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**Datasheet for the decision
of 5 October 2012**

Case Number: T 1583/08 - 3.4.03

Application Number: 05012023.7

Publication Number: 1605531

IPC: H01L 51/20

Language of the proceedings: EN

Title of invention:

Organic electro-luminescent display and method for
manufacturing the same

Applicant:

LG Display Co., Ltd.

Headword:

-

Relevant legal provisions:

EPC Art. 123(2)

Relevant legal provisions (EPC 1973):

EPC Art. 56

Keyword:

"Inventive step (no)"

Decisions cited:

-

Catchword:

-



Case Number: T 1583/08 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 5 October 2012

Appellant:
(Applicant)

LG Display Co., Ltd.
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Seoul (KR)

Representative:

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Decision under appeal:

Decision of the Examining Division of the
European Patent Office posted 21 January 2008
refusing European patent application
No. 05012023.7 pursuant to Article 97(1) EPC
1973.

Composition of the Board:

Chairman: G. Eliasson
Members: V. L. P. Frank
P. Mühlens

Summary of Facts and Submissions

- I. This is an appeal from the refusal of application 05 012 023 for the reason that the subject-matter of the claims did not involve an inventive step (Article 56 EPC 1973).
- II. At the oral proceedings before the board the appellant applicant requested that the decision under appeal be set aside and that a patent be granted on the basis of claims 1-11 of the main request or on the basis of claims 1-11 of auxiliary requests 1 or 2, all filed with the letter of 5 September 2012, or on the basis of claims 1 to 11 of auxiliary requests 3 or 4 filed at the oral proceedings.
- III. Claim 1 of the main request reads:
- "1. An organic electro-luminescent display having a plurality of R, G, and B pixels comprising:
- a transparent substrate (21);
 - a plurality of anodes (28) having a high reflectivity each formed in a pixel region over the transparent substrate (21);
 - an organic electro-luminescent layer (30-34) including R, G, or B light emitting layers (32) according to each pixel region formed over the anodes (28);
 - a common transparent cathode (35-36) formed over the organic electroluminescent layer (30-34), wherein the common transparent cathode (35-36) comprises a laminated structure of a transparent metal cathode (35) and an auxiliary cathode (36) made of a transparent conductive material;

- a protective film (37) formed over the cathode (35-36), the protective film (37) having a multi-layer structure and serving as micro-cavity; and a sealant (38) formed over the protective film (37), and provided with grains distributed in the sealant, the grains having a size smaller than a thickness of the sealant and are made of a metal."

Claim 1 of auxiliary request 1 specifies that the display comprises "a plurality of anodes (28) having a high reflectivity **and a high work function**" (emphasis added by the board). Otherwise it is identical to claim 1 of the main request.

Claim 1 of auxiliary request 2 adds the following feature at the end of claim 1 of auxiliary request 1:

"- a transparent protective cap (39) made of glass attached to the upper surface of the sealant (38)."

Claim 1 of auxiliary request 3 reads:

- "1. An organic electro-Luminescent display having a plurality of R, G, and B pixels comprising:
 - a transparent substrate (21);
 - a plurality of anodes (28) having a high reflectivity and a high work function each formed in a pixel region over the transparent substrate (21);
 - an organic electro-luminescent layer (30-34) including R, G, or B light emitting layers (32) according to each pixel region formed over the anodes (28);

- a common transparent cathode (35-36) formed over the organic electroluminescent layer (30-34), wherein the common transparent cathode (35-36) comprises a laminated structure of a transparent metal cathode (35) and an auxiliary cathode (36) made of a transparent conductive material;
- a protective film (37) formed over the cathode (35-36), the protective film (37) having a multi-layer structure and serving as micro-cavity; and a sealant (38) formed over the protective film (37), and provided with grains distributed in the sealant, the grains having a size smaller than a thickness of the sealant and are made of transparent nitride which has a refractive index different from that of the sealant."

Claim 1 of auxiliary request 4 adds the following feature at the end of claim 1 of auxiliary request 3:

"- a transparent protective cap (39) made of glass attached to the upper surface of the sealant (38)."

All requests comprise method claim 6 directed at manufacturing an organic electro-luminescent display.

