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**Datasheet for the decision  
of 5 June 2008**

**Case Number:** T 1295/05 - 3.4.03

**Application Number:** 01121175.2

**Publication Number:** 1184833

**IPC:** G09G 3/32

**Language of the proceedings:** EN

**Title of invention:**

Method of driving EL display device

**Applicant:**

SEL SEMICONDUCTOR ENERGY LABORATORY CO., LTD.

**Opponent:**

-

**Headword:**

-

**Relevant legal provisions (EPC 1973):**

EPC Art. 56

**Keyword:**

"Inventive step (no)"

**Decisions cited:**

-

**Catchword:**

-



Case Number: T 1295/05 - 3.4.03

**D E C I S I O N**  
of the Technical Board of Appeal 3.4.03  
of 5 June 2008

**Appellant:** SEL SEMICONDUCTOR ENERGY LABORATORY CO., LTD.  
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**Decision under appeal:** Decision of the Examining Division of the  
European Patent Office posted 17 May 2005  
refusing European application No. 01121175.2  
pursuant to Article 97(1) EPC.

**Composition of the Board:**

**Chairman:** R. G. O'Connell  
**Members:** R. Q. Bekkering  
T. Bokor

## Summary of Facts and Submissions

I. This is an appeal against the refusal of application 01 121 175 for lack of an inventive step over

D1: K. Inukai et al.: "4.0 in. TFT-OLED Displays and a Novel Digital Driving Method" 2000 SID International Symposium, Digest of Technical Papers, Vol. 31, 16 - 18 May 2000, Pages 924-927

and *inter alia*

D11: US 5 969 710 A

The appellant requested at the oral proceedings that the decision under appeal be set aside and a patent granted on the basis of

*Main request*

Claims 1 to 11 filed with letter dated 28 April 2008, titled "*New Claims - Auxiliary Request I*".

*Auxiliary request*

Claims 1 to 7 filed with letter dated 28 April 2008, titled "*New Claims - Auxiliary Request II*".

II. Claim 1 of the main request reads as follows:

"1. A method of driving an EL display device in which a plurality of pixels, each having a first TFT (405,507), a second TFT (406,508) and an organic EL element

(407,510), are formed using an  $n$ -bit digital video signal, wherein

the first bit to the  $n$ -th bit of the digital video signal corresponds to display periods  $Tr_1$  and  $Tr_n$ , respectively;

one or more of the display periods  $Tr_1$  to  $Tr_n$  being divided into two or more divided display periods such that  $n + m$  display periods with  $n$  and  $m$  being natural numbers of one or more appear in one frame period;

the  $n + m$  display periods each correspond to one bit of a digital video signal among  $n$  bits of the digital video signal;

a plurality of display periods, among the  $n + m$  display periods, correspond to the same bit of the digital video signal;

other display periods corresponding to other bits of the digital video signal, among the  $n + m$  display periods, appear between the plurality of display periods;

for each of the  $n + m$  display periods, the corresponding bit of the digital video signal is input to a gate electrode of the second TFT (406,508) by the first TFT (405,507) turning on; and

the organic EL element (407,510) emits light when the second TFT (406,508) is turned on, and does not emit light when the second TFT (406) is turned off;

wherein after each of the  $n + m$  display periods begins, the respective display periods are completed by the beginning of another display period, and

whereby the ratio of the lengths of the display periods  $Tr_1$  to  $Tr_n$  is  $2^0:2^1:2^2:\dots:2^{n-1}$ ,

the number of divisions  $m_i$  of each display period corresponding to a bit  $i$  of the video signal having a length  $L_i, i=1, \dots, n$ , is selected so as to make the

values of  $Li/m_i^3$  or  $Li/m_i^2$  as equal as possible for a given total number of display periods  $n + m$ ."

