

Display device

The invention relates to a display device comprising a layer of liquid crystal in a space enclosed by a rim of sealing material between two supporting plates of which one supporting plate has a pattern of electrodes to be driven individually by supply electrodes, which supporting plate furthermore has a number of external connection electrodes, said supply electrodes and connection electrodes being connected to contact pads of at least one non-encapsulated IC-crystal.

Such a display device is known from the article "A Hybrid Liquid Chrystal Display with a Small Number of Interconnections" in Proceedings of the I.E.E., Vol. 61, No. 7 (1973), p. 829—832. By providing a part of the control electronics in the form of an integrated circuit (IC) directly on the supporting plate with the pattern of electrodes to be driven individually, a considerable reduction is obtained of the number of electric connections to be made from the liquid crystal display device to the exterior. For the example described of a numerical display device having nine digits each constructed from seven segments, this means that the number of connections is reduced from 63 to 4. As described in the above-mentioned article, a non-encapsulated IC-crystal, that is a crystal without the usual housing, can be provided on the supporting plate. The use of non-encapsulated IC-crystals results in an important saving of the visually useless space compared with an IC having a housing. The contact pads of the IC crystal can be secured to the supply electrodes and connection electrodes by means of soldering balls. The usual soldering methods and thermocompression methods may be used in combination with a suitable metallization of the supply electrodes and connection electrodes.

In the known device the IC-crystal is provided on the supporting plate outside the envelope of the actual liquid crystal cell. After assembly of the IC-crystal, the IC-crystal should be provided with a mechanical and electrical protection. The possibility of damage of the IC-crystal, however, for example when incorporating the display device in an apparatus or exposing it to a warm moist atmosphere, is not entirely excluded. The French patent specification 2 103 542 discloses a liquid crystal display device with an annular plastic frame connecting its plates. An IC is placed in the plastic frame. It is the object of the invention to provide a display device in which the possibility of damage of the non-encapsulated IC-crystal is substantially excluded.

According to the invention, a display device of the kind mentioned in the opening paragraph is characterized in that the at least one IC-crystal is accommodated in the rim so that it is enclosed by the supporting plates and—in

the space between the plates—by the sealing material. The glass plates and the rim of sealing material provide a good mechanical and impervious protection of the IC-crystals.

An embodiment of a display device according to the invention is characterized in that the other supporting plate has a cavity to partly accommodate the IC-crystals. In the nowadays conventionally used liquid crystal display devices the distance between the supporting plates is approximately 4—30 μm . The thickness of an IC-crystal is approximately 250 μm . In order to be able to accommodate an IC-crystal in the rim of sealing material, a cavity is recessed in the other supporting plate, for example, by means of ultrasonic drilling.

A further embodiment of a display device in accordance with the invention is characterized in that the connections between the surfaces of the supply electrodes and connection electrodes and the contact pads of the IC-crystal are each formed by a ball of gold which is provided on one of the surfaces to be joined and which is secured to the other surface by means of a conductive glue. The contact surfaces of IC-crystal are usually of aluminium. An oxide layer is rapidly formed on said aluminium which impedes the making of a good electric connection. The advantage of the use of gold balls is that they penetrate through the oxide layer. The adhesion is obtained by means of a conductive glue which can be incorporated with the gold balls in a simple manner.

It is to be noted that it is known *per se* from Japanese Patent Application 53-59398 laid open to public inspection to connect an IC-crystal to the electrode pattern of a liquid crystal display device by means of conductive resin balls.

Another further embodiment of a display device in accordance with the invention is characterized in that each of the supporting plates is provided with a liquid crystal-orienting layer, the orienting layer on the supporting plate on which the IC-crystal is provided also covering the IC-crystal. As a result of this the IC-crystal is provided with an extra protective layer.

A suitable liquid crystal-orienting layer is a polyparaxylylene layer. This layer is provided by means of a chemical vapour deposition method. The advantage of this method is that the surface of the IC-crystal facing the supporting plate, the so-called active surface, is also covered and passivated.

In a display device in accordance with the invention the rim of the sealing material is preferably formed by a frame of a thermoplastic material, in particular a polyethylene frame. The cavity for the IC-crystal can be provided simply in such a frame. The frame is laid between the

glass plates over the IC-crystal after which the assembly is joined by heating.