IV. The following prior art documents are cited in this decision:

D1: US 5 674 636 A

D3: US 2002/0061418 A

D4: US 2004/0081855 A

V. The examining division essentially argued that:

- Document D1 represented the closest prior art from which the display of the main request differed in that the small grains in the sealant layer were made of an opaque material, eg a metal. The use of metallic fine particles to widen the radiation angle was however disclosed in document D3. The skilled person would thus consider an obvious alternative to replace the small grains of fumed silica used in D1 by the metal particles of D3. The claimed display did not involve therefore an inventive step (Article 56 EPC 1973).

- The display according to claim 1 of the 3rd auxiliary request required the presence of a transparent protective cap. The skilled person knew however from the manufacture of LCD or plasma flat display panels to provide the screen of the display with an anti-reflection and/or anti-scratch protective pane usually made of glass or plastics. As no unexpected effect was apparent from the addition of a protective cap to the structure disclosed in D1, the display of claim 1 of this request did not involve an inventive step.

VI. The appellant applicant argued essentially as follows:

- It was an object of the invention to provide an organic electro-luminescent display having a plurality of R, G, and B pixels having not only an improved luminance and color purity, but also achieving an improvement in viewing angle. The

organic electro-luminescent layer was located between a plurality of anodes having high reflectivity and a common protective film having a multilayer structure, to form a micro-cavity greatly enhancing the color purity of each R, G and B colored pixel of the display, when the reflective index and thickness of each layer in the protective film was optimized. The use of the micro-cavity enhancing the luminance and color purity lead however to a narrow viewing angle. Thus a sealant formed over the protective film was provided with grains distributed in the sealant to diffuse the different colored light incident from the R, G, and B pixels into the sealant.

- It was not necessary to specify in claim 1 of the main request that the anode was made of a material having a high work function, since this was the usual practice. This feature should thus be considered to be implicit in claim 1. Although the material of the anodes was specified throughout the description as having a high reflectivity and a high work function it was directly and unambiguously clear that, for the present invention, only the high reflectivity was an essential feature of the invention but not the characteristic of having a high work function. As could be seen from the whole specification, the present invention was directed to improvements of the optical characteristics of an organic electro-luminescent display and consequently the optical characteristics of the material selected for the anode were essential but not the electrical characteristics like a high work function. Consequently, it was directly and unambiguously

clear for a skilled person that this feature could be omitted when specifying the anodes as having a high reflectivity.

- The invention provided grains made of metal in the sealant, having the advantage that the scattering of the light from the different colored pixel regions was based on reflection, thus, not showing any dispersion effects of scattering light with different wavelengths. The use of a sealant provided with metal grains distributed in the sealant had the further technical effect that the thermal conductivity of the sealant layer was enhanced as a result of excellent thermal conductivity of the metal grains. Thus the multilayer structure was prevented from overheating which could result in a damage to the structure, which further could result in damage to the organic electro-luminescent layer. Although the inclusion of metal grains in the sealant resulted in an inhomogeneous thermal expansion of this layer, which could lead to mechanical stress in the boundary between the sealant and the multilayer structure, it was found that the advantages of high thermal conductivity and homogenous light scattering overbalanced the presumed negative effect of mechanical stress. A person skilled in the art would not deviate from the solution of D1, ie a sealant having a colloidal dispersion of fumed silica.

- The use of a laminated cathode formed by a transparent metal cathode and an auxiliary cathode made of a transparent conductive material increased the thermal conductance of the cathode. Although a

similar structure was disclosed in document D4, it was used in the invention for a different purpose.

- The use of a transparent protective cap made of glass attached to the upper surface of the sealant provided mechanical stability to the protective film, thus reducing possible mechanical stress within the multilayer structure. Herein, the use of glass instead of plastics further supported the provision of mechanical stability to the underlying sealant layer and protective film.

- The use of a sealant provided with grains made of transparent nitride having a reflective index different from that of the sealant was not disclosed in any of the cited prior art documents or in a combination thereof. The provision of grains made of transparent nitride had the technical advantageous effect that the thermal conductance of the sealant layer was enhanced due to the excellent thermal conductivity of silicon nitride.

- The combination of a transparent protective cap made of glass attached to the upper surface of a sealant being provided with grains distributed in the sealant and made of transparent nitride had the advantageous effect that the difference in the expansion coefficient of the glass protective cap and the sealant was low and thus mechanical stress between the transparent protective cap and the sealant layer was minimized.