III. Claim 1 of the auxiliary request reads as follows:

"1. A method of driving an EL display device in which a plurality of pixels, each having a first TFT (405,507), a second TFT (406,508) and an organic EL element (407,510), are formed, wherein  $n + m$  display periods ( $Tr$ ) with  $n$  and  $m$  being natural numbers of one or more appear in one frame period ( $1F$ ); the  $n + m$  display periods ( $Tr$ ) each correspond to one bit of a digital video signal among  $n$  bits of the digital video signal; whereby the ratio of the lengths of the display periods  $Tr_1$  to  $Tr_n$  which corresponds to the same bit of the video signal is  $2^0:2^1:2^2:\dots:2^{n-1}$ , whereby the lengths of the plurality of the display periods which correspond to the same bit of the digital video signal may not be all the same; a plurality of display periods ( $Tr$ ), among the  $n + m$  display periods, correspond to the same bit of the digital video signal; other display periods ( $Tr$ ) corresponding to other bits of the digital video signal, among the  $n + m$  display periods ( $Tr$ ), appear between the plurality of display periods ( $Tr$ ); for each of the  $n + m$  display periods ( $Tr$ ), the corresponding bit of the digital video signal is input to a gate electrode of the second TFT (406,508) by the first TFT (405,507) turning on; after each of the  $n + m$  display periods ( $Tr$ ) begins, the respective display periods ( $Tr$ ) are completed by the beginning of another display period ( $Tr$ ); and

*the organic EL element (407,510) emits light when the second TFT (406,508) is turned on, and does not emit light when the second TFT (406) is turned off."*

IV. The appellant applicant argued as follows:

The subject-matter of the claims of the main and auxiliary request involved an inventive step over the cited prior art.

Document D1 disclosed a method of driving a display without any division of the display periods within a frame corresponding to each of the bits of the video signal. Document D11 disclosed a division of the display periods but with a higher number of such divisions. In particular, according to D11 the display times were limited to no more than 1/16 of the total frame time. The method of claim 1 resulted in fewer divisions providing a trade-off between display quality and driving speed. The selection criterion for the number of divisions given in claim 1, last feature, provided a convenient subset, not obvious to the person skilled in the art.

Claim 1 of the auxiliary request provided for the option of the lengths of the plurality of the display periods corresponding to the same bit of the digital video signal not being all the same. This was not obvious to the skilled person.

## **Reasons for the Decision**

1. The appeal is admissible.

2. *Main request*

2.1 *Novelty*

2.1.1 *Document D1*

Document D1 discloses a method of driving an electro-luminescent display device, in particular an organic light emitting diode display with a plurality of pixels. The simplest pixel structure consists of two thin film transistors (TFT), a writing switch TFT (Sw) and a driving TFT (Dr), and an organic light emitting diode (OLED) (see figure 1 and corresponding description). The OLED emits light when the driving TFT is switched on. Gray-scale display is achieved by time division ("*time-ratio gray scale (TRG)*"). Each frame period is divided into 6 sub-frames (each corresponding to a bit of the 6-bit gray-scale input digital video signal) in order to display 64 gray-scales.

In particular, D1 (see 2.1 "*Pixel design*", 3.1 "*DPS driving*" and figures 1 and 5) discloses a method wherein, using the terminology of the application,

- the first bit to the 6-th bit of the digital video signal corresponds to display periods SF1 to SF6, respectively;
- the ratio of the lengths of the display periods SF1 to SF6 is 20:21:22:..:25;
- for each of the display periods, the corresponding bit of the digital video signal is input to a gate electrode of the second (driving) TFT (Dr) by the first (writing-switch) TFT (Sw) turning on; and

- the organic EL element (OLED) emits light when the second (driving) TFT (Dr) is turned on, and does not emit light when the second (driving) TFT (Dr) is turned off.

2.1.2 A division of the display periods (sub-frames) corresponding to each bit of the digital video signal as per claim 1 is not disclosed.

The subject-matter of claim 1 is, thus, new over document D1 (Articles 52(1) EPC 2000 and 54(1), (2) EPC 1973). It is also new over the remaining available, more remote prior art.

## 2.2 *Inventive step*

2.2.1 The technical effect of a division of display periods as claimed is the reduction of visual artefacts ("*pseudo contours*" in the application) which consist of pixels being perceived as unduly bright or dark.

