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(71) Applicant *(for all designated States except US)*: **THE UNIVERSITY OF HONG KONG** [CN/CN]; Pokfulam Road, Hong Kong (CN).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **CHE, Chiming** [CN/CN]; Flat 5, 5th Floor, Block A, Parkway Court, 4 Park Road, Hong Kong (CN).

(74) Agent: **CHINA PATENT AGENT (H.K.) LTD.**; 22/F, Great Eagle Centre, 23 Harbour Road, Wanchai, Hong Kong (CN).

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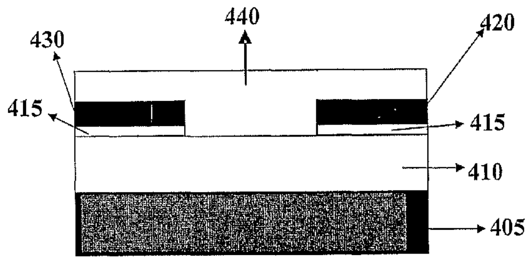
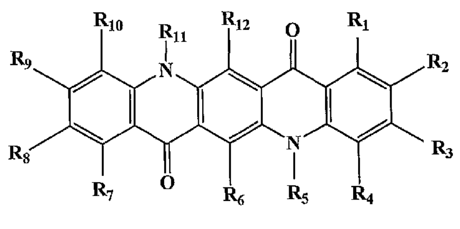
(54) Title: MATERIALS FOR ORGANIC THIN FILM TRANSISTORS





(I)

(57) Abstract: The invention provides organic thin film transistors including quinacridone derivatives with formula (I). These OTFTs are useful in making flat panel displays, photovoltaic devices and sensors. In the present invention, the disclosed quinacridone derivatives exhibit as *p*-type organic semiconductors in OTFTs.

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MATERIALS FOR ORGANIC THIN FILM TRANSISTORS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Patent Provisional Application No. 60/742,893 filed December 7, 2005, the entire contents of which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to organic thin film transistors (OTFTs) that contain at least one quinacridone derivative as a charge-transporting material. Disclosed quinacridone derivatives exhibit hole-transporting properties in OTFTs. This invention further relates to quinacridone derivative-based OTFTs for applications in electronics including flat panel displays, photovoltaic devices, and sensors.

REFERENCES

Several publications are referenced herein. Full citations for these publications are provided below. The disclosures of these publications are hereby incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Organic thin film transistors (OTFTs) have been used as alternatives to conventional silicon-based TFTs because of their low fabrication cost, high compatibility with glass and plastic substrates, large-area device coverage and simple fabrication process (*see* Horowitz, *Adv.Mater.*, 10:365 (1998)). OTFTs can be used as flexible displays (*see* Sheraw *et al.*, *Appl. Phys. Lett.*, 80:1088

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(2002)); sensors (*see* Bartic *et al., Appl. Phys. Lett.*, 82:475 (2003)); and memory devices (*see* Chabinyc *et al., Chem. Mater.*, 16:4509 (2004)). There are few stable, inexpensive organic semiconductors that have been found to be useful for OTFT applications.

Considerable progresses for OTFTs have been made, particularly focusing on the development of π-conjugated organic semiconductors (*see* Inoue *et al., J. Appl. Phys.*, 95:5795 (2004); Sheraw *et al., Adv. Mater.*, 15:2009 (2003); Yan *et al., Adv. Mater.*, 17:1191 (2005)). π-Conjugated organic materials containing rigid and fused-ring structures are of interest where strong π-π interactions between the adjacent molecules could be achieved.

Investigations have been carried out in connection with *p*-type pentacene and its derivatives as organic semiconductors for OTFTs (*see* US 6,284,562; US 6,734,038 B2; US 6,869,821 B2; Meng *et al., J. Am. Chem. Soc.*, 127:2406 (2005); Anthony *et al., J. Am. Chem. Soc.*, 127:4986 (2005)). Nonetheless, this class of materials is difficult to modify structurally due to its poor solubility in common organic solvents.

Oligothiophenes (*see* Katz *et al., Chem. Mater.*, 7:2235 (1995)) and thiophene derivatives (*see* Yang *et al., Adv. Funct. Mater.*, 15:671 (2005); Garnier *et al., J. Am. Chem. Soc.*, 115:8716 (1993)) are another class of *p*-type organic semiconductors. It have been proven that the device performance increases by attaching long alkyl chains to the thiophene rings (*see* Katz *et al., Chem. Mater*, 10:633 (1998)). Arylacetylene-based *p*-type OTFTs have also been demonstrated (*see* Che *et al.*, *Adv. Mater.*, 17:1258 (2005)). Through the incorporation of electron-donor/-acceptor groups to π-conjugated arylacetylene oligomers, a charge carrier mobility of 0.3 $cm^2V^{-1}s^{-1}$ and prolonged device stability were achieved.

Other *p*-type fused aromatic compounds such as dibenzothienobisbenzodithiophene (μ = 0.2 $cm^2V^{-1}s^{-1}$; I_{on}/I_{off} = ~10^6) (*see* Sirringhaus *et al.*, *J. Mater. Chem.*, 9:2095 (1999)), bisdithienothiophene (μ = 0.05 $cm^2V^{-1}s^{-1}$; I_{on}/I_{off} = 10^8) (*see* Holmes *et al.*, *J. Am. Chem. Soc.*, 120:2206 (1998)), dihydrodiazapentacene (μ = 0.006 $cm^2V^{-1}s^{-1}$; I_{on}/I_{off} = 5 × 10^3) (*see* Nuckolls *et al.*, *J. Am. Chem. Soc.*, 125:10284 (2003)) and diphenylbenzodichalcogenophenes (μ = 0.17 $cm^2V^{-1}s^{-1}$; I_{on}/I_{off} = 10^5) (*see* Takimiya *et al.*, *J. Am. Chem. Soc.*, 126:5084 (2004)) have also been used for OTFTs.

