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(54) **THIN FILM TRANSISTOR MANUFACTURING METHOD AND ORGANIC ELECTROLUMINESCENT DISPLAY DEVICE**

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(57) **ABSTRACT**

The invention reduces display unevenness of a horizontal streak and a vertical streak of an organic EL display device to improve display quality. A silicon oxide film is deposited on a glass substrate by a plasma CVD method, and an amorphous silicon film is further deposited on the silicon oxide film by the plasma CVD method. Next, an excimer laser is irradiated to the amorphous silicon film for heating the film until the film melts and the film is crystallized to form a polysilicon film. Then, this polysilicon film is etched in a predetermined pattern. After then, a p-type impurity, for example, boron is ion-implanted in the polysilicon film. Then, a gate insulation film formed of a silicon oxide film is deposited by a CVD method, covering the polysilicon film. Next, a gate electrode is formed on the gate insulation film.

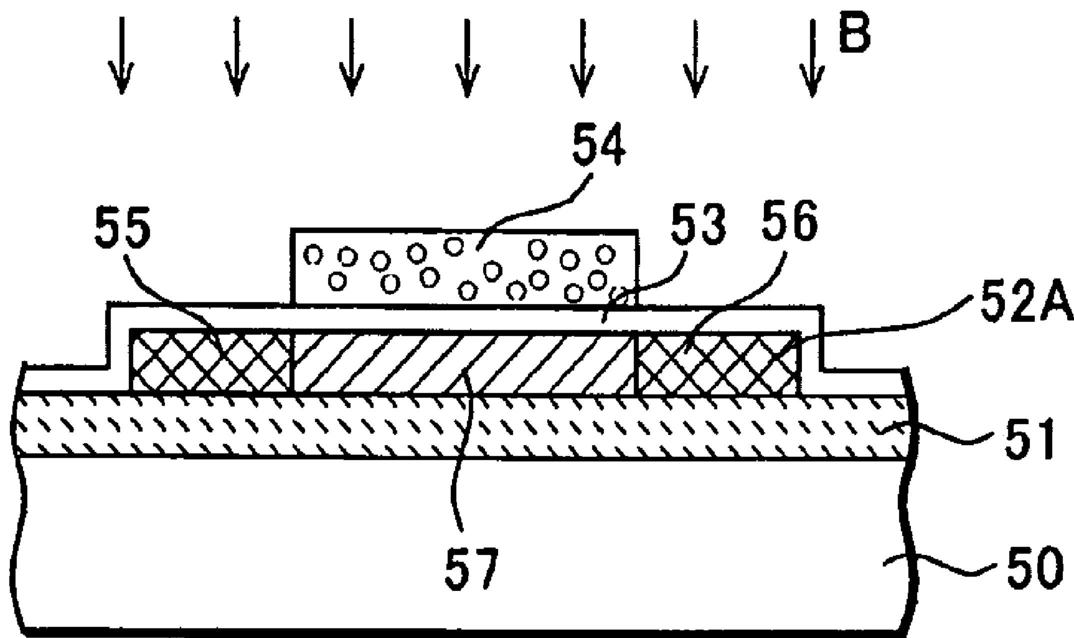

FIG.1A

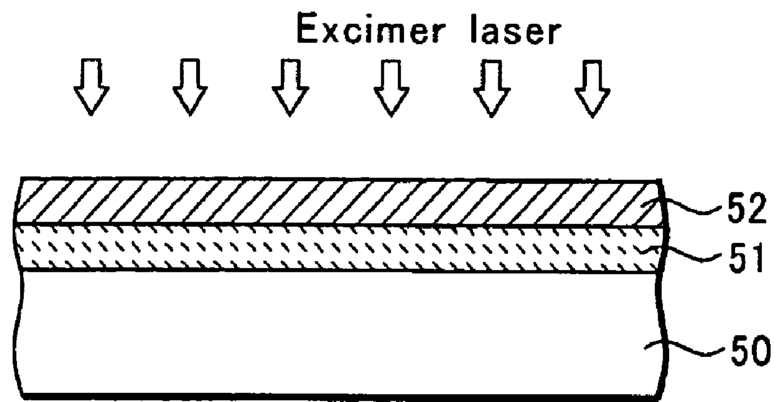

FIG.1B