As explained in the application, for instance in case of a 6-bit digital video signal allowing for 64 gray-scales, both in static and moving images, at the interface between portions of the display displaying the 32nd gray-scale gradation and portions displaying the 33rd gradation, bright or dark visual artefacts may occur. When displaying gray-scales by time division, the bits of the data for each pixel are displayed one at the time, the display time varying from a long display period for the most significant bit (MSB) to a short display period for the least significant bit (LSB), the ratio of the lengths of the display periods being  $2^0:2^1:2^2:2^3:2^4:2^5$ . Thus, the most significant bit



takes half of the frame period and the remaining bits take the other half. Hence, for the 32nd gray-scale gradation (011111) the second half of the frame period is bright and for the 33rd gradation (100000) the first half of the frame period is bright. When displaying consecutively the 32nd and the 33rd gradation in a moving image, two bright half-frames will be displayed in succession which will be perceived as a bright visual artefact. Similarly, when displaying the 32nd and the 33rd gradation adjacent to each other in a static image, because of saccadic movement of the eye's visual point, two bright half frames may be perceived in succession resulting in a bright visual artefact. Conversely, when displaying consecutively the 33rd and the 32nd gradation, two dark half-frames will be displayed in succession which will be perceived as a dark visual artefact.

- 2.2.2 The objective problem to be solved relative to document D1 can, therefore, be formulated as reducing these visual artefacts.

The problem *per se* is well known in the technical field of displays using time division modulation (pulse-width modulation) for displaying gray-scales at issue in the present case.

Document D11, for example, which is concerned with a method of implementing pulse-width modulation in a display based on spatial light modulators (SLM) such as micro mirror devices or liquid crystal displays (LCD) having individually driven pixels (column 1, lines 11 to 62), addresses the same problem of visual artefacts caused by displaying in succession intensity (ie gray-

scale) gradations (column 2, lines 32 to 44) resulting in two successive dark (or bright) half-frames. As would be apparent to the person skilled in the art, the problem stems from the pulse width modulation and thus occurs irrespective of whether the display is a micro mirror device, an LCD or an OLED display.

The formulation of the problem *per se*, thus, would be obvious to the person skilled in the art.

2.2.3 The solution to the above problem of visual artefacts offered in D11 is to divide the display times of the bit planes of the more significant bits into smaller segments and to distribute the segments throughout the frame period (column 4, line 30 to column 5, line 25). By way of example, for 8-bit pixel data, the MSB is split into eight segments, MSB-1 into four, MSB-2 into two segments, resulting in a 8,4,2,1,1,1,1,1 segmentation with a corresponding redistribution throughout the frame period (see figures 3A and 3B). According to D11, however, many other combinations of splitting and distributing bit-planes are possible (column 4, lines 64, 65). An alternative segmentation method that yields good results uses an 8,4,2,2,1,1,1,1 pattern.

Generally, D11 notes that "*the smaller the segments, the more times data is required to be loaded to the SLM, which imposes a bandwidth constraint on the number of segments*" (column 4, lines 6 to 8).

For displays providing colour by sequentially displaying data for each colour, the frame is divided in three, one part for each colour, so that the display

times are shorter and as a result the display is less prone to artefacts. In this case fewer segments are required. A segmentation of 3,2,1,1,1,1,1,1 may be suitable, ie only three segments for the MSB and two for MSB-1 (column 4, lines 12 to 25).

In the board's judgement the skilled person would, thus, in order to solve the above problem of visual artefacts, apply display period division and redistribution as proposed in D11 to the method of driving the display of D1.

- 2.2.4 The appellant applicant argued that since D11 stated that *"by experimentation, it is believed that limiting display times to no more than 1/16 to total frame time effectively reduces artifacts"*, the person skilled in the art would be led away from selecting fewer divisions than for instance the eight divisions suggested for the MSB in the example of D11. The last feature of claim 1, however, would result in fewer divisions (ie three for the MSB, see page 20, table 2 of the application as filed).

