(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 June 2010 (17.06.2010)

PCT

(10) International Publication Number
WO 2010/068269 A1

(51) International Patent Classification:
G02B 26/02 (2006.01) *H01L 27/32* (2006.01)

(21) International Application Number:
PCT/US2009/006485

(22) International Filing Date:
10 December 2009 (10.12.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0822756.3 13 December 2008 (13.12.2008) GB

(71) Applicant *(for all designated States except US)*: **EASTMAN KODAK COMPANY** [US/US]; 343 State Street, Rochester, New York 14650 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **FYSON, John Richard** [GB/GB]; 8 Meynell Crescent, London Hackney E9 7AS (GB).

(74) Common Representative: **EASTMAN KODAK COMPANY**; 343 State Street, Rochester, New York 14650 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: BACKLIT DISPLAY

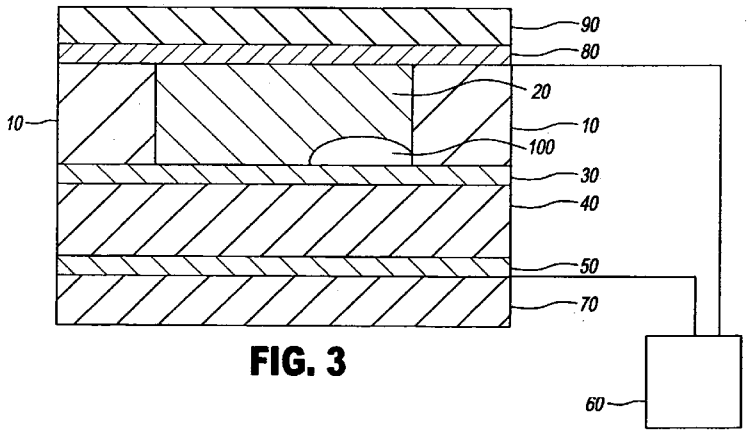

FIG. 3

(57) Abstract: A display or indicating device has at least one pixel, each pixel being provided with electrodes which are adapted to simultaneously provide power to an illumination element and control to an electrowetting element.

WO 2010/068269 A1

BACKLIT DISPLAY

FIELD OF THE INVENTION

This invention relates to a display or indicating device which is provided with backlighting, in particular to electroluminescent devices.

BACKGROUND OF THE INVENTION

There are a number of electroluminescent devices that rely on the electroluminescence. This is a general term for an optical phenomenon and electrical phenomenon where a material emits light in response to an electric current passed through it, or to a strong electric field. This is distinct to light emission resulting from heat (incandescence) or from the action of chemicals (chemoluminescence). There are many types of this phenomenon such as OLEDS, PLEDS, thin film electroluminescence and AC electroluminescence.

Taking AC electroluminescence as an example, this consists of a layer containing a phosphor powder suspended in a transparent dielectric (insulator) sandwiched between two electrodes, at least one of which is transparent. This conductor is usually a thin evaporated doped tin oxide layer on a transparent support such as glass or plastic. The amount of light given out from the device is controlled by applying an alternating voltage between the electrodes. If a pixellated device such as a display is required, at least one of the electrodes is segmented such that each element can be controlled.

Basic electrowetting displays are known in the art. A basic electrowetting optical element is described in EP1069450. This document discloses an optical element having a first fluid and an electro-conductive second fluid. The fluids are immiscible with each other and confined in a sealed space. The first and second fluids have different light transmittances. By varying a voltage applied to the second fluid the shape of the interface between the two fluids is changed. This voltage can be alternating. The amount of light passing through the element can thus be changed. A further refinement to this concept using said optical element to

create a pixel as part of an electrowetting display device is described in WO2004/104670. If a pixilated device such as a display is required, at least one of the electrodes is segmented such that each element can be controlled.

Similarly, Liquid Crystal Display (LCD) elements can control the amount of light passing through an element. This is also controlled by changing the AC electric field applied.

