DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2002-084924, filed Mar. 26, 2002, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a display device and a method of manufacturing the same.

[0004] 2. Description of the Related Art

[0005] An active matrix type display device in which an active element such as a thin-film transistor (TFT) is placed in each pixel can realize a high-quality, flat display device. In a display part of this active matrix type display device, it is possible to use, e.g., a liquid crystal which functions as a light shutter, an organic EL which emits light, or an electrophoretic element encapsulated in a microcapsule. These active matrix type display devices can be made thin and light in weight, so they are optimum for portable information apparatuses such as a notebook model personal computer and PDA (Portable Digital Assistance).

[0006] In a TFT used as an active element, a semiconductor film made of, e.g., amorphous silicon, polycrystalline silicon, crystalline silicon in which lattice continuity is obtained in the grain boundary, or single-crystal silicon is used as an active layer. In the fabrication of these TFTs, to improve the film quality of a semiconductor film, gate insulating film, and the like, a process temperature of about 250 to 350° C. is required for amorphous silicon, and about 400 to 650° C. for highly crystalline silicon such as polycrystalline silicon. Since this restricts the substrate material, glass substrates such as non-alkaline glass have been conventionally used.

[0007] Portable information apparatuses will be widely used with the development of radio networks in the future, so display devices are required to be made thinner and lighter in weight. To meet this requirement, active matrix type display devices using a plastic substrate instead of a glass substrate are proposed.

[0008] As an example of these active matrix type display devices using a plastic substrate, a method is reported in which a TFT is formed at as a low process temperature as possible by improving the heat resistance of a plastic substrate. Since the specific gravity of a plastic substrate is half that of a glass substrate or less, the weight of the display device can be reduced. In addition, the flexibility of plastic makes the display device bendable, and this increases the impact resistance.

[0009] Unfortunately, a plastic substrate not only has a low heat resistance of about 100° C. to 200° C. but also deforms by moisture absorption. Also, the coefficient of linear expansion of a plastic substrate is larger by an order of magnitude than that of a glass substrate. These tendencies are particularly conspicuous in a transparent plastic substrate necessary for a display device. For these reasons, peeling or disconnection occurs when active elements and the like are formed on a plastic substrate. Additionally, the mask alignment accuracy lowers because layers of active elements are stacked on a plastic substrate which deforms. When a plastic substrate is used, therefore, it is impossible to form such high-accuracy patterns as formed when active elements and the like are formed on a glass substrate. Also, the use of a plastic substrate lowers the performance of pixel switches and driving circuits in a display part using TFTs. Furthermore, when a plastic substrate is used, many limitations are imposed on usable materials because cracks are easily formed if brittle metals or insulating materials are used.

[0010] As another example of the active matrix type display devices using a plastic substrate, a method in which TFTs formed on a glass substrate or silicon substrate are transferred onto a plastic substrate is proposed in, e.g., Jpn. Pat. Appln. KOKAI Publication No. 2001-7340 (U.S. Pat. No. 5,834,327). This conventional transfer method will be explained below with reference to **FIGS. 1A** to 1E.

[0011] First, as shown in **FIG. 1A, a** separation layer **1302** such as an insulating film which functions as an etching stopper is formed on an element formation substrate **1301** made of, e.g., glass. On this separation layer **1302**, elements **1303** such as TFTs **1308** and electrodes **1309** are formed using a conventional process.

[0012] Next, as shown in **FIG. 1B, a** temporary adhesion layer **1304** having adhesion properties is formed on an intermediate substrate **1305**, and the elements **1303** formed on the element formation substrate **1301** are bonded to this intermediate substrate **1305** via the temporary adhesion layer **1304**.

[0013] As shown in **FIG.** 1C, the element formation substrate **1301** is removed by etching or the like so that the separation layer **1302** remains.

[0014] As shown in **FIG.** 1D, an adhesion layer **1306** having adhesion properties is formed on a final substrate **1307** to be transferred which is made of plastic. The separation layer **1302** is bonded to this final substrate **1307** via the adhesion layer **1306**.

[0015] Finally, as shown in **FIG.** 1E, the temporary adhesion layer **1304** is, e.g., solved by a solvent to transfer the elements **1303** from the intermediate substrate **1305** onto the final substrate **1307**.

[0016] In the above transfer method, glass or the like having high heat resistance can be used as the material of the element formation substrate **1301**. Hence, the method can presumably form high-performance TFTs with high accuracy.

[0017] In this method, the element formation substrate **1301** is completely removed. Therefore, if the separation layer **1302** which remains has holes or if an excessively thin region is formed in this separation layer **1302** and etched together with the element formation substrate **1301**, there is a possibility that the elements **1303** are damaged. Since the possibility of this damage is particularly high in large-screen, active matrix type display devices, the yield of such display devices may lower.

[0018] In addition, a liquid crystal or organic EL used as a display part significantly deteriorates because plastic used as the final substrate **1307** allows easy permeation of water