Reasons for the Decision

1. The appeal is admissible.
2. *Main request - Amendments*
 - 2.1 The application as filed discloses an organic electro-luminescent display comprising an anode made of a conductive material having a high reflectivity and a high work function (claim 8 and [0049]). The feature of amended claim 1 "*a plurality of anodes having a high reflectivity*" comprises however anodes made of materials having low or high work functions.
 - 2.2 The appellant applicant argued that anodes were usually made of materials having a high work function and that this feature was therefore implicit in the feature "anode".
 - 2.3 The board however is not persuaded by this argument, since the claim as it stands comprises anodes made of materials having also a low work function. Since, as argued by the appellant, the use of low work function materials for anodes is contrary to the usual practice, its inclusion in the claim requires an explicit disclosure in the application as filed, which is absent in the present case.
 - 2.4 The board finds for this reason that claim 1 of the main request contains subject-matter which extends beyond the content of the application as filed (Article 123(2) EPC).

3. *Auxiliary requests 1 to 4 - Amendments*

Since claim 1 of these requests contains the specification that the anodes have a high reflectivity and a high work function, these requests overcome the above objection.

4. *Auxiliary request 1 - Inventive step*

4.1 It is common ground that document D1 represents the closest prior art. It discloses in the words of claim 1:

An organic electro-luminescent display comprising:
- a transparent substrate (20);
- a cathode (26) having a high reflectivity formed over the transparent substrate (20);
- an organic electro-luminescent layer (25);
- a transparent anode (23) formed over the organic electroluminescent layer;
- a protective film (21) formed over the anode, the protective film having a multi-layer structure and serving as micro-cavity; and
a sealant (28) formed over the protective film, and provided with grains distributed in the sealant, the grains having a size smaller than a thickness of the sealant (column 1, line 63 to column 2, line 13; column 3, line 12 to column 4, line 61; Figure 2).

4.2 Although document D1 discloses in relation to Figure 2 a structure formed successively by a substrate (S), a cathode (C), an electro-luminescent layer (EL) and an anode (A), it states that the position of the electron and hole injection contacts may be interchanged, so

that a structure as in the present invention is also disclosed, namely a S/A/EL/C structure (column 4, lines 28 to 34).

4.3 The display of claim 1 therefore differs from the display disclosed in document D1 in that:

- (a) the electro-luminescent layer includes R, G and B light emitting layers, so that the display has a plurality of R, G and B pixels;
- (b) the anode is made of a material with a high work function;
- (c) the cathode comprises a laminated structure of a transparent metal cathode and an auxiliary cathode made of a transparent conductive material;
- (d) the grains distributed in the sealant are made of metal.

4.4 As will be shown below, the following group of features (a)/(d), (b) and (c) address three different technical problems.

4.4.1 Feature (a) is directed to manufacturing an RGB display. The application does not disclose any steps that would be necessary for obtaining a RGB electro-luminescent display other than providing R, G or B light emitting layers on the hole transfer layer at the pixel sites ([0052] to [0053]).

The problem addressed by feature (a) is thus to provide an RGB display.

4.4.2 Feature (b): the board shares the view of the appellant applicant that it is usual that anodes are made of materials with a high work function, since this eases the extraction of electrons or conversely the injection of holes.

The problem addressed by feature (b) is thus to provide an anode with good electrooptic characteristics.

4.4.3 Feature (c): the application does not disclose any technical effect achieved by using a laminated cathode ([0054]-[0056]). In particular, the use of an auxiliary cathode is disclosed as being optional ([0056]).

Document D4 on the other hand discloses that cathodes formed of indium tin oxide (ITO) or indium zinc oxide (IZO) are very sensitive to deposition temperature and require substrate temperatures of 200-300°C. However, the underlying organic electro-luminescent layer is susceptible to temperatures higher than 100°C. Thus cathode films made of only ITO or IZO have poor electrooptic characteristics ([0010]-[0011]). D4 thus discloses a cathode formed of a laminated stack comprising a first layer of metal (eg Ag) and a second layer of a transparent material (eg ITO or IZO) having good electrooptic characteristics (0012)-[0018]; Figure 2).

