

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
23 September 2004 (23.09.2004)

PCT

(10) International Publication Number
WO 2004/081141 A1

(51) International Patent Classification⁷: **C09K 11/08**,
H05B 33/12

Standards GmbH, Weissshausstr. 2, 52066 Aachen (DE).
JÜSTEL, Thomas [DE/DE]; c/o Philips Intellectual Prop-
erty & Standards GmbH, Weissshausstr. 2, 52066 Aachen
(DE).

(21) International Application Number:
PCT/IB2004/050171

(74) Agent: **VOLMER, Georg**; Philips Intellectual Property &
Standards GmbH, Weissshausstr. 2, 52066 Aachen (DE).

(22) International Filing Date: 1 March 2004 (01.03.2004)

(25) Filing Language: English

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

(26) Publication Language: English

(30) Priority Data:
03100601.8 11 March 2003 (11.03.2003) EP

(71) Applicant (for DE only): **PHILIPS INTELLECTUAL
PROPERTY & STANDARDS GMBH** [DE/DE]; Stein-
damm 94, 20099 Hamburg (DE).

(71) Applicant (for all designated States except DE, US):
KONINKLIJKE PHILIPS ELECTRONICS N.V.
[NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven
(NL).

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),
Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), Euro-
pean (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR,
GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
ML, MR, NE, SN, TD, TG).

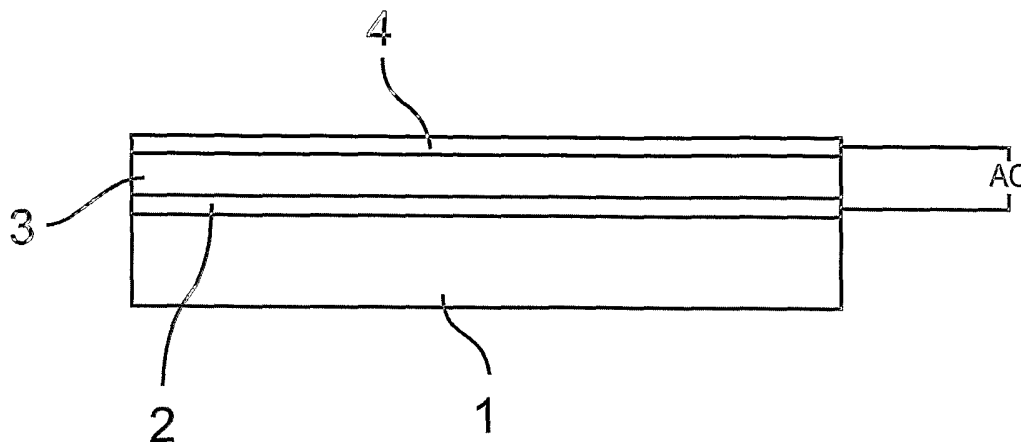
(72) Inventors; and

(75) Inventors/Applicants (for US only): **BERTRAM, Diet-
rich** [DE/DE]; c/o Philips Intellectual Property & Stan-
dards GmbH, Weissshausstr. 2, 52066 Aachen (DE). **HUM-
MEL, Helga** [DE/DE]; c/o Philips Intellectual Property &

Published:
— with international search report

[Continued on next page]

(54) Title: ELECTROLUMINESCENT DEVICE WITH QUANTUM DOTS



(57) Abstract: The invention describes an electroluminescent device equipped with a first electrode and a second electrode and with a compressed optical layer with quantum dots, wherein the compressed optical layer emits radiation under the influence of an electrical field. The electroluminescent device in accordance with the invention exhibits increased stability and improved efficiency and brightness.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Electroluminescent device with quantum dots

The invention relates to an electroluminescent device equipped with a first electrode and a second electrode and with an optical layer with quantum dots, wherein the optical layer emits radiation under the influence of an electrical field. The invention also relates to a method of manufacturing an electroluminescent device.