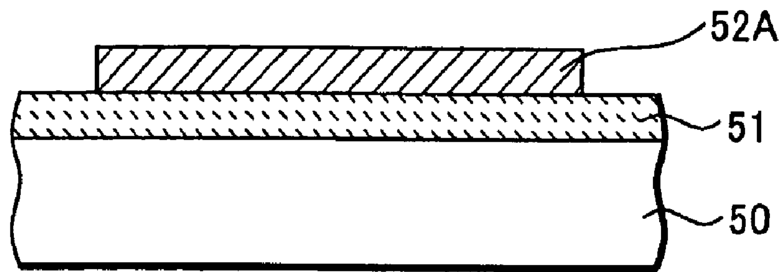

FIG.1C

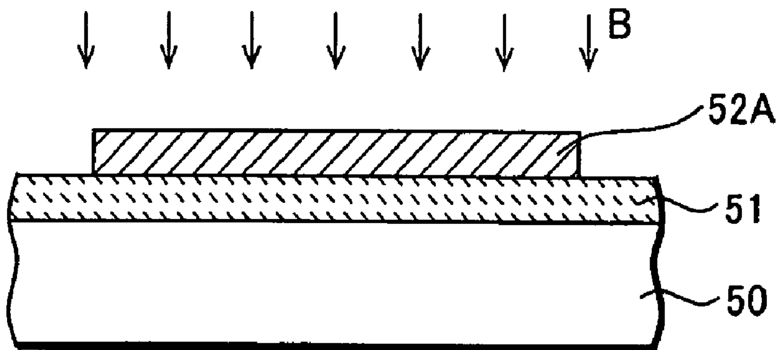

FIG.1D

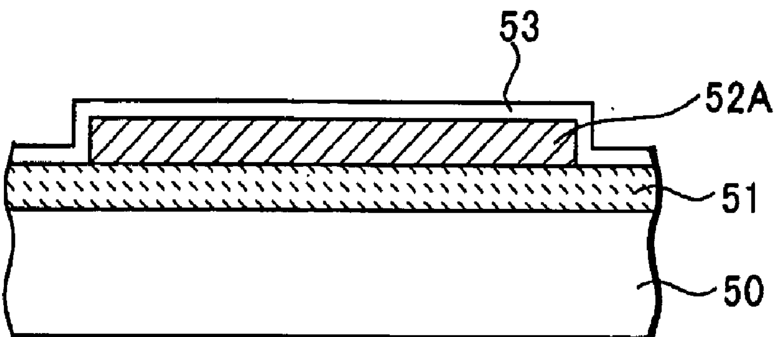

FIG.2A

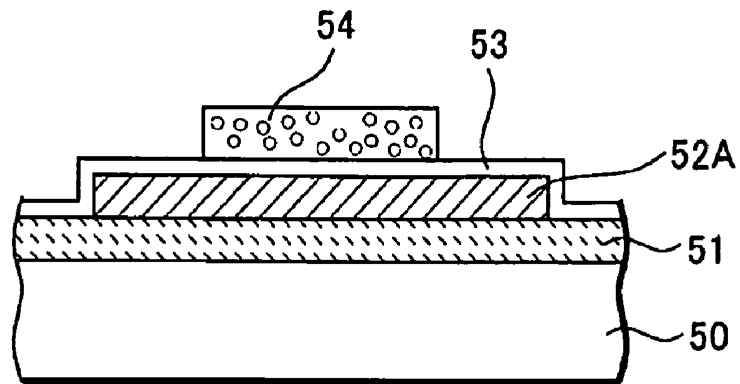

FIG.2B

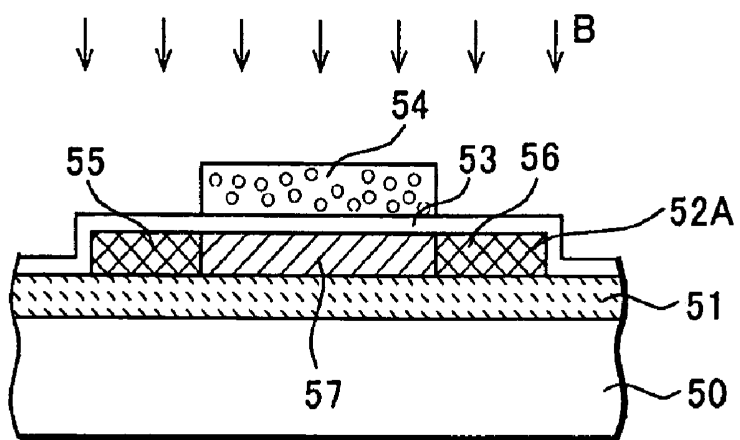

FIG.3

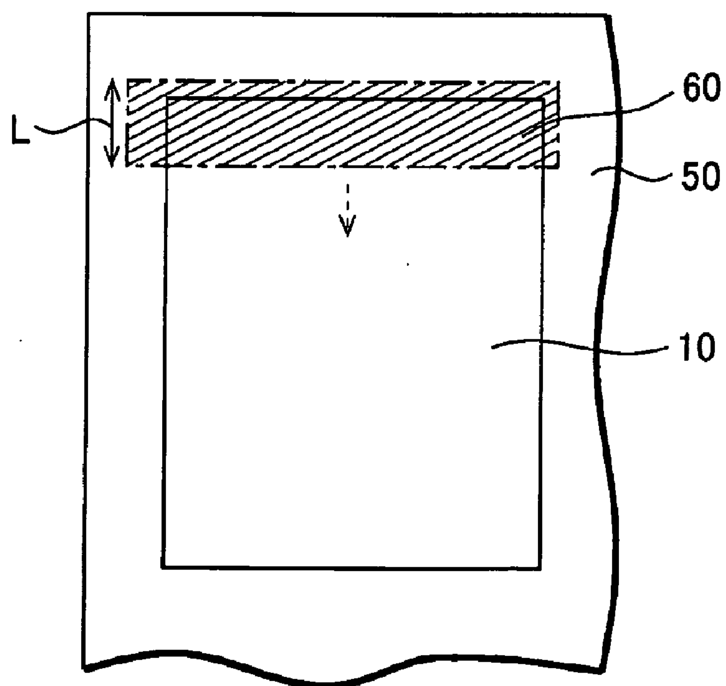

FIG.4

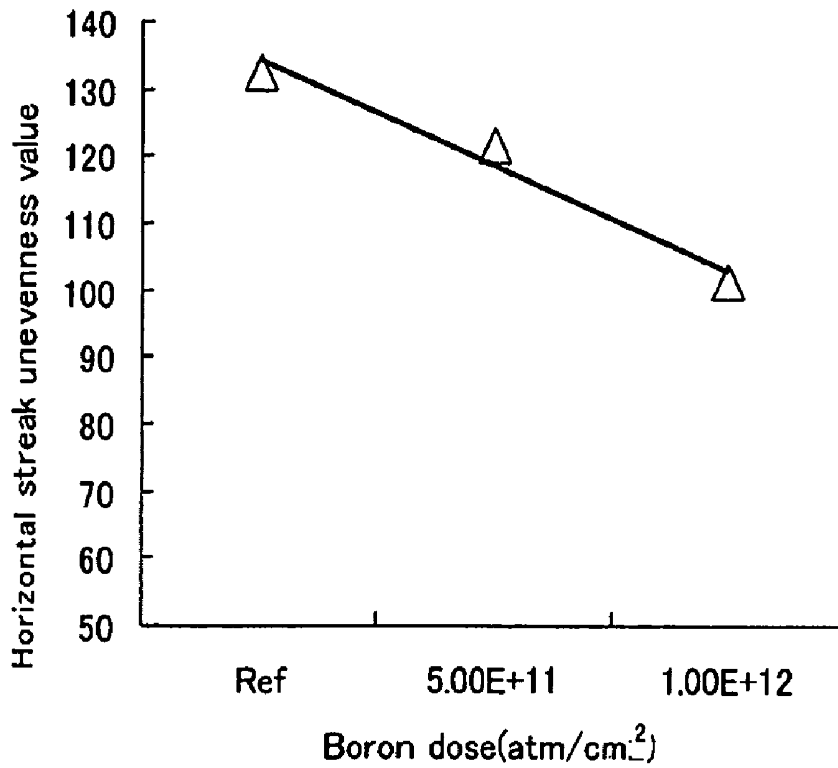

FIG.5

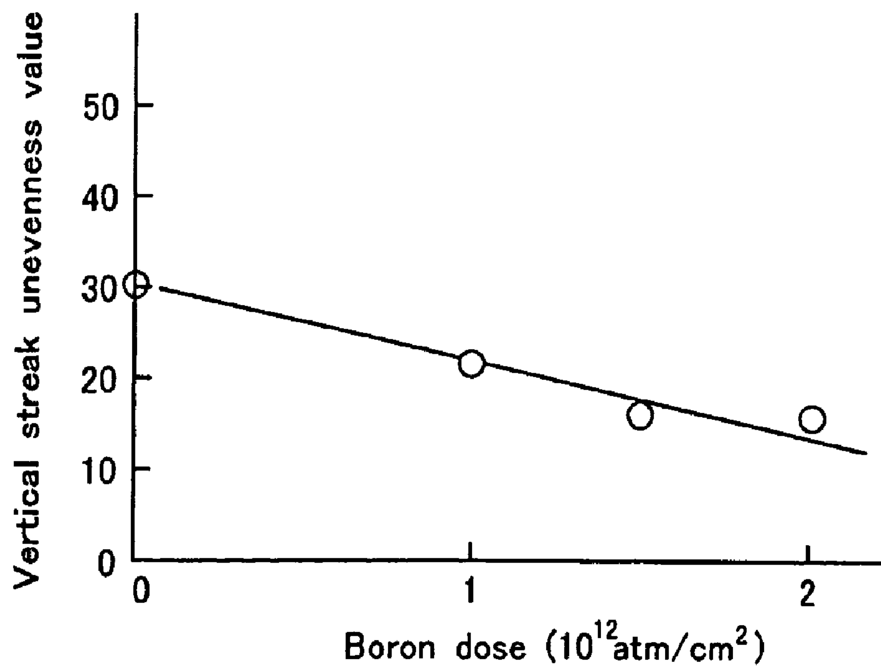

FIG.6

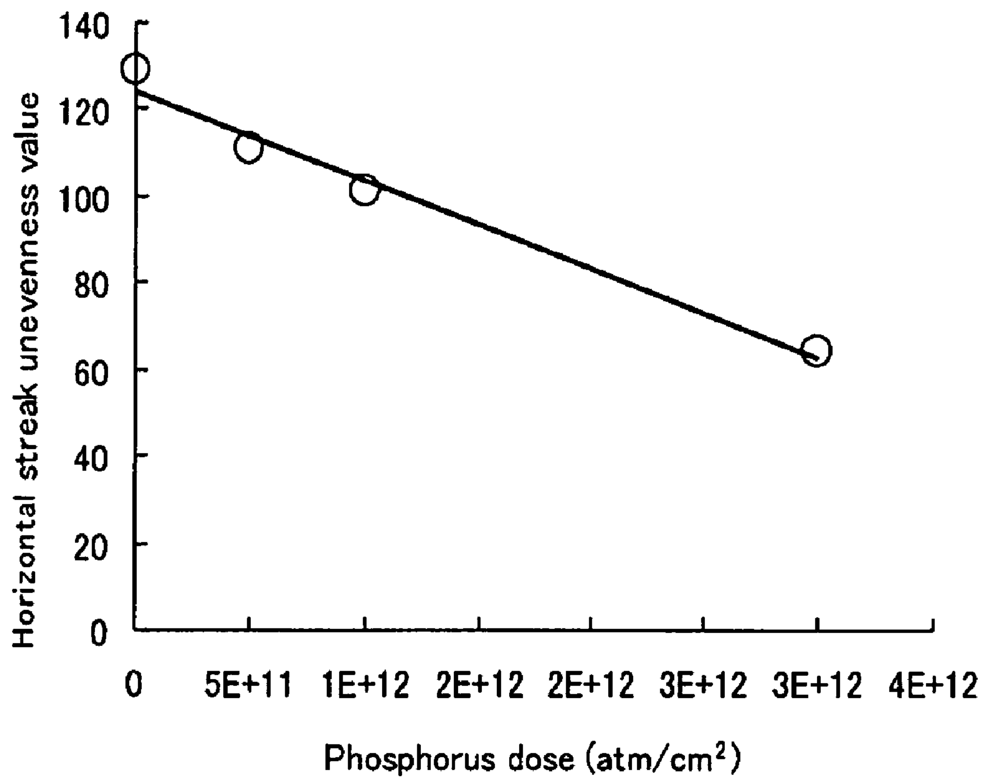

FIG.7

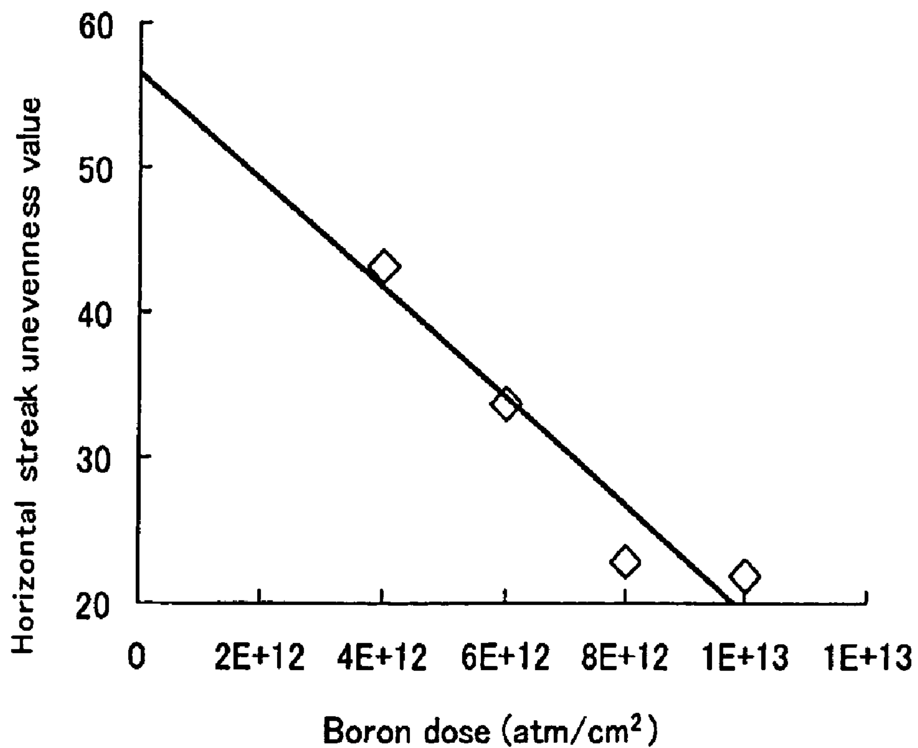

FIG.8
PRIOR ART

FIG.9
PRIOR ART

THIN FILM TRANSISTOR MANUFACTURING METHOD AND ORGANIC ELECTROLUMINESCENT DISPLAY DEVICE

CROSS-REFERENCE OF THE INVENTION

[0001] This invention is based on Japanese Patent Applications No. 2004-323613 and 2005-302700 the content of which is incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to a thin film transistor manufacturing method and an organic EL display device. This thin film transistor manufacturing method can be applied to a manufacturing method of a driving transistor of an organic electroluminescent element, for example.

[0004] 2. Description of the Related Art