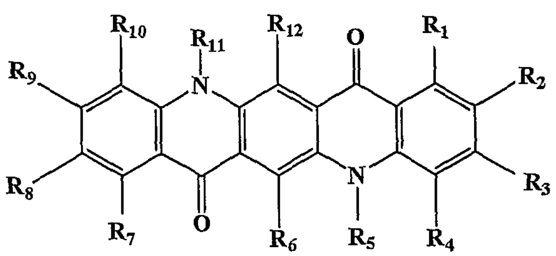
The luminescent, light-sensitizing and structural properties of quinacridone and its derivatives have been widely studied (*see* Wightman *et al.*, *J. Am. Chem. Soc.*, 122:4972 (2000); Wang *et al.*, *J. Phys. Chem. B,* 109:8008 (2005); Shi *et al.*, *Appl. Phys. Lett.,* 70:1665 (1997); Hiramoto *et al.*, *Jpn. J. Appl. Phys.,* 35:L349 (1996)), these compounds are stable in ambient environment and widely utilized as light-emitting and photoconductive materials.

SUMMARY OF THE INVENTION

The present invention can provide organic thin film transistors (OTFTs) comprising one or more active layers, which employ at least one quinacridone derivatives as charge-transporting materials. The active charge-transporting material can conduct transport charges under applied bias. The transistors exhibit field effect mobility which is comparable to other organic thin film transistors. The present invention provides quinacridone derivative-based OTFTs for use in flat panel displays, photovoltaic devices and sensors.

The present invention can also provides organic thin film transistors (OTFTs), which employ an active layer comprising at least one quinacridone derivative as an active charge-transporting material. Preferably, the transistors can be operated as *p*-type OTFT.

In one embodiment of the present invention, an organic thin film transistor (OTFT) is provided and can comprise a gate electrode, an adhesive layer, a drain electrode, a source electrode, and an active layer comprising at least one quinacridone derivatives. In a preferred embodiment of the present invention, the quinacridone derivative can have the following formula:



(I)

wherein each R^1-R^{12} is independently -H, -OH, -NH_2, -halogen, -SH, -CN, -NO_2, -R^{13}, -OR^{14}, -SR^{14}, -NHR^{14}, or -$N(R^{14})_2$; each R^{13} is -(C_1-C_{30})alkyl, -phenyl, -naphthyl or thiophene; each of which is unsubstituted or substituted with one or more -(C_1-C_{15})alkyl, -phenyl, -naphthyl or -thiophene; R^{14} is defined as above for R^{13}.

More preferably, the organic thin film transistors (OTFTs) employing quinacridone derivatives as illustrated in Formula (I) herein demonstrate a hole mobility of at least 0.1 cm^2V(1s(1 and current on/off ratio of at least 104 while voltage is applied.

The quinacridone derivatives-based OTFTs of the present invention can be applied to the fields of electronics, including flat panel displays, photovoltaic devices, sensors, and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the invention can be understood by reviewing the following detailed description of the preferred embodiments taken together with attached drawings in which:

Figure 1 shows a schematic diagram of field effect transistor including the quinacridone derivatives of the present invention;

Figure 2 shows current-voltage (I-V) characteristics of OTFT fabricated with Q8 (channel length of 40 μm, channel width of 3000μm) drain current (I_{DS}) versus drain voltage (V_{DS}) characteristic as a function of gate voltage (V_G);

Figure 3 shows current-voltage (*I-V*) characteristics of OTFTs fabricated with **Q8** (channel length of 40 μm, channel width of 3000μm): transfer curve in saturated regime at constant source-drain voltage of −40 V and square root of the absolute value of the current as a function of gate voltage;

Figure 4 shows a scanning electron micrograph image of **Q1** on silicon dioxide surface;

Figure 5 shows a scanning electron micrograph image of **Q2** on silicon dioxide surface;

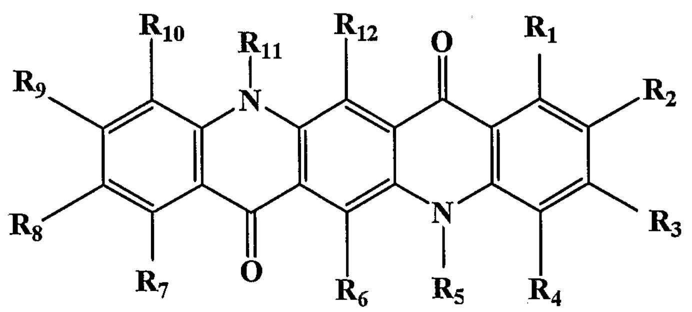
Figure 6 shows a scanning electron micrograph image of **Q3** on silicon dioxide surface;

Figure 7 shows a scanning electron micrograph image of **Q6** on silicon dioxide surface; and