5 Electroluminescent devices have become enormously important in recent years, and are used, in particular, as display devices or background illumination systems.

The best-known electroluminescent devices currently are conventional LEDs
10 (Light Emitting Diodes) and also OLEDs (Organic Light Emitting Diodes).

In conventional LEDs, the light emission arises from the recombination of electron-hole pairs (excitons) in the transition region of a p-n junction polarized in the conducting direction (semiconductor). The size of the band gap of this semiconductor largely determines the wavelength of the emitted light.

15 In OLEDs, one (or more) semiconductive, organic layers are arranged between two electrodes. When a voltage is applied to the two electrodes in the conducting direction, electrons migrate from the cathode, and holes from the anode, into the semiconductive organic layer, recombine and generate photons. The wavelength of the emitted light hereby depends on the electronic properties of the organic, semiconductive material.

20 Also known are inorganic, electroluminescent devices comprising thin films, which, although exhibiting a high degree of stability, have only low efficiency and brightness. The operation of these inorganic electroluminescent devices with alternating current in an order of magnitude of 50 to 100 V gives rise to further problems, such as those associated with EMC or screening, for example.

25 Especially suitable as light-emitting materials in thin-film electroluminescent devices are quantum dots. Quantum dots are semiconductor nano-particles with a state structure lying between that of molecules and solids. Quantum dots emit light when an electron in the lowest vacant conductive state and a hole in the highest vacant valency state recombine and emit a photon. The energy of the emitted photon hereby corresponds to the

size of the band gap, which, in the case of the quantum dots, is a combination of the band gap of the volume material plus the quantization energy. The latter is determined by the size of the particles. The wavelength of the emitted photon, and thereby the emission color, thus depend directly on the size of the particle. By size variation of the quantum dots, an emission
5 in the ultraviolet, visible or infrared spectral range may be obtained.

In order to stabilize the individual quantum dots, i.e. to prevent agglomeration, organic ligands, such as trioctyl phosphine oxide (TOPO), are applied to the surface. The distance between two quantum dots in a layer is approximately twice the length of the organic ligand. This means that layers with quantum dots exhibit only a low conductivity.

10 The low conductivity has a detrimental effect on light generation in the case of electroluminescent devices which comprise, as the light-emitting layer, a thin film with quantum dots. One disadvantage is that, owing to the low conductivity, the optical layer can only exhibit a thickness less than 200 nm. In turn, this leads to a diminished robustness of the electroluminescent device, in particular of the optical layer.

15 It is therefore an object of the present invention to provide an electroluminescent device with high stability, efficiency and brightness, which can be manufactured in large dimensions.

20 This object is achieved by an electroluminescent device equipped with a first electrode and a second electrode and with a compressed optical layer with quantum dots, wherein the compressed optical layer emits radiation under the influence of an electrical field.

In a compressed optical layer, the quantum dots no longer exhibit organic
25 ligands on their surfaces. As a result, the distance between two quantum dots in the optical layer is reduced. This means that an optical layer of this kind exhibits an increased conductivity and therefore can be manufactured with greater layer thicknesses. A further advantage is that the increased conductivity gives rise to more opportunities, i.e. more design freedom, in the structuring of an electroluminescent device. Overall, the electroluminescent
30 device has greater stability.

The advantageously selected quantum dots as claimed in claims 2 and 3 exhibit good fluorescent properties as a result of the surface modification.

The advantageously selected structure as claimed in claims 4 and 5 ensures that no short-circuits occur in that electrons travel directly from the anode to the cathode through holes between the individual quantum dots.

5 The advantageously selected structure as claimed in claim 6 ensures that between the quantum dots there are conductive bridges, which improve the charge transfer within the compressed optical layer.