[0005] In recent years, an organic electroluminescent (hereafter, referred to as EL) display device with an organic EL element has been gathering attention as a display device replacing a CRT and an LCD. Particularly, the development efforts for the organic EL display device with a thin film transistor (referred to as TFT, hereafter) as a switching element for driving the organic EL element has been made accordingly.

[0006] An equivalent circuit diagram of an organic EL display panel **300** is shown in **FIG. 8**. A plurality of gate signal lines **11** supplying a gate signal and a plurality of drain signal lines **12** supplying a display signal Vsig are crossing each other. Pixels are disposed at intersections of both the signal lines, forming a display screen **10**. Each of the pixels includes a pixel selecting TFT **13**, an organic EL element **14**, a driving TFT **15** driving this organic EL element **14**, and a storage capacitor **16** temporarily storing the display signal Vsig.

[0007] A gate of the pixel selecting TFT **13** is connected with the gate signal line **11** and supplied with a gate signal, and a drain thereof is connected with the drain signal line **12** and supplied with a display signal Vsig. A source of the pixel selecting TFT **13** is connected with a gate of the driving TFT **15**. The gate signal is outputted from a vertical drive circuit **30**. The display signal Vsig is supplied through a horizontal drive circuit **20**.

[0008] A source of the driving TFT **15** is supplied with a positive potential PVdd, and a drain thereof is connected with an anode of the organic EL element **14**. A cathode of the organic EL element **14** is supplied with a negative potential CV.

[0009] An operation of the organic EL display device having the above-described structure will be described. When a gate signal becomes high level for a horizontal period, the pixel selecting TFT **13** turns on. Then, a display signal Vsig is applied from the drain signal line **12** to the gate of the driving TFT **15** through the pixel selecting TFT **13**.

[0010] Then, the conductance of the driving TFT **15** changes in response to the display signal Vsig supplied to the gate, a corresponding amount of drive current is supplied to the organic EL element **14** through the driving TFT **15**, and the organic EL element **14** turns on a light. When the driving TFT **15** turns off in response to a display signal supplied to the gate, an electric current does not flow in the driving TFT **15**, so that the organic EL element **14** turns off the light.

[0011] The relevant technology is disclosed in the Japanese Patent Application Publication No. 2002-175029.

[0012] In the described organic EL display panel **300**, however, as shown in **FIG. 7**, there has been a problem that a horizontal streak (a streak pattern in a horizontal direction on the screen) or a vertical streak (a streak pattern in a vertical direction on the screen) appears on the display screen **10** as display unevenness, or "mura" as known in the art.

[0013] The inventor founds that a cause of the appearance of the horizontal streak or the vertical streak on the display screen **10** is variation in the drive current driving the organic EL element **14** among the driving TFTs **15**, and such variation in the drive current occurs by variation in energy of excimer laser irradiation within the display screen **10**, which is performed when an amorphous silicon film forming the driving TFT **15** is crystallized.