Still another embodiment of a display device is characterized in that the rim of sealing material is formed by a rim of glass enamel. Prior to providing the IC-crystal the glass enamel is provided by silk screening and then previtrified. After providing the IC-crystal the supporting plates are joined by heating to a temperature of approximately 450—550°C.

In a rim of glass enamel the connections between the surfaces of the supply electrodes and connection electrodes and the contact pads of the IC-crystal are preferably each formed by a thermocompression bond or a soldered joint. Glued joints cannot be used in this case since they cannot withstand temperatures of 450—550°C.

The invention will now be described in greater detail with reference to the accompanying drawing, of which

Figure 1 is a sectional view of a display device according to the invention,

Figure 2 shows in detail the connection of the IC-crystal of Figure 1, and

Figure 3 is a sectional view taken on the line AA' of Figure 1.

The display device shown in Figure 1 comprises two parallel glass supporting plates 1 and 2. A pattern of electrodes 3 to be driven individually is provided on the supporting plate 1 with supply electrodes 4 and external connection electrodes 5. An opposite electrode 6 which is common for the pattern of electrodes 3 is provided on the supporting plate 2. In addition to one common opposite electrode, several opposite electrodes may alternatively be used as is usual in a so-called time multiplexing drive of the display device. The electrodes 3, 4, 5 and 6 are transparent and are manufactured from indium-tin oxide which may be provided by vapour deposition, sputtering, silk screening or a chemical vapour deposition process.

In order to reduce the resistance of the thin supply electrodes 4 and connection electrodes 5, these are provided with a metallization 7 formed by successively provided layers of Ti, Ni and Au, which may be provided by means of electrodeposition or electroless deposition or by vacuum sputtering or vapour deposition. The metallization 7 may also be formed by successively provided layers of Cr, Ni and Au or by a layer of electroless Ni or by layers of other metals. The thickness of the metallization 7 is determined by the sheet resistance of the metals. The indium-tin oxide electrodes 3, 4, 5 and 6 have a thickness of approximately 0.15 μm and the thickness of the metallization layer 7 is approximately 0.3 μm . An IC-crystal 9 is secured to the metallization layer 7 on the supply electrodes 4 and the connection electrodes 8 by means of gold balls 12. The connection of the IC-crystal will be described in detail with reference to Figure 2. The IC-crystal 9 is

approximately 2 mm square and has a thickness of approximately 250 μm . A cavity 10 is drilled in the glass supporting plate 2 so as to partly accommodate the IC-crystal 9. The cavity 10 has a diameter of approximately 3.5 mm and a depth of approximately 350 μm and is provided in the supporting plate 2 by ultrasonic drilling. Liquid crystal-orienting layers 11 of polyparaxylylene are provided on the supporting plates 1 and 2 in a thickness of approximately 0.1 μm . The polyparaxylylene is provided by means of a so-called chemical vapour deposition process, after which the layer obtains further orienting properties by polishing it in one direction. This has the advantage that not only the free surface but also the surface facing the supporting plate 1, the so-called active surface, of the IC-crystal 9 is coated.

The liquid crystal-orienting layers 11 may also be provided by the oblique vapour deposition of, for example, SiO and MgF_2 or by using surface-active substances, such as soaps, silane and alcohol. Liquid crystal-orienting layer is to be understood to mean not only a layer which orients the liquid crystal molecules in one given direction, but also a layer which produces a random orientation of the liquid crystal molecules. This latter is used, for example, in display devices which use the so-called dynamic scattering effect. The supporting plates 1 and 2 are kept at a distance of 12 μm and the device is sealed by a polyethylene frame 13 in which a cavity 14 for the IC-crystal 9 is recessed. During the manufacture of the device the frame 13 is laid between the supporting plates 1 and 2 over the IC-crystal 9 after which a joint which is uniform in thickness is produced between the supporting plates 1 and 2 by heating to a temperature of approximately 120°C to 220°C.

It is also possible to seal the display device by means of a rim of glass enamel. The glass enamel is provided by silk screening and then previtrified by heating preferably prior to assembling the IC-crystal 9. After providing the IC-crystal 9 the supporting plates are joined by heating to a temperature of approximately 450—550°C. It is to be noted that when a glass enamel sealing rim is used, only inorganic liquid crystal-orienting layers may be used, for example, SiO and MgF_2 .