All the art concerning the combination of a light modulating device such as an LCD screen or electrowetting device and an illumination device, even if each is pixellated, have separate voltage supplies to the light modulating device and illumination element. Examples of this are demonstrated in WO2003/048849 where an LCD or electrowetting panel is placed over an electroluminescent panel. The two panels are controlled independently although may be in synchrony.

PROBLEM TO BE SOLVED BY THE INVENTION

Electrowetting and LCD displays have a relatively low contrast unless they are illuminated from behind. In reflection mode the base density and the absorption of the liquid crystal or the electrowetting liquids define the maximum and minimum reflectivity of the pixels in the device. In brightly lit conditions such as bright daylight this may be sufficient. If it is dark or the contrast is inadequate, the illumination can be from behind. Also if the contrast must be increased the contrast is dependent on the brightness of the illuminant as well as the adsorption of LCD or electrowetting component. If the backlight is turned on over the whole area of a device, energy is wasted by illuminating areas where light is to be absorbed as well as lit areas as well as 'leaking' through the LED or electrowetting element reducing the contrast.

SUMMARY OF THE INVENTION

By careful choice of architecture of a device a display can be constructed which has a number of luminescent elements and light modulating elements which are in register and are controlled by the same (AC) voltage. Application of the AC voltage causes the electroluminescent material to glow and the light modulator to allow more light through. In the case of an electrowetting modulator, the cell can be designed such that the electroluminescent material will glow brighter under the

conducting fluid than under the non-conducting liquid in a two liquid cell because the electric field is reduced under the non-conducting liquid.

According to the present invention there is provided a display or indicating device having at least one pixel wherein each pixel is provided with electrodes which are adapted to simultaneously provide power to an illumination element and control to an electrowetting element.

ADVANTAGEOUS EFFECT OF THE INVENTION

Providing one set of electrodes to control both the illuminant element and the electrowetting element results in simpler construction than using a separately controlled ACEL and LCD device.

The device of the invention saves power since the ACEL can be turned off during the day when it is not required. Only the area under the pixel is illuminated which also saves power.

The device is easy to manufacture. Only one substrate is used with the layers being coated in one set of coating processes. The phosphor acts as a white scattering layer under the electrowetting cell which is an advantage in high light conditions when the backlight is not good. The contrast of the image is higher as the uncovered layer glows more than the reflected light and there is now light under the dark area of the electrowetting oil that is pushed aside.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawing in which:

Figure 1 is a schematic view of the layer structure of a pixel element;

Figures 2a and 2b illustrate the "on" and "off" state of an element; and

Figure 3 is a schematic view of a device according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The layer structure of a pixel element is shown in Figure 1. It illustrates the structure of a possible coating for use as a combination of ACEL and electrowetting elements.

The coating consists of a base 70. The base may be opaque or transparent, conducting or otherwise. If the base 70 is not conducting a conducting layer 50, such as doped tin oxide or an organic conductor such as polythiophen, is coated onto it by a method appropriate to the material being coated. A layer 40 comprising a dielectric compound in which is dispersed an ECEL phosphor is coated onto layer 50, or layer 70 if layer 50 is not required. A layer 30 which exhibits electrowetting behaviour is coated above layer 40. An example of this layer is a polyfluorinated hydrocarbon. It will be understood by those skilled in the art that any appropriate material exhibiting electrowetting behaviour may be used for layer 30.

Figure 2a illustrates the "on" state of the element. Figure 2b illustrates the "off" state. The coating as described with respect to Figure 1 is used, i.e. having layers 30, 40, 50 and 70. A droplet 20 of, for example, 2M potassium chloride solution, is provided above the layer 30. This liquid sits on the surface. The liquid can be any conducting solution or conducting liquid that does not attack the polyfluorinatedhydrocarbon. This could be an ionic liquid. The liquid should be conducting, mobile and non-viscous. The diameter of the droplet is between about 1mm and 10mm. Into this is inserted a syringe needle 10. The syringe needle and the conducting substrate 50 are connected to a 400v AC power supply 60 (1kHz).