Figure 8 shows a scanning electron micrograph image of **Q8** on silicon dioxide surface.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention can provide organic thin film transistors (OTFTs), which contain a quinacridone derivative or derivatives as an active charge-transporting material to facilitate charge flow in the transistors. In one embodiment, quinacridone derivatives can be used in an OTFT as illustrated in Formula **I** below, which can demonstrate a hole mobility of at least 0.1 $cm^2V^{-1}s^{-1}$ and a current on/off ratio of at least 10^4 respectively:

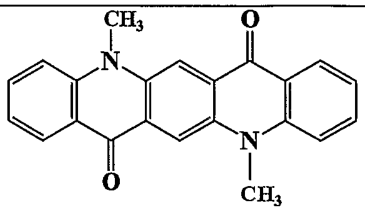
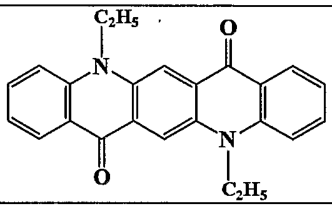
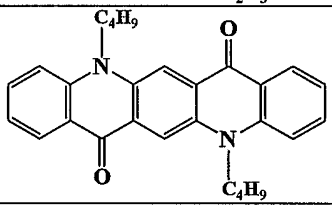
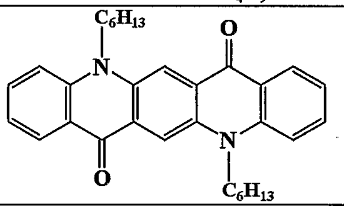
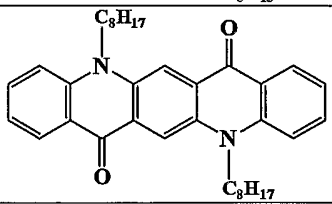
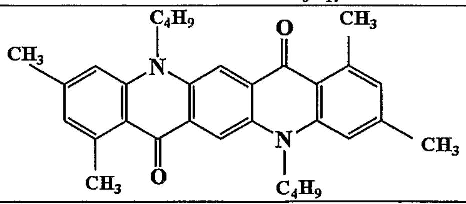
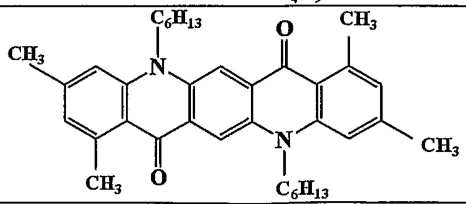


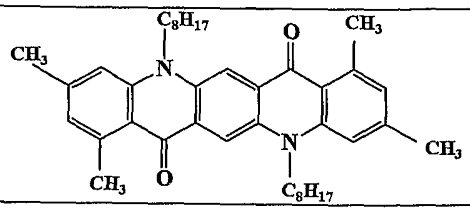
(I)

wherein each R^1-R^{12} is independently -H, -OH, $-NH_2$, -halogen, -SH, -CN, $-NO_2$, -R^{13}, $-OR^{14}$, $-SR^{14}$, $-NHR^{14}$, or $-N(R^{14})_2$; each R^{13} is $-(C_1-C_{30})$alkyl, -phenyl, -naphthyl or thiophene; each of which is unsubstituted or substituted with one or more $-(C_1-C_{15})$alkyl, -phenyl, -naphthyl or -thiophene; R^{14} is defined as above for R^{13}.

Illustrative examples and exemplary compounds of formulae (**I**) are listed below in Table 1:

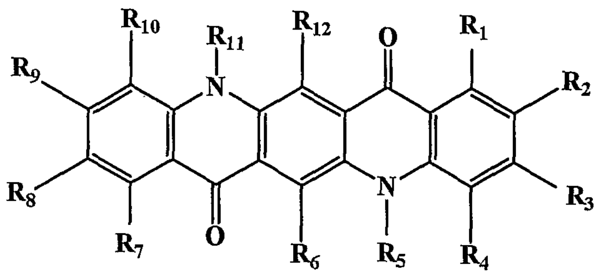
Table 1

Structure	Compound
	Q1
	Q2
	Q3
	Q4
	Q5
	Q6
	Q7

	Q8

The present invention can also provide an organic field effect transistor comprising a gate electrode, a metal oxide layer, an adhesive layer, a drain electrode, a source electrode, and an active layer comprising at least one quinacridone derivative as set forth above. The gate electrode can be silicon, doped silicon or aluminum. The metal oxide layer can be silicon oxide or aluminum oxide. The adhesive layer can be a layer of titanium or a layer of tungsten, or a layer of chromium. The drain electrode can be a layer of gold or a layer of platinum. The source electrode can be a layer of gold or a layer of platinum.

In one embodiment, the quinacridone derivative can be:

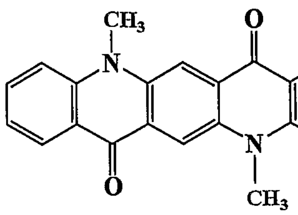


(I)

wherein each R^1-R^{12} is independently -H, -OH, $-NH_2$, -halogen, -SH, -CN, $-NO_2$, -R^{13}, $-OR^{14}$, $-SR^{14}$, $-NHR^{14}$, or $-N(R^{14})_2$; each R^{13} is $-(C_1-C_{30})$alkyl, -phenyl, -

naphthyl or thiophene; each of which is unsubstituted or substituted with one or more -(C_1-C_{15})alkyl, -phenyl, -naphthyl or -thiophene; R^{14} is defined as above for R^{13}.

