E, the aluminum alloy layer **2** is etched by a dry etching process sing Cl_2 gas and H_2 gas, to make the surface of the aluminum alloy layer **2** uneven. Note that this dry etching process can be sequentially carried out with the dry etching process for etching the silicon nitride layer **6**, the amorphous silicon layer **5** and the N+-type amorphous silicon layer **4**.

Finally, referring to FIG. **16**G, the same operation as in a step illustrated in FIG. **15**G is carried out.

Even in the eleventh embodiment, the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

A twelfth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **17**A through **17**G. Note that the twelfth embodiment is a modification of the fourth embodiment as illustrated in FIGS. **5**A through **5**G.

First, referring to FIG. **17**A, an about 20 nm thick ITO layer **13** is deposited by a sputtering process on a glass substrate **1**. Then, an about 80 nm thick Al—Si alloy layer **2'** is deposited by a sputtering process at a substrate temperature higher than 150° C. on the ITO layer **13**. As a result, the surface of the aluminum alloy layer **2'** is made uneven and turbid as aluminum crystal grains grow. Thus, the aluminum alloy layer **2'** can serve as light scattering means as will be light reflecting means. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIGS. **17**B through **17**F, the same operations as in the steps illustrated in FIGS. **5**B through **5**F are carried out.

Finally, referring to FIG. **17**G, a counter glass substrate **8** is prepared. In this case, the surfaces of the counter glass substrate **8** are both flat. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing. Then, the device is sealed by an ultraviolet-setting resin.

Even in the twelfth embodiment the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

A thirteenth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **18**A through **18**G. Note that the thirteenth embodiment is another modification of the fourth embodiment as illustrated in FIGS. **5**A through **5**G.

Referring to FIGS. **18**A through **18**E, the same operations as in the steps illustrated in FIGS. **5**A through **5**E are carried out.

Also, at the step as illustrated in FIG. **18E**, the aluminum alloy layer **2** is etched by a dry etching process using Cl_2 gas and H_2 gas, to make the surface of the aluminum alloy layer **2** uneven. Note that this dry etching process can be sequentially carried out with the dry etching process for etching the silicon nitride layer **6**, the amorphous silicon layer **5** and the N+-type amorphous silicon layer **4**.

Finally, referring to FIG. **18G**, the same operation as in the step illustrated in FIG. **13G** is carried out.

Even in the thirteenth embodiment, the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

A fourteenth embodiment of the method for manufacturing a reflective LCD apparatus according to the present invention will be explained next with reference to FIGS. **19A** through **19G**. Note that the fourteenth embodiment is a modification of the fifth embodiment as illustrated in FIGS. **6A** through **6G**.

First, referring to FIG. **19A**, an about 80 nm thick Al—Si alloy layer **2'** is deposited by a sputtering process at a substrate temperature higher than 150° C. on a glass substrate **1**. Then, an about 20 nm thick ITO layer **13** is formed on the aluminum alloy layer **2'**. As a result, the surface of the aluminum alloy layer **2'** is made uneven and turbid as aluminum crystal grains grow. Thus, the aluminum alloy layer **2'** can serve as light scattering means as well as light reflecting means. Then, a photoresist pattern **3** corresponding to a drain electrode and a source (pixel) electrode is formed by a photolithography process.

Next, referring to FIGS. **19B** through **19F**, the same operations as in the steps illustrated in FIGS. **6B** through **6F** are carried out.

Finally, referring to FIG. **19G**, a counter glass substrate **8** is prepared. In this case, the surfaces of the counter glass substrate **8** are both flat. Then, a transparent common electrode **9** is formed on the glass substrate **8**. Then, after orientation processes including orientation layer coating processes and rubbing processes are performed upon the two substrates **1** and **8**, the two glass substrates **1** and **8** are attached to each other with a predetermined spacing therebetween defined by plastic spacers (not shown). Then, the sides of the two glass substrates **1** and **8** are adhered to each other by epoxy adhesives, and then, a guest-host liquid crystal layer **11** is inserted into this spacing. Then, the device is sealed by an ultraviolet-setting resin.

Also, in the fourteenth embodiment the formation of a light scattering means on the counter glass substrate **8** is unnecessary, which reduces the manufacturing cost.

As explained hereinabove, according to the present invention, since a drain electrode and a pixel electrode made of aluminum alloy can be simultaneously formed, the number of photolithography and etching processes can be reduced, which reduces the manufacturing cost. Note that the number of photolithography and etching processes is 2 in the above-described embodiments.

In addition, since a TFT adopts a staggered type, the light shield for the TET can be enhanced, which reduces a light OFF current.

In addition, since the drain electrode and the pixel electrode as well as a gate electrode are made of low conductive aluminum alloy, a signal delay can be suppressed even in a large scale LCD apparatus, which suppresses the deterioration of the display quality.