Via a filling aperture (not shown) in the supporting plate 2 the display device is filled with a nematic liquid crystal having positive dielectric anisotropy 15, for example, p-alkyl - p' - cyanobiphenyl compounds, which are available from Messrs. Merck under the name of E7, or p-alkyl(oxy) - p'-cyanobiphenylene compounds, phenylcyclohexane compounds and azoxy with thioester compounds which are available also from Messrs. Merck by the names ZLI284 ZLI1132 and ZLI935, respectively. The surfaces of the supporting plates 1 and 2 remote from each

other comprise polarizers 16 and 17 having mutually perpendicular directions of polarization so as to make the twisted nematic field effect visible.

In a display device according to the invention other electro-optical display effects with liquid crystals may also be used, for example, the dynamic scattering effect, the guest-host effect, the electrically induced birefringence effect and the effect of the so-called cholesteric nematic junction.

Figure 2 shows in detail the connection of the IC-crystal 9 to the electrode pattern of Figure 1. The IC-crystal 9 has contact pads 18 of aluminium. First, gold balls 12 are provided on said contact pads 18 which also penetrate through an oxide layer formed on the aluminium surfaces. With the gold balls 12 a little of a conductive glue paste 19, for example, gold filled epoxy resin, is taken up after which the IC-crystal 9 is pressed on the metallization 7 of the supply electrodes 4 and connection electrodes 3. The glue 19 is then cured by thermal heating, the gold balls 12 serving as spacers for the IC-crystal 9 and the metallization layer 7.

It is also possible to connect the IC-crystal 9 to the electrode pattern only by means of balls of a conductive glue. The glue balls may then be provided on the aluminium contact pads of the IC-crystal or on the electrode pattern by means of silk screening or stamping. The IC-crystal may also be connected by means of solder balls to the indium-tin oxide electrodes provided with a suitable metallization.

It is to be noted that when a sealing rim of glass enamel is used, no glue may be used to connect the IC-crystal since this does not withstand temperatures of 450—550°C which are necessary to join the glass plates and the glass enamel sealing rim. In this case the IC-crystal may be connected to the electrode pattern by means of, for example, thermocompression or soldering methods.

Figure 3 is a sectional view taken on the line AA' of the display device shown in Figure 1. The transparent electrode pattern 3 with supply electrodes 4 and connection electrodes 5 provided on the supporting plate 1 is shown in broken lines. The cavity 14 for accommodating the IC-crystal 9 is recessed in the polyethylene frame 13. For this purpose the sealing rim 13 is made wider on the side where the IC-crystal is present than on the other sides.

In addition to the embodiments shown in which one IC-crystal is accommodated in the rim of sealing material, it is also possible in a display device in accordance with the invention to accommodate more than one IC-crystals in the rim of sealing material.

Claims

1. A display device comprising a layer of liquid crystal in a space enclosed by a rim of sealing material between two supporting plates

of which one supporting plate has a pattern of electrodes to be driven individually by supply electrodes, which supporting plate furthermore has a number of external connection electrodes, the said supply electrodes and connection electrodes being connected to contact pads of at least one non-encapsulated IC-crystal, characterized in that the at least one IC-crystal is accommodated in the rim (13) so that it is enclosed by the supporting plates (1, 2) and— in the space between the plates—by the sealing material.

2. A display device as claimed in Claim 1, characterized in that the other supporting plate is provided with a cavity to partly accommodate the IC-crystal.

3. A display device as claimed in Claim 1 or 2, characterized in that the connections between the surfaces of the supply electrodes and connection electrodes and the contact pads of the IC-crystal are each formed by a gold ball which is provided on one of the surfaces to be joined and which is secured to the other surface by means of a conductive glue.

4. A display device as claimed in Claim 1, 2 or 3, characterized in that each of the supporting plates has a liquid crystal-orienting layer, the orienting layer on the supporting plate on which the IC-crystal is provided also covering the IC-crystal.

5. A display device as claimed in Claim 4, characterized in that the liquid crystal-orienting layer is a polyparaxylylene layer.

6. A display device as claimed in any of the preceding Claims, characterized in that the sealing material is a thermoplastic material, in particular polyethylene.

7. A display device as claimed in any of Claims 1, 2 or 4, characterized in that the rim of sealing material is formed by a rim of glass enamel.