In addition, the invention relates to a method of manufacturing an electroluminescent device, equipped with a first electrode and a second electrode, with a compressed optical layer with quantum dots, wherein, under the influence of an electrical
10 field, the compressed optical layer emits radiation, during which the compressed optical layer is produced in that a layer of quantum dots and particles of a filler material is produced and compressed, wherein the particles of filler material exhibit a smaller diameter than the quantum dots.

Advantageously exploited in this method is the melting point reduction of
15 nano-crystalline materials. Through the exploitation of this effect, the optical layer may be compressed at low temperatures T , mostly at $T < 300^{\circ}\text{C}$. In the compression process, the particles of filler material melt before the quantum dots owing to the melting point reduction, and the filler material is distributed homogeneously between the quantum dots. The finished, compressed optical layer is an enclosed layer comprising the filler material, in which layer
20 the quantum dots are distributed.

The invention will be further described with reference to examples of embodiments shown in the drawings, to which, however, the invention is not restricted.

25 Fig. 1 shows, in cross-section, the structure of an electroluminescent device in accordance with the invention.

Fig. 2 shows, in cross-section, the structure of a further electroluminescent device in accordance with the invention.

30

In accordance with Fig. 1, a preferred embodiment of the display device in accordance with the invention has a transparent substrate 1, which comprises, for instance, glass or a plastic. Applied to the transparent substrate 1 is a first electrode 2 comprising a transparent, conductive material, such as ITO (indium-doped tin oxide). Located on the first

electrode 2 is a compressed optical layer 3. The compressed optical layer 3 comprises quantum dots, which emit light under the influence of an electrical field. Located on the compressed optical layer 3 is a second electrode 4, which preferably comprises a metal, such as silver.

5 The two electrodes 2, 4 are each provided with electrical terminals and connected to a voltage source.

The electroluminescent device is preferably provided with a protective enclosure comprising a plastic, such as polymethylmethacrylate, for protection, especially against moisture.

10 Fig. 2 shows a further embodiment of the electroluminescent device in accordance with the invention. In this embodiment, the electroluminescent device is equipped with a substrate to which the compressed optical layer 3 is applied. Applied to the compressed optical layer 3 are the first and second electrodes 2, 4.

 Alternatively, the electroluminescent devices may be equipped with still
15 further layers.

 The compressed optical layer 3 comprises quantum dots. The quantum dots preferably comprise so-called composite semiconductors, i.e. semiconductors composed of various elements of the main groups from the periodic system. The semiconductor material is, for example, a group IV material, a group III/V material, a group II/VI material, a group
20 I/VII material or a combination of one or more of these semiconductor materials. Preferably, the quantum dots comprise group II/VI materials, such as CdSe, CdS, CdTe, ZnS, HgS, ZnTe, ZnSe or group III/V materials, such as InP, InAs, InN, GaAs, GaN, GaP, GaSb, AlAs or AlP.

 Alternatively, the quantum dots may be of a structure such that a quantum dot
25 has a core comprising a semiconductor material, which is surrounded by an inorganic enclosure with a greater band gap. The material of the inorganic enclosure is preferably also a composite semiconductor. Quantum dots of this kind are designated 'Core Shell Quantum Dots'. Preferred quantum dots with a core shell structure are, for example, CdSe/CdS, CdSe/ZnS, CdTe/CdS, InP/ZnS, GaP/ZnS, Si/ZnS, InN/GaN, InP/CdSSe, InP/ZnSeTe,
30 GaInP/ZnSe, GaInP/ZnS, Si/AlP, InP/ZnSTe, GaInP/ZnSTe or GaInP/ZnSSe.

 The diameter of the quantum dots is preferably between 1 and 10 nm. It may, in particular, be preferred that the diameter of the quantum dots is between 1 and 5 nm.

 The quantum dots are generally produced by means of colloidal chemistry synthesis. The reaction partners, usually a metal-containing and a non-metal-containing

compound, are hereby mixed in an organic solvent or in water, and brought to reaction at elevated temperatures.