In Figure 2a the power supply 60 is switched on. Due to the electric field phosphor 45 in the layer 40 underneath the droplet 20 glows, lighting up the area under the droplet 20. The wetting angle of the droplet 20 reduces. The droplet therefore expands over the layer 30 lighting up a larger area of the electroluminescent phosphor below and thus giving out more light.

In Figure 2b the power supply 60 is switched off. As there is no electric field the phosphor 45 within the layer 40 does not glow. The wetting angle of the droplet 20 does not change and the size of the droplet does not change.

The device illustrated in Figure 3 is based on the coating described in Figure 1, i.e. having layers 30, 40, 50 and 70. A plastic well 10 was stuck onto the coating with Vaseline. The plastic well was made by stamping a 6mm hole in

a piece of 200 micron plastic shim. The well was filled with conducting fluid, 2M KCl solution 20. About 0.5 microlitres of 0.1M Oil Blue N in n-decane 100 was injected into the conducting fluid. This liquid must be non conducting and immiscible with the conducting liquid. It should be coloured suitably to modulate a particular colour of light. Alternatively it might be opaque to produce black. A piece of indium tin oxide coated transparent base 80 and 90 was stuck above the solution, conducting side toward the solution. The whole device was inverted such that the oil phase floated and attached to the electrowetting surface 30. The whole device was inverted again and the oil, 100, remained attached to the electrowetting surface 30. The two conduction surfaces, 50 and 80 were connected to a 400v AC power supply 60.

The following examples describe enabling embodiments of the invention.

Example 1

A coating was made as follows with reference to Figures 2a and 2b.

The coating was made on CPfilms™ CP300 indium tin oxide, 50, on heat stabilised PET, 70. A mixture of 2g Radiospares™ polyurethane potting compound (made as instructed 5:2 by weight) and 5g Durel 1PHS002AA blue-green ACEL phosphor was bar coated using a 100 micron bar at a very slow speed. This layer 40 was allowed to set at 65°C in a hotbox oven for 24 hours. Over this was coated a 12 micron layer 30 of 4% Teflon AF1600 dissolved in Fluorinert FC-75.

The coating was then connected to a 400v AC power supply, 60, via the layer of ITO 50, on the base 70, and a drop on 2M KCl solution, 20, into which was inserted a syringe needle, 10. The area under the drop of liquid lit up brightly and evenly and the drop expanded showing a reduction in wetting angle, demonstrating simultaneous electrowetting and ACEL with only two electrodes.

Example 2

A device was made as described in Figure 3. When there was no voltage applied the phosphor did not glow and the oil blue N solution 100 covered the bottom of the well. On applying the voltage the oil blue N solution contracted

leaving 60% of the bottom of the well uncovered and the ACEL phosphor glowing only under the exposed area.

The invention has been described in detail with reference to preferred embodiments thereof. It will be understood by those skilled in the art that variations and modifications can be effected within the scope of the invention.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

CLAIMS:

1. A display or indicating device having at least one pixel wherein each pixel is provided with electrodes which are adapted to simultaneously provide power to an illumination element and control to an electrowetting element.

2. A display or indicating device as claimed in claim 1 wherein the illumination element is an electroluminescent element.

3. A display or indicating device as claimed in claim 1 or 2 wherein the illumination element is an AC electroluminescent element.

4. A display or indicating device as claimed in any preceding claim wherein the electrowetting element is provided above the illumination element.

5. A display or indicating device as claimed in any preceding claim wherein the electrowetting element comprises a fluorocarbon or a fluoropolymer.