What is claimed is:

1. A method for manufacturing a liquid crystal display apparatus, comprising the steps of:

forming an aluminum alloy layer on an insulating substrate;

patterning said aluminum alloy layer to form a drain electrode and a source electrode, said source electrode serving as a light reflecting pixel electrode,

forming impurity-doped semiconductor layers on said drain electrode and said source electrode;

forming a non-doped semiconductor layer, an insulating layer and a conductive layer sequentially on said insulating substrate after said impurity-doped semiconductor layers are formed;

patterning said conductive layer to form a gate electrode; and

etching said insulating layer, said non-doped semiconductor layer, and said impurity-doped semiconductor layers by using said gate electrode as a mask.

2. The method as set forth in claim **1**, further comprising the steps of:

forming a counter common electrode on a transparent insulating layer;

adhering said-transparent insulating substrate with said insulating substrate with a gap; and

inserting liquid crystal into said gap.

3. The method as set forth in claim **2**, wherein at least one surface of said transparent insulating layer is uneven.

4. The method as set forth in claim **1**, further comprising a step of forming a transparent insulating layer having an uneven surface on said drain electrode, said source electrode and said gate electrode, after said etching process is carried out.

5. The method as set forth in claim **4**, wherein said transparent insulating layer is made of photosensitive acrylic resin.

6. The method as set forth in claim **4**, wherein said transparent insulating layer is made of polyimide.

7. The method as set forth in claim **1**, further comprising a step of forming a transparent insulating layer including light scattering particles on said drain electrode, said source electrode and said gate electrode, after said etching process is carried out.

8. The method as set forth in claim **7**, wherein said transparent insulating layer is made of polyimide.

9. The method as set forth in claim **1**, wherein said aluminum alloy layer forming step makes a surface of said aluminum alloy layer uneven and turbid.

10. The method as set forth in claim **1**, further comprising a step of carrying dry-etching operation upon said aluminum alloy layer to make a surface of said aluminum alloy layer uneven, after said etching step is carried out.

11. The method as set forth in claim **1**, further comprising a step of forming an ohmic contact layer on said insulating layer before said aluminum alloy layer is formed,

said aluminum alloy layer patterning layer patterning step also patterning said ohmic contact layer, so that said drain electrode and said source electrode are formed by said aluminum alloy layer and said ohmic contact layer.

12. The method as set forth in claim **11**, wherein said ohmic contact layer is made of Mo.

13. The method as set forth in claim **11**, wherein said ohmic contact layer is made of indium tin oxide.

14. The method as set forth in claim **1**, further comprising a step of forming an ohmic contact layer on said insulating layer after said aluminum alloy layer is formed,

said aluminum alloy layer patterning layer patterning step also patterning said ohmic contact layer, so that said drain electrode and said source electrode are formed by said aluminum alloy layer and said ohmic contact layer.

15. The method as set forth in claim **14**, wherein said ohmic contact layer is non-transparent,

said method further comprising a step of etching said ohmic contact layer by said etching step.

16. The method as set forth in claim **15**, wherein said ohmic contact layer is made of Mo.

17. The method as set forth in claim **14**, wherein said ohmic contact layer is transparent.

18. The method as set forth in claim **17**, wherein said ohmic contact layer is made of indium tin oxide.

19. The method as set forth in claim **9**, wherein said aluminum alloy layer is made of Al—Si.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

Page 1 of 1

PATENT NO. : 6,222,600 B1
DATED : April 24, 2001
INVENTOR(S) : Naoto Hirano

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 3,
Lines 27 and 51, delete "TETs" insert -- TFTs --

Column 9,
Line 50, delete "TET" insert -- TFT --

Column 10,
Line 14, delete "N^4" insert -- N^+ --

Column 11,
Line 13, delete "TET" insert -- TFT --;
Lines 33 and 42, delete "TETs" insert -- TFTs --

Column 14,
Line 11, delete "sing" insert -- using --;

Column 15,
Line 58, delete "TET" insert -- TFT --

Signed and Sealed this

Twenty-first Day of May, 2002

Attest:

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

Attesting Officer

专利名称(译)	反射型液晶显示装置，制造成本低		
公开(公告)号	US6222600	公开(公告)日	2001-04-24
申请号	US09/626890	申请日	2000-07-27
申请(专利权)人(译)	NEC公司		
当前申请(专利权)人(译)	GOLD CHARM LIMITED		
[标]发明人	HIRANO NAOTO		
发明人	HIRANO, NAOTO		
IPC分类号	G02F1/1335 G02F1/1368 G02F1/13 G02F1/1362 G02F1/139 G02F1/136 G09F9/33 H01L21/336 H01L29/786		
CPC分类号	G02F1/133553 G02F1/1368 G02F1/133504 G02F1/136227 G02F1/13725		
优先权	1996205712 1996-08-05 JP		
外部链接	Espacenet USPTO		

摘要(译)

在反射型液晶装置中，漏电极和源电极形成在绝缘基板上，并由铝合金层形成。源电极用作光反射像素电极。而且，在漏电极的一部分和源电极的一部分上形成非掺杂半导体层，并且在漏电极和源电极与非掺杂半导体层之间形成掺杂半导体层。此外，经由非掺杂半导体层上的栅极绝缘层形成栅电极。另外，在透明绝缘基板上形成反公共电极，并且在绝缘基板和透明绝缘基板之间插入液晶层。