SUMMARY OF THE INVENTION

[0014] The invention provide a method of manufacturing a thin film transistor. The method includes depositing an amorphous silicon film on a substrate, performing a laser irradiation to the amorphous silicon film so the amorphous film is melted and crystallized to form a polysilicon film, etching the polysilicon film to form a predetermined pattern, implanting impurities in the polysilicon film, forming a gate insulation film on the polysilicon film, forming a gate electrode on the gate insulation film, and forming a source region and a drain region in the polysilicon film.

[0015] The invention also provides an organic electroluminescent display device having a plurality of pixels arranged in a matrix on a substrate. Each of the pixels includes a pixel selecting thin film transistor, an organic electroluminescent element, and a driving thin film transistor driving the organic electroluminescent element in response to a display signal supplied through the pixel selecting thin film transistor. The driving thin film transistor includes a channel region that contains impurities of a p-type impurity and an n-type impurity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] **FIGS. 1A, 1B**, 1C, and 1D are cross-sectional views showing a thin film transistor manufacturing method of the invention.

[0017] **FIGS. 2A and 2B** are cross-sectional views showing the thin film transistor manufacturing method of the invention.

[0018] **FIG. 3** is a plan view showing the thin film transistor manufacturing method of the invention.

[0019] **FIG. 4** is a graph showing a relation between a horizontal streak unevenness value and a boron dose.

[0020] **FIG. 5** is a graph showing a relation between a vertical streak unevenness value and a boron dose.

[0021] **FIG. 6** is a graph showing a relation between a horizontal streak unevenness value and a phosphorus dose.

[0022] **FIG. 7** is a graph showing a relation between a horizontal streak unevenness value and a boron dose.

[0023] **FIG. 8** is an equivalent circuit diagram of an organic EL display panel.

[0024] **FIG. 9** is a view showing horizontal streaks and vertical streaks appearing on the organic EL display panel.

DETAILED DESCRIPTION OF THE INVENTION

[0025] An embodiment of the invention will be described with reference to figures. **FIGS. 1A, 1B**, 1C, 1D, 2A, and 2B are cross-sectional views showing a thin film transistor manufacturing method of the invention. In this embodiment, the thin film transistor is a driving transistor (P-channel type) of an organic EL element in an organic EL display panel **300** described above.

[0026] First, as shown in **FIG. 1A**, a silicon oxide film **51** is deposited on a glass substrate **50** by a plasma CVD method, and an amorphous silicon film **52** is further deposited on the silicon oxide film **51** by the plasma CVD method so as to have a thickness of about 43 nm.

[0027] Then, the amorphous silicon film **52** is heated to 430° C. (±20° C.) together with a glass substrate **50**, and this heat treatment is continued for one hour or more. By this heat treatment, about 10% of hydrogen in the amorphous silicon film **52** is reduced to 1% or less.

[0028] Then, the amorphous silicon film **52** is irradiated with an excimer laser to heat the amorphous silicon film **52** until the film **52** melts. At this time, since hydrogen contained in the amorphous silicon film **52** is already reduced largely compared with when deposited, the hydrogen is not rapidly released to the outside of the film **52** when silicon melts. By this process, the silicon is crystallized without damaging its surface to form a polysilicon film **52**A.

[0029] An excimer laser irradiation method in this process will be described with reference to **FIG. 3**. A pixel region to be a display screen **10** having a plurality of pixels arrayed in a matrix of rows and columns is determined on the glass substrate **50**. An irradiation region **60** to be irradiated with a shot of excimer laser is shown by a hatched rectangular region in **FIG. 3**, and a plurality of pixels is included therein. The structure of the pixel is the same as the one described with reference to **FIG. 6**. A length L of the irradiation region **60** is several **100** micrometers.

[0030] After one shot irradiation, the irradiation region **60** is shifted in a column direction by a pitch of several **10** micrometers, and a shot of excimer laser is irradiated there, too. By repeating the one shot irradiation and the shift of the irradiation region **60** from one edge to another edge of the pixel region to be the display screen **10**, the excimer laser irradiation is completed over the amorphous silicon film **52** in the pixel region.

[0031] Next, as shown in **FIG. 1B**, the polysilicon film **52**A is etched in a predetermined pattern. Then, as shown in **FIG. 1C**, a p-type impurity, for example, boron (B) is ion-implanted in the polysilicon film **52**A. This process is the most characteristic feature of the invention. Although the details will be described below, this implantation of the impurity can reduce display unevenness of a horizontal streak and a vertical streak on the display screen of the organic EL display panel. It is experimentally proved that an n-type impurity such as phosphorous (P) implanted in the polysilicon film **52**A also has the effect of reducing the display unevenness, and both the p-type impurity and the n-type impurity ion-implanted in the polysilicon film **52**A also have the effect of reducing the display unevenness.