6. A method of illuminating a display from the back surface thereof, the display having a least one pixel, each pixel being provided with electrodes which simultaneously provide power to an illumination element and control to an electrowetting element, wherein when an electric field is present the illumination element provides illumination and the electro wetting element allows more light to pass through.

7. A method as claimed in claim 6 wherein the electrowetting element is provided in front of the illumination element.

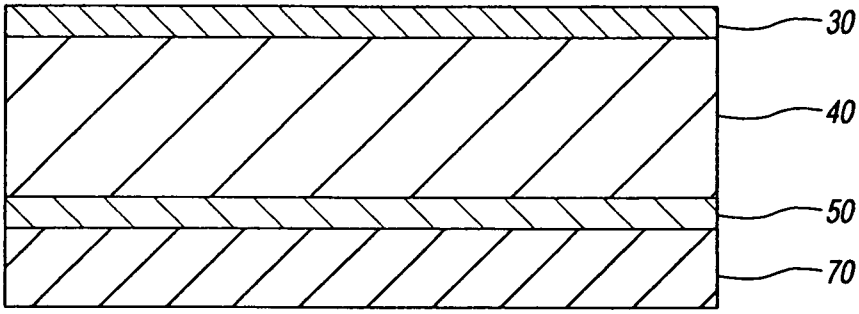

FIG. 1

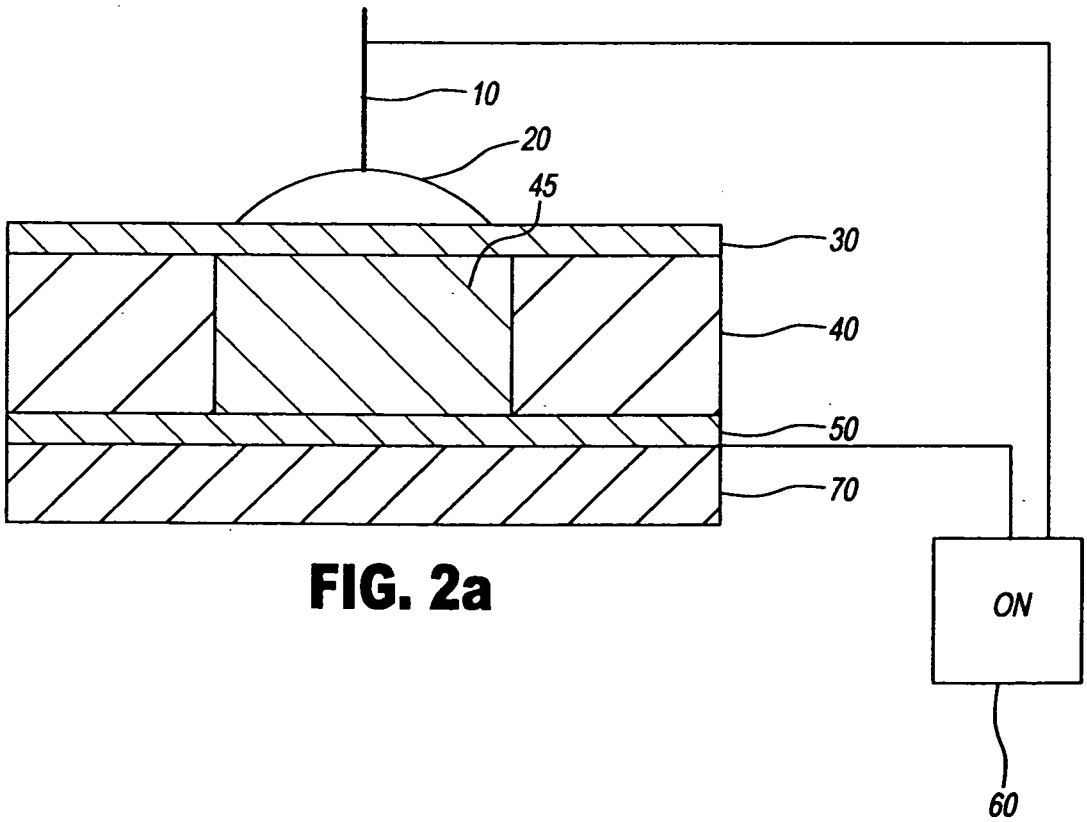

FIG. 2a

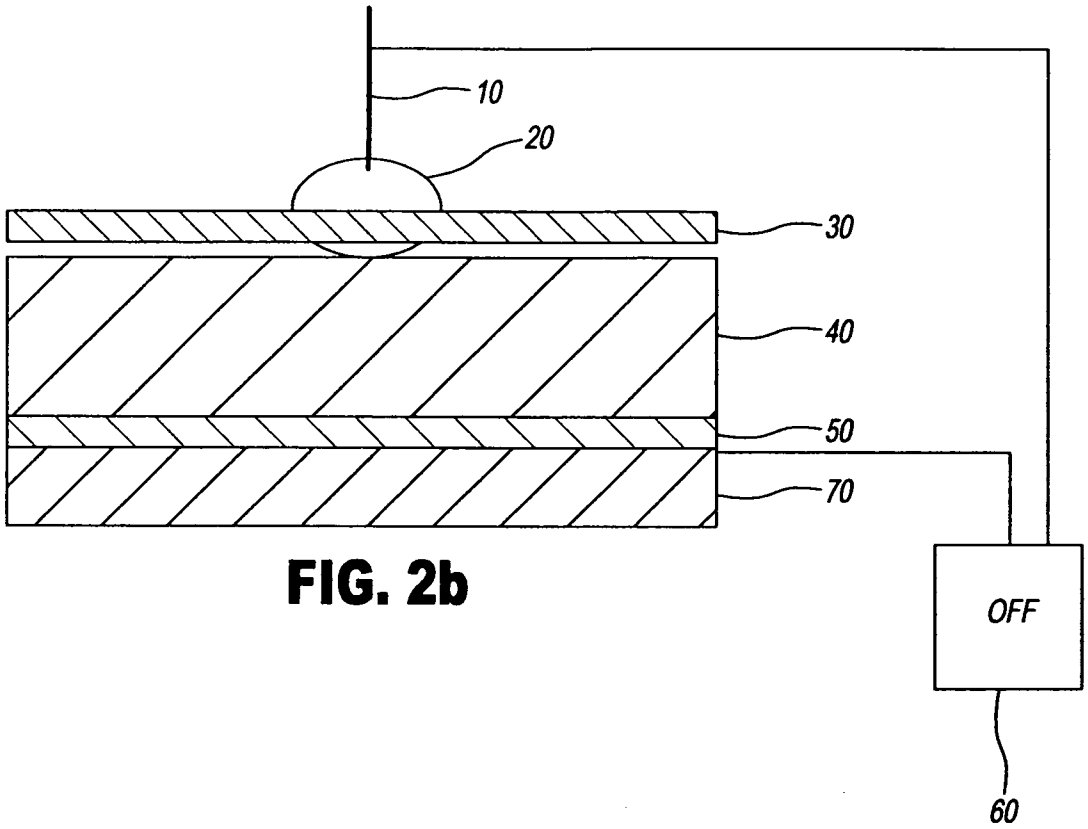

FIG. 2b

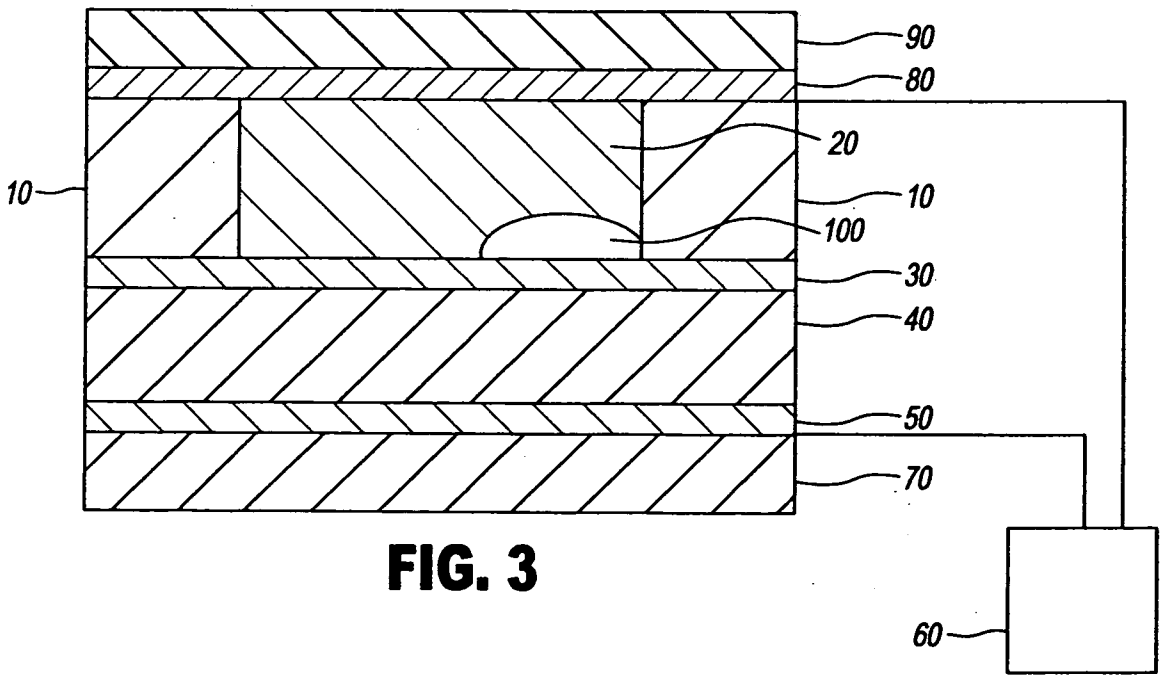

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/006485

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B26/02 H01L27/32