In another embodiment, the quinacridone derivative can be a compound having the formula:



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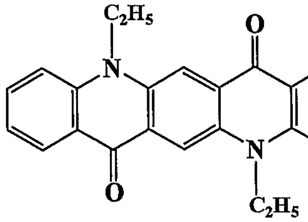

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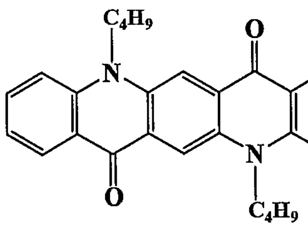

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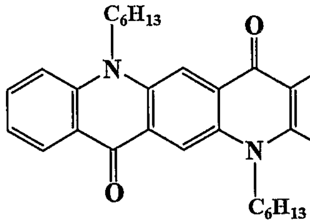

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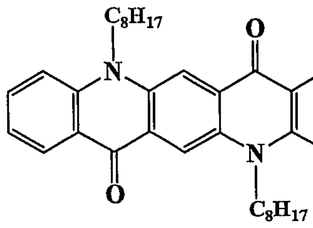

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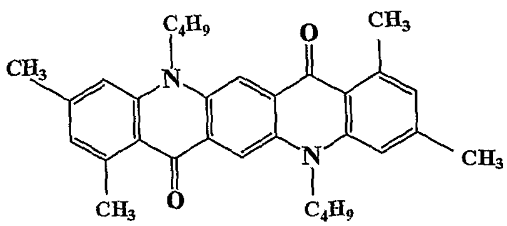
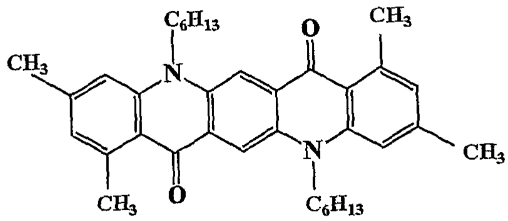


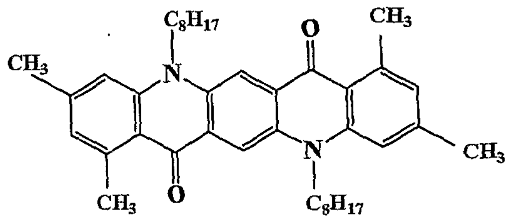
C4H9
O
CH3
CH3
N
N
CH3
CH3
O
C4H9

,



C6H13
O
CH3
CH3
N
N
CH3
CH3
O
C6H13

, or



C8H17
O
CH3
CH3
N
N
CH3
CH3
O
C8H17

.

In a further embodiment, the quinacridone derivative contacts either the drain electrode or the source electrode. In another exemplary embodiment, the quinacridone derivatives act as a hole-transporting material to conduct a current flow under a bias. In one exemplary embodiment, the current flow is at least μA.

In the organic field effect transistor of the present invention, the field effect mobility is at least 0.1 $cm^2V^{-1}s^{-1}$ and a current on/off ratio of at least 10^4. The transistor comprising quinacridone derivatives can be potentially employed in a flat panel display, a photovoltaic device, a sensor, or the like.

The following examples are set forth to aid in understanding of the present invention but are not intended to, and should not be interpreted to limit in any way the present invention.

EXAMPLE 1

The configuration of quinacridone derivatives-based transistor of the present invention is schematically shown in Figure 1. The transistor **400** has multiple layers as shown. Gate oxide **410** preferably comprising SiO_2 is deposited upon gate electrode **405**, *n*-type Si gate. Thin adhesion layer **415** comprising Ti is placed on the top of layer **410**. Gold drain electrode **420** and gold source electrode **430** are in contact with layer **415**. An active layer **440** containing at least one quinacridone derivative is deposited on top of the layer **410**, **420** and **430**. The quinacridone derivative in layer **440** is in contact with drain electrode **420** and source electrode **430**.

In a preferred embodiment, the thickness for the gate oxide **410** is 100 nm (permittivity = 3.9) and the adhesion layer **415** is 10 nm. The active channel of transistor **400** is from 1 to 5 μm which is defined by distance between drain and source electrodes.

EXAMPLE 2

Quinacridone derivative-based transistors can be fabricated on a substrate-gate structure. Gate oxide SiO_2 layer (100 nm, permittivity = 3.9) was thermally grown on *n*-type Si substrates (the gate electrode). Image reversal photolithography was used to form an opening on the photoresist layer for the source and drain patterns. Source and drain metal layers (Au conductive film (50nm)) on a thin Ti adhesion film (10 nm) were deposited by vacuum deposition on top of the SiO_2 layer.

After the deposition of source and drain electrodes, standard lift-off processes in acetone solution was used to remove the unnecessary metal films on top of the photoresist pattern. The source/drain metal patterns on gate oxide substrate were cleaned with isopropyl alcohol and deionized water respectively, followed by drying under a nitrogen atmosphere. The profile of Au electrode was characterized with AFM that reveal smooth slope and regular patterns along the entire channel width. All the devices have a channel length and width of 40 and 3000 μm.