The problem addressed by feature (c) is thus to provide a cathode with good electrooptic characteristics.

4.4.4 Feature (d): document D1 discloses a sealant layer (named in D1 a scattering layer 28) formed of a

transparent polymer with a colloidal dispersion (eg fumed silica) therein or a substantially transparent layer (eg SiN_x) with a mechanically rough surface. This layer randomizes the emission of light over a large solid angle, thereby eliminating or at least reducing the angular dependence of the emission, due to Fabry-Perot cavity effects in the protective film acting as micro-cavity (column 4, lines 47 to 61).

The application discloses that the grains incorporated in the sealant layer diffuse the light incident to the sealant from the protective film and thereby increases the viewing angle ([0069]-[0070]). It further discloses that the grains may be made of a transparent or opaque material, eg that they may be made of transparent silicon or a transparent oxide or nitride or that they may be made of metal ([0061]-[0067]). No special effect associated with the use of metal grains is disclosed in the application.

The board is thus persuaded that the presence of the grains in the sealant layer of the application have the same purpose as the grains in the scattering layer of D1, namely to diffuse the light emitted by the electro-luminescent layer and bundled by the microcavity located above it. Both structures widen the display's viewing angle.

The appellant applicant argued that the use of metal grains had the advantage that the scattering of light from the different colored pixel regions was based on reflection, thus not showing any dispersion effects of scattering light with different wavelengths. Uniform scattering was achieved for each of the different R, G

and B pixels. The display having thus enhanced color purity and exhibiting at the same time a wide viewing angle without any defects in color.

The problem addressed by feature (d) may thus be seen in enhancing the color purity of an RGB display having a large viewing angle.

- 4.5 Resuming, features (a) and (d) address the issue of providing an EL-RGB display having good color purity and large viewing angle; feature (b) addresses the issue of providing an anode and feature (c) addresses the issue of providing a cathode, both with good electrooptic characteristics.
- 4.6 Document D3 discloses an organic electro-luminescent display comprising a layer (named second intermediate layer 33) having internal scattering bodies, such as metallic fine particles, for bending the light emitted by the electro-luminescent layer. This widens the light emitting distribution and increases the viewing angle ([0174] and [0177]; Figure 15; in figure 15 the identification of the different embodiments does not correspond to the one used in the description, the embodiment identified in the figure as 15(e) corresponds in fact to the embodiment named 15(c) in the description).
- 4.7 The skilled person thus knows that either transparent grains (eg fumed silica as in D1) or opaque metallic grains (as in D3) can be employed as light scattering centers for widening the angle over which light is emitted by an organic electro-luminescent display. He also knows that contrary to light refraction, light

reflection does not produce color dispersion. This last effect is also achieved in D3 since it is a property of light reflection.

4.8 The board considers for these reasons that the skilled person would use R, G and B electroluminescent materials in the display of D1 and replace the grains of fumed silica by grains of metal as in D3 to obtain an electroluminescent RGB display having good color purity and large viewing angle. On the other hand he would use the laminated cathode disclosed in D4 in the display of D1 to obtain a cathode having good electrooptic characteristics. Finally, he would use a material having a high work function for the anode, if that was not already the case in the display of D1.

4.9 The appellant applicant argued that the skilled person would be reluctant to use metal particles in an electroluminescent display with a microcavity, since there was the danger of metallic diffusion in the protective multilayer. The appellant applicant mentioned in this respect the care with which Cu diffusion into Si substrates was prevented.

The board is not persuaded by this argument, since there is no indication in the application that the use of metal grains should be made carefully or that any precautions are to be applied. Although the application does not provide details on the materials forming the microcavity, document D1 discloses that exemplary materials may be $\text{SiO}_2/\text{SiN}_x$ and $\text{SiO}_2/\text{TiO}_2$ (column 3, lines 36 to 45). It is not apparent that any significant metal diffusion into these layers would occur. Moreover, the board considers the analogy to the Cu/Si system not

appropriate, since in that case the electric properties of a semiconductor device and not the optical properties of a multilayer structure are affected. In particular, in manufacturing semiconductor devices metal conductor made of Al or Au are usually employed. There is thus no reluctance in using metals in general, but only some specific metallic elements.