To produce quantum dots comprising a core and an inorganic enclosure, the core is firstly produced as described above. The solution is then cooled and one or more pre-
5 stages for the inorganic enclosure are added to the solution. In the case of sulfide-based inorganic enclosures, such as CdS, it is possible to add initially to the solution just one Cd-containing pre-stage, which is then converted into the CdS enclosure with H₂S.

During the precipitation reaction, complexing ligands are added, which adhere to the surface of a quantum dot. In order to improve the size distribution, a size fractionation
10 may subsequently be undertaken.

Preferably used as complexing ligands are organic ligands that evaporate without residue at the compression temperatures. Preferably used as a complexing ligand is pyridine. Alternatively, other complexing ligands, such as hexadecylamine (HAD), trioctyl phosphine oxide (TOPO) and/or trioctyl phosphine (TOP), may be used initially during the
15 synthesis of the quantum dots. Before the compressed optical layer is produced, they are replaced with pyridine by washing multiple times with pyridine.

In this context, compression describes the physical process of uniting particles, namely the quantum dots, at the same time developing the optical layer 3. This may take place by means of heat, pressure, light exposure, chemical reaction or a combination of these
20 means. It is, in particular, preferred for the compression process to take place by means of heat. This process may also be designated the sintering of the optical layer 3.

In order to produce a compressed optical layer 3, the suspension with the stabilized quantum dots is applied to the substrate 1. This may, for instance, take place by repeated immersion of the substrate in the suspension or spin coating. The substrate 1 may
25 already be provided with the first electrode 2.

The optical layer is subsequently compressed at temperatures of up to 300°C in an inert or reduced atmosphere. The compression temperatures may be reduced on application of an excess pressure during the compression process.

If, in addition to the quantum dots, the compressed, optical layer 3 is to
30 comprise a matrix of a filler material, particles of filler material are added to the suspension with the stabilized quantum dots, wherein the particle diameter of the filler material is smaller than the particle diameter of the quantum dots. The optical layer is then applied to the substrate 1 and compressed, as described above. During the compression process, owing to the melting point reduction of nano-crystalline materials, the particles of filler material melt

before the quantum dots, and are distributed homogeneously between the quantum dots. A compressed optical layer 3 is obtained, comprising an enclosed film of the filler material in which the quantum dots are distributed.

The manufacture of the electroluminescent device itself takes place using
5 known methods.

Example of embodiment 1

In order to produce an electroluminescent device in accordance with the invention, a suspension of pyridine-stabilized CdSe/ZnS quantum dots is produced in toluol,
10 wherein the CdSe/ZnS quantum dots have a particle diameter of 5 nm. By means of spin coating, a layer of this suspension is applied as the substrate 1 to a glass plate, which has been coated with a first electrode 2 of ITO. The layer structure obtained was compressed in an inert atmosphere for 20 minutes at temperatures of up to 300°C. Following cooling to ambient temperature, the second electrode 4 of Al was applied to the compressed optical
15 layer 3 by means of vapor deposition. The first and second electrodes 2, 4 were provided with electrical terminals and connected to a voltage source. Following application of a voltage greater than 2 V, a light emission in the range of 620 nm was obtained, with a spectrum corresponding to the photoluminescence spectrum of the suspension of CdSe/ZnS quantum dots in toluol.

20 The electroluminescent device obtained exhibited increased stability and improved efficiency and brightness.

Example of embodiment 2

In order to produce an electroluminescent device in accordance with the invention, a suspension of pyridine-stabilized CdSe/CdS quantum dots is produced in
25 trichloromethane, wherein the CdSe/CdS quantum dots have a particle diameter of 5 nm. By means of spin casting, a layer of this suspension is applied to a plastic film as the substrate 1. The layer structure obtained was compressed at an excess pressure of approximately 1000 bar in an inert atmosphere for 10 minutes at temperatures of up to 150°C. Following cooling to
30 ambient temperature, the first electrode 2 of Al/Au and the second electrode 4 of Al/Au were applied to the compressed optical layer 3 in the form of finger electrodes by means of vapor deposition. The first and second electrodes 2, 4 were provided with electrical terminals and connected to a voltage source. Following application of a voltage greater than 2 V, a light emission in the range of 620 nm was obtained.