8. A display device as claimed in Claim 7, characterized in that the connections between the surfaces of the supply electrodes and connection electrodes and the contact pads of the IC-crystal are each formed by a thermocompression bond or a soldered joint.

Patentansprüche

1. Anzeigevorrichtung, die eine Flüssigkristallschicht in einem von einem Rahmen aus Abdichtungsmaterial umschlossenen Raum zwischen zwei Stützplatten enthält, von denen eine mit einem Muster einzeln anzusteuender Elektroden mit Zuleitungselektroden und einer Anzahl äusserer Anschlusselektroden versehen ist, wobei die Zuleitungselektroden und Anschlusselektroden mit Kontaktoberflächen mindestens eines nichteingekapselten IC-Kristalls verbunden sind, dadurch gekennzeichnet, dass der IC-Kristall in Rahmen (13) angeordnet ist, so dass er von den Stützplatten (1, 2) und, in Raum zwischen den Platten, vom Abdichtungsmaterial eingeschlossen ist.



other comprise polarizers 16 and 17 having mutually perpendicular directions of polarization so as to make the twisted nematic field effect visible.

In a display device according to the invention other electro-optical display effects with liquid crystals may also be used, for example, the dynamic scattering effect, the guest-host effect, the electrically induced birefringence effect and the effect of the so-called cholesteric junction.

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It is also possible to connect the IC-crystal 9 to the electrode pattern only by means of balls of a conductive glue. The glue balls may then be provided on the aluminium contact pads of the IC-crystal or on the electrode pattern by means of silk screening or stamping. The IC-crystal may also be connected by means of solder balls to the indium-tin oxide electrodes provided with a suitable metallization.

It is to be noted that when a sealing rim of glass enamel is used, no glue may be used to connect the IC-crystal since this does not withstand temperatures of 450—550°C which are necessary to join the glass plates and the glass enamel sealing rim. In this case the IC-crystal may be connected to the electrode pattern by means of, for example, thermocompression or soldering methods.

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In addition to the embodiments shown in which one IC-crystal is accommodated in the rim of sealing material, it is also possible in a display device in accordance with the invention to accommodate more than one IC-crystals in the rim of sealing material.

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of which one supporting plate has a pattern of electrodes to be driven individually by supply electrodes, which supporting plate furthermore has a number of external connection electrodes, the said supply electrodes and connection electrodes being connected to contact pads of at least one non-encapsulated IC-crystal, characterized in that the at least one IC-crystal is accommodated in the rim (13) so that it is enclosed by the supporting plates (1, 2) and—in the space between the plates—by the sealing material.

2. A display device as claimed in Claim 1, characterized in that the other supporting plate is provided with a cavity to partly accommodate the IC-crystal.

3. A display device as claimed in Claim 1 or 2, characterized in that the connections between the surfaces of the supply electrodes and connection electrodes and the contact pads of the IC-crystal are each formed by a gold ball which is provided on one of the surfaces to be joined and which is secured to the other surface by means of a conductive glue.

4. A display device as claimed in Claim 1, 2 or 3, characterized in that each of the supporting plates has a liquid crystal-orienting layer, the orienting layer on the supporting plate on which the IC-crystal is provided also covering the IC-crystal.

5. A display device as claimed in Claim 4, characterized in that the liquid crystal-orienting layer is a polyparaxylene layer.

6. A display device as claimed in any of the preceding Claims, characterized in that the sealing material is a thermoplastic material, in particular polyethylene.

7. A display device as claimed in any of Claims 1, 2 or 4, characterized in that the rim of sealing material is formed by a rim of glass enamel.

8. A display device as claimed in Claim 7, characterized in that the connections between the surfaces of the supply electrodes and connection electrodes and the contact pads of the IC-crystal are each formed by a thermocompression bond or a soldered joint.

Patentansprüche

1. Anzeigevorrichtung, die eine Flüssigkristallschicht in einem von einem Rahmen aus Abdichtungsmaterial umschlossenen Raum zwischen zwei Stützplatten enthält, von denen eine mit einem Muster einzeln anzusteuender Elektroden mit Zuleitungselektroden und einer Anzahl äusserer Anschlusselektroden versehen ist, wobei die Zuleitungselektroden und Anschlusselektroden mit Kontaktoberflächen mindestens eines nichteingekapselten IC-Kristalls verbunden sind, dadurch gekennzeichnet, dass der IC-Kristall in Rahmen (13) angeordnet ist, so dass er von den Stützplatten (1, 2) und, in Raum zwischen den Platten, vom Abdichtungsmaterial eingeschlossen ist.



2. Anzeigevorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass die andere Stützplatte mit einem Hohlraum zum teilweisen Umschliessen des IC-Kristalls versehen ist.

3. Anzeigevorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass die Verbindungen zwischen den Oberflächen der Zuleitungs- und Anschlusselektroden und den Kontaktflächen des IC-Kristalls durch je eine auf einer der mit einander zu verbindenden Oberflächen angebrachte Goldkugel gebildet werden, die mit Hilfe eines leitenden Klebers an der anderen Oberfläche befestigt ist.

4. Anzeigevorrichtung nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, dass jede der Stützplatten mit einer Flüssigkristallorientierungsschicht versehen ist, wobei die Orientierungsschicht auf der Stützplatte, auf der der IC-Kristall angebracht ist, ausserdem den IC-Kristall bedeckt.

5. Anzeigevorrichtung nach Anspruch 4, dadurch gekennzeichnet, dass die Flüssigkristallorientierungsschicht eine Polyparaxylenschicht ist.

6. Anzeigevorrichtung nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, dass das Abdichtungsmaterial ein thermoplastisches Material, insbesondere Polyäthylen, ist.

7. Anzeigevorrichtung nach einem der vorstehenden Ansprüche 1, 2 oder 4, dadurch gekennzeichnet, dass der Rahmen aus Abdichtungsmaterial durch einen Rahmen aus Glasemail gebildet wird.

8. Anzeigevorrichtung nach Anspruch 7, dadurch gekennzeichnet, dass die Verbindungen zwischen den Oberflächen der Zuleitungs- und Anschlusselektroden und den Kontaktoberflächen des IC-Kristalls durch je eine Thermokompressionsverbindung oder eine Lötverbindung gebildet werden.

Revendications

1. Dispositif d'affichage comportant une couche de cristal liquide dans un espace enfermé par un bord de matériau d'obturation entre deux plaques de support, dont une plaque de support présente une configuration d'électrodes à exciter individuellement par des électrodes

d'alimentation, plaque de support qui présente en outre plusieurs électrodes de connexion externes, lesdites électrodes d'alimentation et électrodes de connexion étant reliées à des surfaces de contact d'au moins un cristal de circuit intégré non encapsulé, caractérisé en ce qu'au moins un cristal de circuit intégré est logé dans le bord de façon à être enfermé par les plaques de support et—dans l'espace compris entre les plaques—par le matériau d'obturation.

2. Dispositif d'affichage selon la revendication 1, caractérisé en ce que l'autre plaque de support est munie d'une cavité pour loger partiellement le cristal de circuit intégré.

3. Dispositif d'affichage selon la revendication 1 ou 2, caractérisé en ce que les connexions entre les surfaces des électrodes d'alimentation et les électrodes de connexion et les surfaces de contact du cristal de circuit intégré sont formées chacune par une boule d'or qui est appliquée à l'une des surfaces à lier et qui est fixée à l'autre surface à l'aide d'une colle conductrice.

4. Dispositif d'affichage selon la revendication 2 ou 3, caractérisé en ce que chacune des plaques de support est munie d'une couche assurant l'orientation de cristaux liquides, la couche d'orientation sur la plaque de support sur laquelle est appliqué le cristal de circuit intégré étant appliquée de façon à recouvrir le cristal de circuit intégré.

5. Dispositif d'affichage selon la revendication 4, caractérisé en ce que la couche d'orientation de cristal liquide est une couche en polyparaxylène.

6. Dispositif d'affichage selon l'une des revendications précédentes, caractérisé en ce que le matériau d'obturation est un matériau thermoplastique, notamment du polyéthylène.

7. Dispositif d'affichage selon l'une des revendications 1, 2 ou 4, caractérisé en ce que le bord en matériau d'obturation est formé par un bord en émail vitrifié.

8. Dispositif d'affichage selon la revendication 7, caractérisé en ce que les connexions entre les surfaces des électrodes d'alimentation et des électrodes de connexion et les surfaces de contact du cristal de circuit intégré sont formés chacune par un joint de thermo-compression ou une soudure.