EXAMPLE 3

In this example, the patterned transistor was cleaned before the deposition of active layer. The procedures are shown as follows: first, the transistor was washed with acetone, toluene, methanol and 18 MΩ water in sequence. Afterwards, the transistor was kept under a nitrogen atmosphere until dry and then transferred to a UV-ozone chamber. The transistor was cleaned under a UV ozone treatment for 15 min. and dried under a nitrogen atmosphere. Bottom contact OTFT devices comprising the quinacridone derivatives as active layers were fabricated respectively. All transistors were fabricated with quinacridone derivatives (thickness = 50 nm; deposition rate = 2 Å/s) on top of the patterned substrates under high vacuum conditions (1.0×10^{-6} Torr) respectively.

EXAMPLE 4

Thermal stabilities of **Q1**–**Q8** were characterized by thermogravimetric analysis (TGA) before vacuum deposition. The decomposition temperature (T_d) was measured with a scanning rate of 15 °C/min under a nitrogen atmosphere and the results are listed in Table 2. All quinacridone derivatives are thermally stable for vacuum thermal deposition with T_d up to 406 °C for **4**.

Table 2. Thermal properties and field-effect characteristics of **Q1–Q8**.

Compound	TGA (^{o}C)	Mobility ($cm^2V^{-1}s^{-1}$)	I_{on}/I_{off}	Threshold (V)
Q1	401	1.5×10^{-3}	2×10^2	−18
Q2	375	-	-	-
Q3	406	-	-	-
Q4	393	-	-	-
Q5	373	-	-	-
Q6	375	1.5×10^{-3}	1×10^3	−4
Q7	376	3.1×10^{-3}	1×10^2	−12
Q8	388	1.0×10^{-1}	1×10^4	−17

EXAMPLE 5

The field-effect mobilities in saturation regime of OTFTs fabricated with **Q1**–**Q8** were measured respectively and their performances are listed in Table 2. **Q1**–**Q8** have a similar chemical structure; however, their transistor behaviors are significantly different. Only **Q1** and **Q6**–**8** show field effect mobilities in their corresponding OTFTs. Though **Q2**–**Q5** have similar chemical structures to their **Q6**–**8** counterparts and differ by having no methyl groups attached to quinacridone core, no transistor behavior was observed in these quinacridone derivative-based transistors.

In this invention, *N*,*N*'-Di(*n*-octyl)-1,3,8,10-tetramethylquinacridone **Q8** was found to exhibit the best field-effect mobility. Figures 2 and 3 show the output and transfer curves of an organic transistors fabricated with **Q8**. The device demonstrates typical *p*-type FET behavior in both saturated and linear regimes, which are comparable to the conventional transistor models. A field mobility and current on/off ratio (I_{on}/I_{off}) as high as 1×10^{-1} $cm^2V^{-1}s^{-1}$ and ~10^4 was achieved.

Devices fabricated with *N,N'*-di(*n*-butyl)- or *N,N'*-di(*n*-hexyl)-1,3,8,10-tetramethylquinacridone **Q6** and **Q7** also exhibited field effect mobilities of 1.5 and 3.1×10^{-3} $cm^2V^{-1}s^{-1}$. In comparison, a device fabricated with **Q1** containing *N,N'*-dimethyl substituents on the quinacridone core showed a mobility of $1.5 \times 10^{-3} cm^2V^{-1}s^{-1}$. The field-effect mobility of quinacridone-based OTFTs increases with increasing the side alkyl chain length of quinacridone moiety.

EXAMPLE 6

The film morphologies of **Q1**–**Q3**, **Q6**, and **Q8** on silicon dioxide surface were characterized by SEM respectively under same condition. All films were deposited with a deposition rate of 2 $Ås^{-1}$. As shown in Fig. 4, **Q1** exhibits a homogenous packing film with small crystal grains and the field effect mobility of **Q1**-based OTFT was $1.5 \times 10^{-3}cm^2V^{-1}s^{-1}$. **Q2** and **Q3** which containing *N,N'*-diethyl and *N,N'*-di(*n*-butyl) side chains show large-gap and discontinuous flat crystals which separate far from each others (Figs. 5 and 6). The loose-fitting flat crystals of **Q2** and **Q3** result in less π–π interaction between their contiguous molecules.

Compared to **Q3**, **Q6** containing *N,N'*-di(*n*-butyl) groups plus four methyl substituents on the quinacridone core showed a field effect mobility of 1.5 $\times 10^{-3}cm^2V^{-1}s^{-1}$. This finding is supported by the SEM micrograph of **Q6** film (Fig. 7) where polycrystalline grain structure was observed. By increasing the chain lengths from $-C_4H_9$ (**Q6**) to $-C_8H_{17}$ (**Q8**), the crystal packing structure transforms from loose (**Q6**, Fig. 7) to compact grains structure (**Q8**, Fig. 8). Evidently, a condensed crystal structure is far more preferable for charge carriers flow. Thus, the field effect mobility of **Q6**-based OTFT was $1.5 \times 10^{-3} cm^2V^{-1}s^{-1}$ which was two orders of magnitude less than that reported for **Q8** (Table 2).

These results reveal that the charge carrier mobility of quinacridone molecules is highly dependent on the film morphology, which in turn depends on the chemical structure of the molecules. The presence of four methyl substituents and long *N,N'*-di(*n*-octyl) side chains in **Q8** induce formation of a dense and squashed crystal packing structure with polycrystalline grains. The mobility of **Q8**-based OTFT ($10^{-1} cm^2V^{-1}s^{-1}$) was about 100 times better than that of the other corresponding quinacridone derivatives (~ $10^{-3} cm^2V^{-1}s^{-1}$).