- 4.10 The appellant applicant also argued that the use of metal grains and the provision of a laminated cathode had a synergetic effect, namely to contribute to improving heat transfer from the microcavity, since they increased the thermal conductivity of the sealant layer and the cathode, respectively.
- 4.11 The board is however not persuaded that the problem of heat transfer is derivable from the application as filed. There is no mention of this problem neither in the application nor in the prior art documents. A skilled person when reading the application would not have deduced that the claimed display contributes to solving a heat transfer problem. For this reason, the board does not consider this a valid technical problem addressed by the present invention, since it is not derivable from the application as filed.
- 4.12 The board finds for the above reasons that the electro-luminescent display of claim 1 of auxiliary request 1 does not involve an inventive step (Article 56 EPC 1973). Auxiliary request 1 is thus not allowable.

5. *Auxiliary request 2 - Inventive step*

5.1 The display of claim 1 of auxiliary request 2 differs from the display of claim 1 of the previous request in that a transparent protective cap made of glass is attached to the upper surface of the sealant.

5.2 The claimed display is a top emitting display in which light is emitted through the sealant layer. It is common practice, as already argued by the examining division in relation to the 3rd auxiliary request that a protective layer of glass or plastic is provided at the front surface of a display. The board considers thus that the skilled person would have provided such a protective layer on top of the sealant layer of the display disclosed in figure 2 of document D1. One of the possibilities available to the skilled person is to directly attach the glass layer to the uppermost layer of the display, as done in the present case.

5.3 The board for these reasons and the reasons given in relation to auxiliary request 1 cannot recognize the presence of an inventive step in the display of claim 1 of auxiliary request 2 (Article 56 EPC 1973). Auxiliary request 2 is therefore not allowable.

6. *Auxiliary request 3 - Inventive step*

6.1 The display of claim 1 of auxiliary request 3 differs from the display of claim 1 of auxiliary request 1 in that the grains in the sealant layer are made of transparent nitride.

6.2 As mentioned previously the display disclosed in D1 comprises a colloidal dispersion of transparent grains, eg fumed silica, in the sealant layer. The appellant applicant argued that silicon nitride had a better thermal conductivity than silica and that therefore the sealant layer helped to remove heat from the display.

6.3 Leaving aside the fact that claim 1 specifies "transparent nitride" and not silicon nitride, the board is of the view that the problem of thermal load of the electroluminescent display is not derivable from the application as filed and does not accept this as the technical problem addressed by the present invention (see point 4.11 of this decision).

6.4 The use of grains of a transparent nitride or even of silicon nitride instead of grains of fumed silica is thus an alternative available to the skilled person which does not involve an inventive step.

6.5 The board finds for these reasons and the reasons given in relation to auxiliary request 1 that the display of claim 1 of auxiliary request 3 does not involve an inventive step (Article 56 EPC 1973). Auxiliary request 3 is thus not allowable.

7. *Auxiliary request 4 - Inventive step*

7.1 The display of claim 1 of auxiliary request 4 differs from the display of auxiliary request 3 in that a transparent protective cap made of glass is attached to the upper surface of the sealant, ie the feature discussed in relation with auxiliary request 2 (point 5 of this decision).

- 7.2 The appellant applicant argued that the thermal expansion coefficients of silicon nitride and the glass used for the protective cap were close to each other and that therefore the attachment between the protective glass cap to the sealant layer was improved.
- 7.3 The board however considers this to be an unproven assertion, in particular, since the kind of glass used for the protective cap is not disclosed in the application which merely discloses the use of glass as optional ("*A transparent protective cap 39, which may be made of glass, is attached to the upper surface of the sealant 38*" ([0060])). There is thus no synergetic effect between the use of a protective glass cap and the use of grains of silicon nitride that is derivable from the application as filed. These features are not a combination, but an aggregation.
- 7.4 The use of a protective cap for protecting the underlying layers is however an obvious choice for a person skilled in the art and does not involve inventiveness.
- 7.5 The board finds for this reason and the reasons given in relation to auxiliary requests 2 and 3 that the display of claim 1 of auxiliary request 4 does not involve an inventive step (Article 56 EPC 1973). Auxiliary request 4 is thus not allowable.

Order

For these reasons it is decided that:

The appeal is dismissed.

Registrar

Chair

S. Sánchez Chiquero

G. Eliasson