[0032] Although, an impurity is ion-implanted in the polysilicon film **52**A after the polysilicon film **52**A is etched in a predetermined pattern in the above-described process, it is possible that the polysilicon film **52**A is etched in the predetermined pattern after the impurity is ion-implanted in the polysilicon film **52**A, contrarily.

[0033] Next, as shown in **FIG. 1D**, a gate insulation film **53** formed of a silicon oxide film is deposited covering the polysilicon film **52**A by a CVD method. Then, as shown in **FIG. 2A**, a gate electrode **54** formed of molybdenum and so on is formed on the gate insulation film **53**. Then, as shown in **FIG. 2B**, a high concentration of p-type impurity such as boron is ion-implanted in the polysilicon film **52**A by using the gate electrode **54** as a mask to form a source region **55** and a drain region **56**. The polysilicon film **52**A between the source region **55** and the drain region **56** serves a channel region **57**.

[0034] Next, description will be made on a result of an experiment in an effect of the ion-implantation to the polysilicon film **52**A. FIG.**4** shows a relation between a horizontal streak unevenness value and a boron dose. The horizontal streak unevenness value means an index of a degree of appearance of the horizontal streak on the display screen of the organic EL display panel, and is measured by a commercial measuring device, "Eye System" (a product from Eye System Corporation). The less the horizontal streak unevenness value is, the less the horizontal streak is. As apparent from **FIG. 4**, there is an effect of reducing the horizontal streak unevenness value even with a small dose of 5×10^{11}atm/cm^2, and the horizontal streak unevenness value reduces according as the boron dose increases. The horizontal streak unevenness value in the case of no boron doping is 132.5, while the horizontal streak unevenness value in the case of 1×10^{12}atm/cm^2 of boron doping is reduced to 101.2, providing an improvement effect of 23.6%.

[0035] **FIG. 5** shows a relation between a vertical streak unevenness value and a boron dose. The vertical streak unevenness value means an index of a degree of appearance of the vertical streak on the display screen of the organic EL display panel, and is also measured by the "Eye system". The less the vertical streak unevenness value is, the less the vertical streak is. As apparent from **FIG. 5**, the vertical streak unevenness value reduces according as the boron dose increases. The vertical streak unevenness value in the case of no boron doping is **30.6**, while the vertical streak unevenness value in the case of 1.5×10^{12}atm/cm^2 of boron doping is reduced to 15.9, providing an improvement effect of 48.07%.

[0036] Furthermore, it was found that the horizontal streak unevenness value and the vertical streak unevenness value reduce by ion-implantation of phosphorous or ion-implantation of phosphorous and boron, too. **FIG. 6** shows a relation between the horizontal streak unevenness value and

a phosphorus dose. As apparent from **FIG. 6**, the horizontal streak unevenness value reduces according as the phosphorus dose increases. The horizontal streak unevenness value in the case of no phosphorus doping is **128.8**, while the horizontal streak unevenness value in the case of $1'10^{12}$ atm/cm^2 of phosphorus doping is reduced to 101.2. Furthermore, the horizontal streak unevenness value in the case of 3×10^{12} atm/cm^2 of phosphorus doping is 64.1, providing an improvement effect of 50%.

[**0037**] **FIG. 7** shows a relation between the horizontal streak unevenness value and a boron dose. Compared with the experiment of **FIG. 4**, the boron dose is increased to 1×10^{13}atm/cm^2. It may be seen that **FIGS. 4 and 7** do not correspond with each other with the same dose, but this is because each of the experiments is performed using a panel extracted from a different lot. As apparent from **FIG. 7**, the horizontal streak unevenness value reduces according as the dose increases, but the change is little between 8×10^{12} atm/cm^2 and 1×10^{13}atm/cm^2. It can be expected that the horizontal streak unevenness value does not largely reduce even when the dose is increased more than 1×10^{13}atm/cm^2. Furthermore, it can be expected that the increase of the boron dose changes the threshold voltage of the thin film transistor to affect the operation of the organic EL display panel, but it is confirmed that the organic EL display panel operates properly when the boron dose is 1×10^{13}atm/cm^2 or less. It is noted that the boron is diluted with hydrogen (H_2) to 1% concentration, and the phosphorous is diluted with hydrogen (H_2) to 0.5% concentration in the described experiments.