The above description and examples are only illustrative of preferred embodiments which achieve the objects, features, and advantages of the present invention, and it is not intended that the present invention be limited thereto. Any modifications of the present invention which come within the spirit and scope of the following claims is considered part of the present invention.

REFERENCES

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WHAT IS CLAIMED IS:

1. An organic field effect transistor, comprising: a gate electrode; a metal oxide layer; an adhesive layer; a drain electrode; a source electrode, and an active layer comprising at least one quinacridone derivatives.

2. The transistor of claim **1**, wherein the gate electrode is silicon, doped silicon or aluminum.

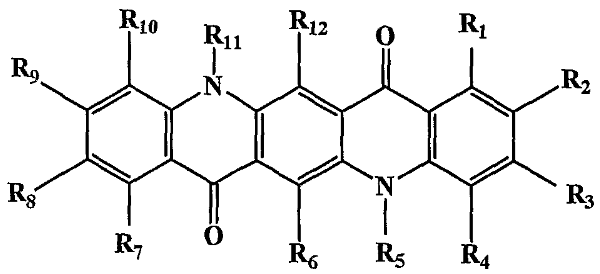
3. The transistor of claim **1**, wherein the metal oxide layer is silicon oxide or aluminum oxide.

4. The transistor of claim **1**, wherein the adhesive layer is a layer of titanium or a layer of tungsten, or a layer of chromium.

5. The transistor of claim **1**, wherein the drain electrode is a layer of gold or a layer of platinum.

6. The transistor of claim **1**, wherein the said source electrode comprising is a layer of gold or a layer of platinum.

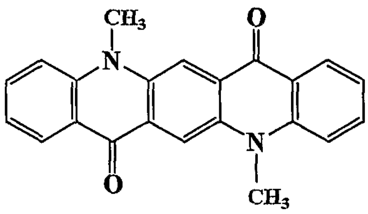
7. The transistor of claim **1**, wherein the quinacridone derivative is:



(I)

each R^1-R^{12} is independently -H, -OH, -NH_2, -halogen, -SH, -CN, -NO_2, -R^{13}, -OR^{14}, -SR^{14}, -NHR^{14}, or -$N(R^{14})_2$; each R^{13} is -(C_1-C_{30})alkyl, -phenyl, -naphthyl or thiophene; each of which is unsubstituted or substituted with one or more -(C_1-C_{15})alkyl, -phenyl, -naphthyl or -thiophene; R^{14} is defined as above for R^{13}.

8. The transistor of claim **7**, wherein the quinacridone derivative is a composition having the following structure:



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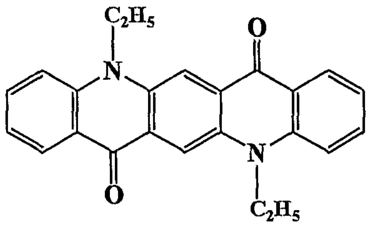

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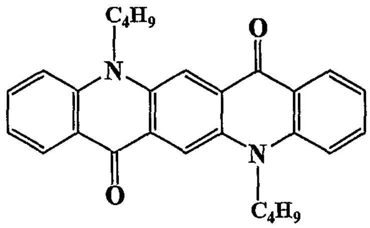

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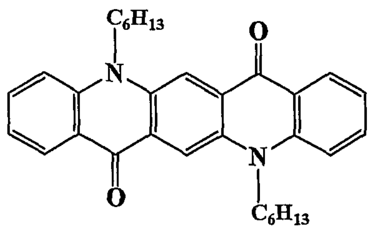

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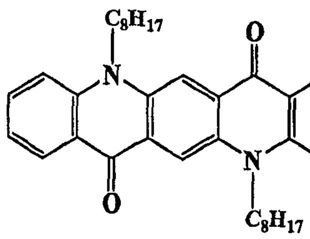

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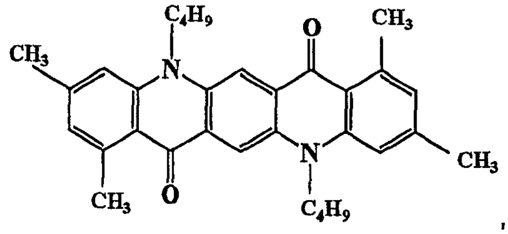

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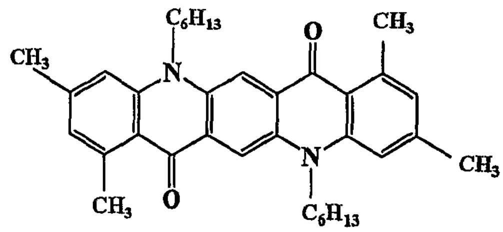

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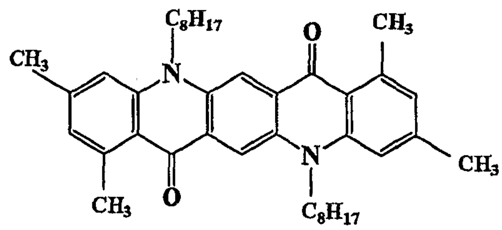

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9. The transistor of claim 7, wherein the quinacridone derivative contacts either the drain electrode or the source electrode.

10. The transistor of claim 7, wherein the quinacridone derivative acts as a hole-transporting material to conduct a current flow under a bias.