The electroluminescent device obtained exhibited increased stability and improved efficiency and brightness.

Example of embodiment 3

5 In order to produce an electroluminescent device in accordance with the invention, a suspension of pyridine-stabilized InP/ZnS quantum dots is produced in toluol, wherein the InP/ZnS quantum dots have a particle diameter of 4 nm. By repeated immersion in the suspension of a glass plate as substrate 1, which was coated with a first electrode 2 of SnO₂:F, a layer of this suspension was applied to the SnO₂:F-coated substrate 1. The layer
10 structure obtained was compressed in an inert atmosphere for 15 minutes at temperatures of up to 300°C. Following cooling to ambient temperature, the second electrode 4 of Au was applied to the compressed optical layer 3. The first and second electrodes 2, 4 were provided with electrical terminals and connected to a voltage source. Following application of a voltage greater than 2.5 V, a light emission in the range of 590 nm was obtained.

15 The electroluminescent device obtained exhibited increased stability and improved efficiency and brightness.

Example of embodiment 4

20 In order to produce an electroluminescent device in accordance with the invention, a suspension of pyridine-stabilized CdTe quantum dots and ZnS particles with a particle diameter of 2 nm was produced in toluol. By means of spin coating, a layer of this suspension is applied to a glass plate as the substrate 1, which has been coated with a first electrode 2 of ITO. The layer structure obtained was compressed in an inert atmosphere for 20 minutes at temperatures of up to 120°C. Following cooling to ambient temperature, a
25 compressed optical layer 3 of an enclosed film of ZnSe, in which CdTe quantum dots were embedded, was obtained. The second electrode 4 of In/Ni was applied to the compressed optical layer 3 by means of vapor deposition. The first and second electrodes 2, 4 were provided with electrical terminals and connected to a voltage source. Following application of a voltage greater than 3 V, a light emission in the range of 580 nm was obtained.

30 The electroluminescent device obtained exhibited increased stability and improved efficiency and brightness.

Example of embodiment 5

In order to produce an electroluminescent device in accordance with the invention, a suspension of pyridine-stabilized CdSe/CdS quantum dots with a particle diameter of 4.5 nm and CdS particles with a particle diameter of 2 nm was produced in
5 toluol. By means of spin coating, a layer of this suspension is applied to a glass plate as the substrate 1, which has been coated with a first electrode 2 of ITO. The layer structure obtained was compressed in an inert atmosphere for 20 minutes at temperatures of up to 120°C. Following cooling to ambient temperature, a compressed optical layer of an enclosed film of CdS, in which CdSe/CdS quantum dots were embedded, was obtained. The second
10 electrode 4 of In/Ni was applied to the compressed optical layer 3 by means of vapor deposition. The first and second electrodes 2, 4 were provided with electrical terminals and connected to a voltage source. Following application of a voltage greater than 2.8 V, a light emission in the range of 600 nm was obtained.

The electroluminescent device obtained exhibited increased stability and
15 improved efficiency and brightness.

CLAIMS:

1. An electroluminescent device equipped with a first electrode and a second electrode and with a compressed optical layer with quantum dots, wherein the compressed optical layer emits radiation under the influence of an electrical field.
- 5 2. An electroluminescent device as claimed in claim 1, characterized in that a quantum dot comprises a core of a semiconductor material, which is surrounded by an inorganic enclosure with a greater band gap.
3. An electroluminescent device as claimed in claim 2, characterized in that the
10 inorganic enclosure comprises a semiconductor material.
4. An electroluminescent device as claimed in claim 1, characterized in that the compressed optical layer comprises a matrix of a filler material, in which quantum dots are embedded.
15
5. An electroluminescent device as claimed in claim 4, characterized in that the filler material exhibits a greater band gap than the semiconductor material of a quantum dot of a semiconductor material or the semiconductor material of a quantum dot with a core of a semiconductor material.
20
6. An electroluminescent device as claimed in claim 5, characterized in that the filler material and the inorganic enclosure comprise the same semiconductor material.
7. A method of manufacturing an electroluminescent device equipped with a first
25 electrode and a second electrode, with a compressed optical layer with quantum layers, which emits radiation under the influence of an electrical field, during which the compressed optical layer is produced in that a layer of quantum dots and particles of a filler material is produced and compressed, wherein the particles of filler material exhibit a smaller diameter than the quantum dots.

1/1

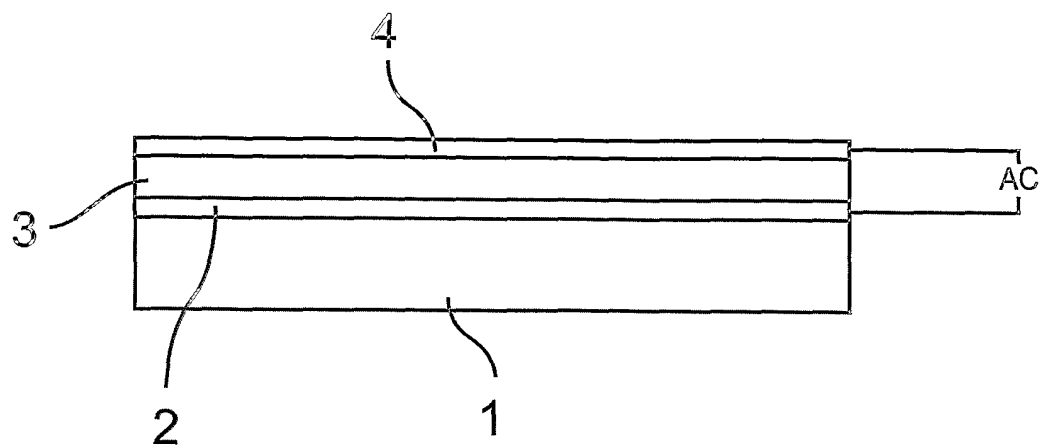


Fig. 1

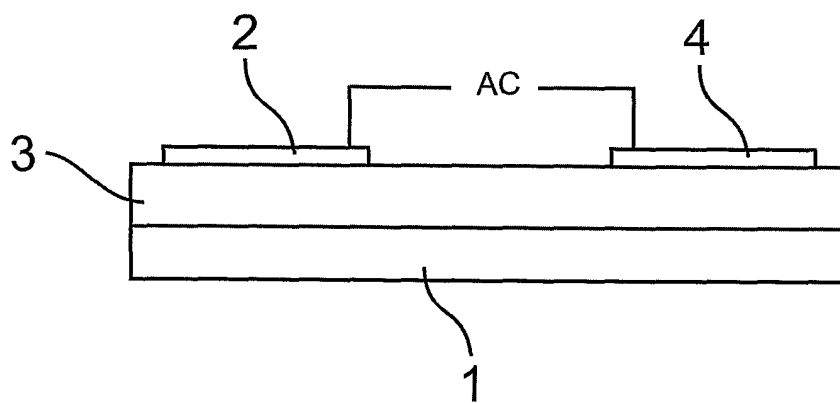


Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB2004/050171

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C09K11/08 H05B33/12

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)

IPC 7 C09K H05B

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, INSPEC, COMPENDEX, WPI Data, PAJ, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MATTOUSSI H ET AL: "Composite thin films of CdSe nanocrystals and a surface passivating/electron transporting block copolymer: Correlations between film microstructure by transmission electron microscopy and electroluminescence" JOURNAL OF APPLIED PHYSICS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 86, no. 8, 15 October 1999 (1999-10-15), pages 4390-4399, XP002237381 ISSN: 0021-8979 page 4395 - page 4396; figures 1,6,7	1-7
X	US 2002/153830 A1 (ANDRIESSEN HIERONYMUS) 24 October 2002 (2002-10-24) paragraph '0057! - paragraph '0060!; claim 1	1-7
	----- -/--	

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in 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.