[**0038**] On the other hand, by ion-implanting both phosphorous and boron in the polysilicon film **52**A, the change of the threshold voltage can be compensated. Therefore, the dose of the ion-implantation can be increased, so that the horizontal streak unevenness value and the vertical streak unevenness value can be reduced with minimizing the change of the threshold voltage. For example, by ion-implanting 3×10^{12}atm/cm^2 of boron and 2.5×101^2atm/cm^2 of phosphorus, the reduction effect of the horizontal streak unevenness value becomes 51.7%, and the reduction effect of the vertical streak unevenness value becomes 50.7%, providing a larger effect than in the ion-implantation of phosphorous or boron only.

[**0039**] The implantation of the p-type or n-type impurity in the polysilicon film **52**A can thus reduce the display unevenness of the horizontal streak and the vertical streak, and its physical mechanism is as follows. The excimer laser irradiation is performed over the amorphous silicon film **52** and the amorphous silicon film **52** is crystallized to form the polysilicon film **52**A, as described above. At this time, since spatial variation occurs in the energy of the excimer laser (variation in row and column directions on the display screen), the grain size of the channel region **57** of the thin film transistor and the height of the potential barrier of the crystal grain boundary differ among pixels.

[**0040**] In the channel current flowing in the thin film transistor, the higher the potential barrier of the crystal grain boundary is, the more the free electron trapped in the crystal grain boundary is and the less the channel current flows. For solving this, by implanting a donor impurity (n-type impurity) increasing the free electrons or an acceptor impurity (p-type impurity) trapping the free electrons in the channel region as in the embodiment, the heights of the potential barriers of the crystal grain boundaries are equalized, and the channel current flowing in the thin film transistors can be equalized.

What is claimed is:

1. A method of manufacturing a thin film transistor, comprising:

depositing an amorphous silicon film on a substrate;

performing a laser irradiation to the amorphous silicon film so the amorphous film is melted and crystallized to form a polysilicon film;

etching the polysilicon film to form a predetermined pattern;

implanting impurities in the polysilicon film;

forming a gate insulation film on the polysilicon film;

forming a gate electrode on the gate insulation film; and

forming a source region and a drain region in the polysilicon film.

2. The method of claim 1, wherein the implanted impurities are of a p-type impurity or of an n-type impurity.

3. The method of claim 1, wherein the implanting of the impurities comprises implanting a dose of 1×10^{13}atm/cm^2 or less of boron.

4. The method of claim 1, wherein the implanted impurities are of a p-type impurity and an n-type impurity.

5. The method of claim 1, wherein the thin film transistor is a driving transistor of an organic electroluminescent element.

6. The method of claim 1, wherein the etching of the polysilicon film is performed prior to the implanting of the impurities.

7. The method of claim 1, wherein the etching of the polysilicon film is performed subsequent to the implanting of the impurities.

8. An organic electroluminescent display device comprising a plurality of pixels arranged in a matrix on a substrate, each of the pixels comprising:

a pixel selecting thin film transistor;

an organic electroluminescent element; and

a driving thin film transistor driving the organic electroluminescent element in response to a display signal supplied through the pixel selecting thin film transistor, the driving thin film transistor comprising a channel region that contains impurities of a p-type impurity and an n-type impurity.

* * * * *

patsnap

专利名称(译)	薄膜晶体管的制造方法和有机电致发光显示装置		
公开(公告)号	US20060108938A1	公开(公告)日	2006-05-25
申请号	US11/267585	申请日	2005-11-07
[标]申请(专利权)人(译)	三洋电机株式会社		
申请(专利权)人(译)	SANYO ELECTRIC CO., LTD.		
当前申请(专利权)人(译)	SANYO ELECTRIC CO., LTD.		
[标]发明人	HISHIDA MITSUOKI		
发明人	HISHIDA, MITSUOKI		
IPC分类号	G09G3/10		
CPC分类号	H01L27/1285 H01L27/1296 H01L27/3244		
优先权	2004323613 2004-11-08 JP		
其他公开文献	US7524728		
外部链接	Espacenet USPTO		

摘要(译)

本发明减少了有机EL显示装置的水平条纹和垂直条纹的显示不均匀性，从而提高了显示质量。通过等离子体CVD法在玻璃基板上沉积氧化硅膜，并通过等离子体CVD法在氧化硅膜上进一步沉积非晶硅膜。接下来，将准分子激光照射到非晶硅膜上以加热膜，直到膜熔化并使膜结晶以形成多晶硅膜。然后，以预定图案蚀刻该多晶硅膜。之后，在多晶硅膜中离子注入p型杂质，例如硼。然后，通过CVD方法沉积由氧化硅膜形成的栅极绝缘膜，覆盖多晶硅膜。接下来，在栅极绝缘膜上形成栅电极。