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02B H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ROQUES-CARMES THIBAULT ET AL: "Liquid behavior inside a reflective display pixel based on electrowetting" JOURNAL OF APPLIED PHYSICS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US LNKD-DOI:10.1063/1.1667595, vol. 95, no. 8, 15 April 2004 (2004-04-15) , pages 4389-4396, XP012067801 ISSN: 0021-8979 the whole document	1-7
X	WO 2007/071904 A1 (EASTMAN KODAK CO [US]; BOWER CHRISTOPHER [GB]; RIDER CHRISTOPHER [GB];) 28 June 2007 (2007-06-28) paragraph [0005] - paragraph [0032]; figures 1,3,5,6	1-7

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 May 2010	01/06/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Henderson, Richard

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/006485

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/048849 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]) 12 June 2003 (2003-06-12) page 6, line 5 - line 16; claims 1-5; figure 1	1-7
X	WO 2008/053144 A1 (EASTMAN KODAK CO [US]; BOWER CHRISTOPHER [GB]; RIDER CHRISTOPHER [GB];) 8 May 2008 (2008-05-08) page 1, line 17 - page 3, line 20; figure 1	1-7

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2009/006485

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2007071904 A1	28-06-2007	EP 1963904 A1	03-09-2008
		JP 2009521003 T	28-05-2009
		US 2008316564 A1	25-12-2008
WO 03048849 A1	12-06-2003	AU 2002347466 A1	17-06-2003
		CN 1809781 A	26-07-2006
		EP 1470445 A1	27-10-2004
		JP 2005512124 T	28-04-2005
		US 2003103021 A1	05-06-2003
WO 2008053144 A1	08-05-2008	EP 2078223 A1	15-07-2009
		US 2009231670 A1	17-09-2009