G document member of the same patent family

Date of the actual completion of the international search

17 June 2004

Date of mailing of the international search report

25/06/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Lehnert, A

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/050171

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BABBOUSI B O ET AL: "ELECTROLUMINESCENCE FROM CDSE QUANTUM-DOT/POLYMER COMPOSITES" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 66, no. 11, 13 March 1995 (1995-03-13), pages 1316-1318, XP000503587 ISSN: 0003-6951 the whole document	1-7
X	COLVIN V L ET AL: "LIGHT-EMITTING DIODES MADE FROM CADMIUM SELENIDE NANOCRYSTALS AND ASEMICONDUCTING POLYMER" NATURE, MACMILLAN JOURNALS LTD. LONDON, GB, vol. 370, no. 6488, 4 August 1994 (1994-08-04), pages 354-357, XP000466647 ISSN: 0028-0836 the whole document	1-7
X	QUE W ET AL: "PHOTOLUMINESCENCE AND ELECTROLUMINESCENCE FROM COPPER DOPED ZINC SULPHIDE NANOCRYSTALS/POLYMER COMPOSITE" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 73, no. 19, 9 November 1998 (1998-11-09), pages 2727-2729, XP000788556 ISSN: 0003-6951 the whole document	1-7
X	ARTEMYEV M V ET AL: "Electroluminescence in thin solid films of closely-packed CdS nanocrystals" JOURNAL OF CRYSTAL GROWTH, NORTH-HOLLAND PUBLISHING CO. AMSTERDAM, NL, vol. 184-185, 2 February 1998 (1998-02-02), pages 374-376, XP004370758 ISSN: 0022-0248 the whole document	1,7
A	KASH K ET AL: "STRAIN-INDUCED CONFINEMENT OF CARRIERS TO QUANTUM WIRES AND DOTS WITHIN AN INGAAS-INP QUANTUM WELL" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 55, no. 7, 14 August 1989 (1989-08-14), pages 681-683, XP000080886 ISSN: 0003-6951 the whole document	1-7

-/--

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/050171

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 322 901 B1 (RODRIGUEZ-VIEJO XAVIER ET AL) 27 November 2001 (2001-11-27) the whole document -----	1,7
A	US 2001/000336 A1 (KIM KI BUM ET AL) 19 April 2001 (2001-04-19) the whole document -----	1,7
X	HUANG J ET AL: "PHOTOLUMINESCENCE AND ELECTROLUMUNESCENCE OF ZNS:CU NANOCRYSTALS IN POLYMERIC NETWORKS" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 70, no. 18, 5 May 1997 (1997-05-05), pages 2335-2337, XP000701328 ISSN: 0003-6951 the whole document -----	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IB2004/050171

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002153830 A1	24-10-2002	EP 1231249 A1 JP 2002305082 A	14-08-2002 18-10-2002
US 6322901 B1	27-11-2001	CA 2309967 A1 EP 1034571 A1 JP 2001523758 T WO 9926299 A1 US 6207229 B1 US 6607829 B1 US 2004033359 A1	27-05-1999 13-09-2000 27-11-2001 27-05-1999 27-03-2001 19-08-2003 19-02-2004
US 2001000336 A1	19-04-2001	KR 268936 B1 DE 19857060 A1 GB 2332564 A ,B JP 3000360 B2 JP 11238869 A US 6194237 B1	16-10-2000 24-06-1999 23-06-1999 17-01-2000 31-08-1999 27-02-2001