11. The transistor of claim 7, wherein the current flow is at least in μA.

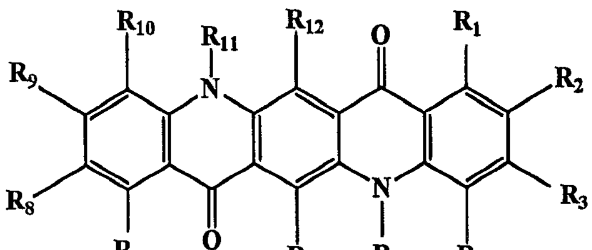
12. The transistor of claim **7**, wherein the field effect mobility is at least 0.1 $cm^2V^{-1}s^{-1}$ and a current on/off ratio of at least 10^4.

13. The transistor of claim **7**, wherein the transistor is in a flat panel display, a photovoltaic device or a sensor.

14. A method for mailing an organic field effect transistor comprising: providing a gate oxide on a gate electrode; providing a thin adhesion layer on top of the gate electrode and a drain electrode and a source electrode in contract with the adhesion layer; and providing a layer of a quinacridone derivative in contact with the drain electrode and the source electrode.

15. A method according to claim 16 wherein the drain and source electrodes are gold or platinum.

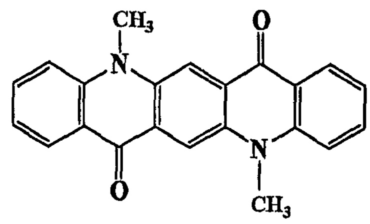
16. A method according to claim 16, wherein the quinacridone derivative is



(I)

each R^1-R^{12} is independently -H, -OH, $-NH_2$, -halogen, -SH, -CN, $-NO_2$, -R^{13}, $-OR^{14}$, $-SR^{14}$, $-NHR^{14}$, or $-N(R^{14})_2$; each R^{13} is $-(C_1$-$C_{30})$alkyl, -phenyl, -naphthyl or thiophene; each of which is unsubstituted or substituted with one or more -(C_1-C_{15})alkyl, -phenyl, -naphthyl or -thiophene; R^{14} is defined as above for R^{13}.

17. A method according to claim 19 wherein the quinacridone derivative has the following structure:



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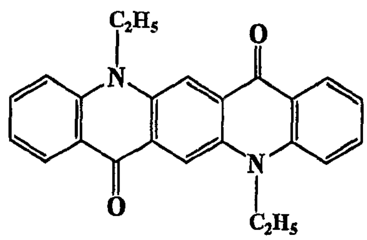

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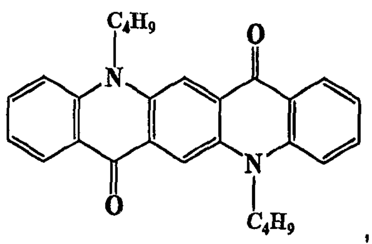

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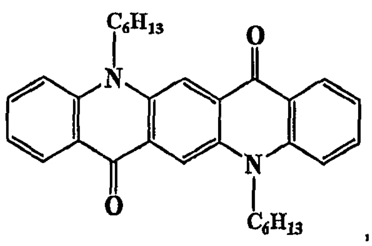

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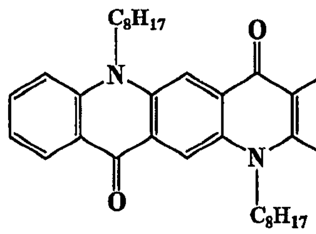
RECTIFIED SHEET (RULE 91)



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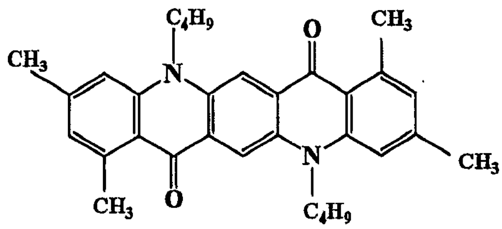

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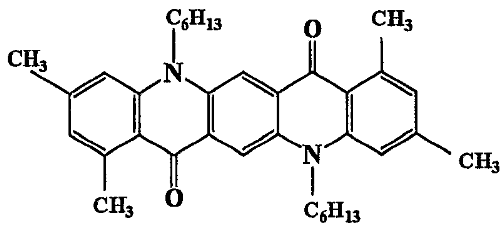

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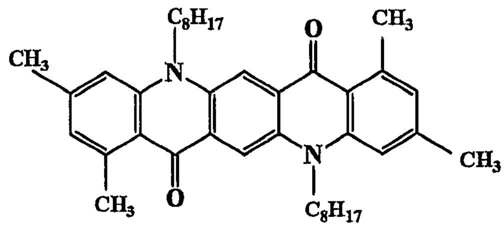

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18. A flat panel display comprising at least one OTFT according to claim **7**.