In the board's judgement, however, it would be readily apparent to the skilled person from D11 that to limit display times to no more than 1/16 of the total frame time is not an absolute criterion to be met, but only valid for a particular frame time, based on an experimental assessment of artefact reduction. For shorter frame times, as may be used in faster displays, or for instance in sequential colour display discussed above, fewer divisions may suffice to reduce effectively the visual artefacts.

Furthermore, D11 points out that the number of divisions is limited by the display characteristics, since the smaller the divisions, the more frequently data needs to be loaded to display. This places higher requirements on the driving circuitry of the display in terms of data handling capabilities and speed. Consequently, the person skilled in the art will seek to reduce the number of divisions to the minimum necessary to obtain an adequate reduction of the visual artefacts in question.

- 2.2.5 The appellant applicant furthermore argued that the last feature of claim 1 selected a convenient subset from the many division schemes available.

According to the appellant, the last feature of claim 1 was to be understood as selecting the number of division so as make the values of  $Li/m_i^3$  or  $Li/m_i^2$  as equal as possible, though within the overall constraint that the number of divisions was fixed beforehand.

In the board's judgement, although the only example given in the application meets this criterion (see description pages 19 to 21), it appears questionable whether this criterion as such is directly and unambiguously derivable from this example. Moreover, it may be doubted whether it is clear to define values for  $Li/m_i^3$  ranging from 1 to 8, as is the case in this example (see page 20, table 2), as being "*as equal as possible*".

However, even so, the claimed criterion merely represents an empirical rule reflecting what is after all an experimentally assessed balance between visual

artefact reduction and driving speed of the display, as confirmed by the appellant. As such there is no technical or physical meaning underlying the claimed squared or cubed expressions.

Finding a balance between artefact reduction and display driving speed is, however, in the board's judgement rendered obvious to the person skilled in the art by document D11. Accordingly, the person skilled in the art would arrive at the same range of possible divisions, depending on what is considered acceptable in terms of artefact reduction and driving load.

No unexpected effect has been alleged, or indeed is seen by the board, to be associated with the claimed selection, going beyond the known balance between artefact reduction and driving load discussed above. The selection is based on convenience of mathematical expression, devoid of physical significance as to the matter expressed, so that it cannot support inventive step.

The appellant's argument that the person skilled in the art would not arrive at the exact claimed expression is irrelevant as long as the person skilled in the art would arrive in an obvious manner at the selection. The requirement of inventive step calls for a non-obvious selection rather than a non-obvious way of defining an obvious selection.

2.2.6 Accordingly, the subject-matter of claim 1 of the main request lacks an inventive step in the sense of Article 56 EPC 1973, contrary to Article 52(1) EPC 2000.

The appellant's main request is therefore not allowable.

3. *Auxiliary request*

3.1 Claim 1 according to the auxiliary request corresponds in substance to claim 1 of the main request, however without the last feature relating to the criterion for selecting the number of divisions, and with the following feature instead: "*whereby the lengths of the plurality of the display periods which correspond to the same bit of the digital video signal may not be all the same*".

3.2 Despite the auxiliary request not being "convergent" with respect to the main request, it was admitted into the proceedings as it was easily dealt with under the reasons given for the main request.

3.3 As acknowledged by the appellant applicant, claim 1 of the auxiliary request includes a method wherein the lengths of the display periods which correspond to the same bit of the video signal are all the same.

According to document D11, "*When the display time for the MSB is divided into segments, each segment contains an integer number of these 128 time slices. Typically, the segments are of equal duration, but this is not necessary*" (column 4, lines 44 to 47). Accordingly, both options are suggested in D11. As for the remainder of the claim, the reasons given above for claim 1 of the main request apply *mutatis mutandis*.

3.4 Accordingly, the subject-matter of claim 1 of the auxiliary request is obvious to the person skilled in

the art and thus lacks an inventive step in the sense of Article 56 EPC 1973, contrary to Article 52(1) EPC 2000.

The appellant's auxiliary request is therefore not allowable either.

**Order**

**For these reasons it is decided that:**

The appeal is dismissed.

Registrar

Chair

S. Sánchez Chiquero

R. G. O'Connell