19. A photovoltaic device comprising at least one OTFT according to claim **7**.

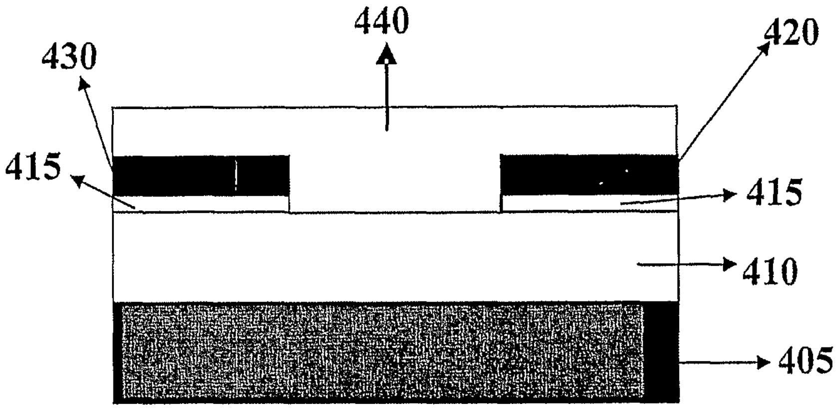


Figure 1

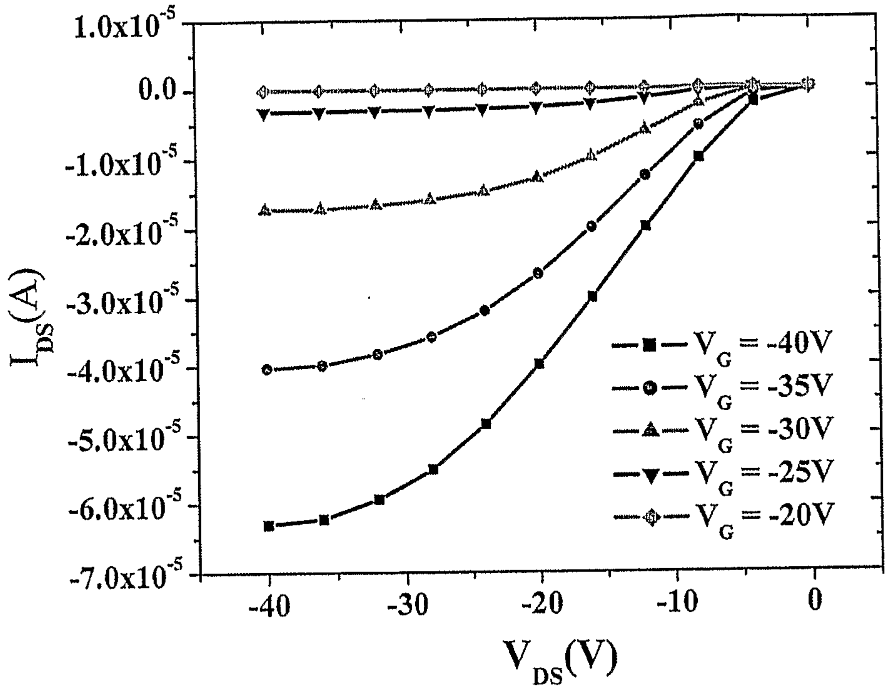

1.0x10-5
0.0
-1.0x10-5
-2.0x10-5
-3.0x10-5
-4.0x10-5
-5.0x10-5
-6.0x10-5
-7.0x10-5
IDS(A)
-40
-30
-20
-10
0
VDS(V)
VG = -40V
VG = -35V
VG = -30V
VG = -25V
VG = -20V

Figure 2

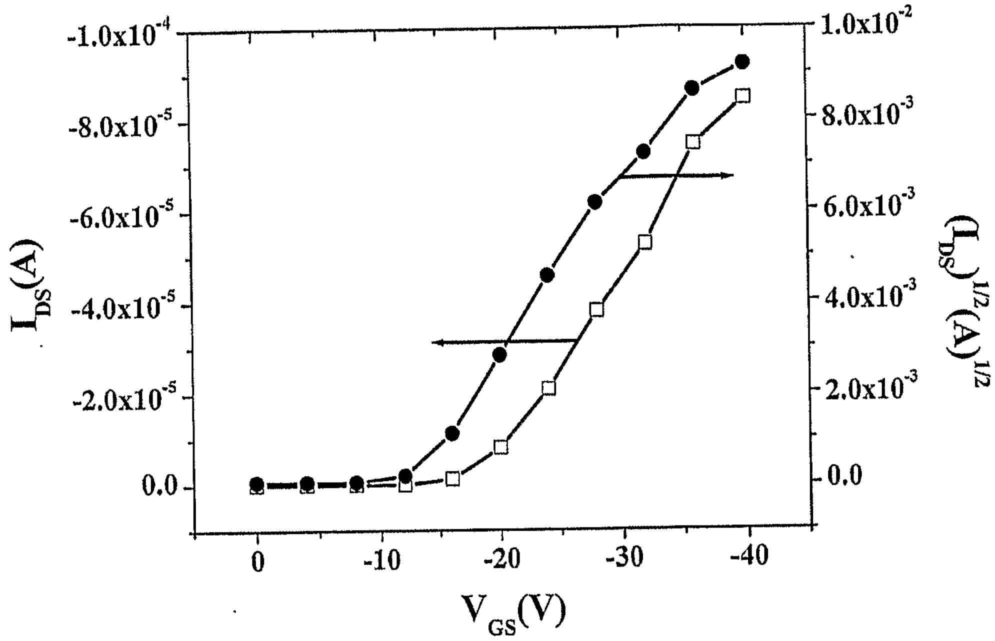

-1.0x10^-4
-8.0x10^-5
-6.0x10^-5
-4.0x10^-5
-2.0x10^-5
0.0
I_DS(A)
1.0x10^-2
8.0x10^-3
6.0x10^-3
4.0x10^-3
2.0x10^-3
0.0
(I_DS)^1/2(A)^1/2
0
-10
-20
-30
-40
V_GS(V)

Figure 3

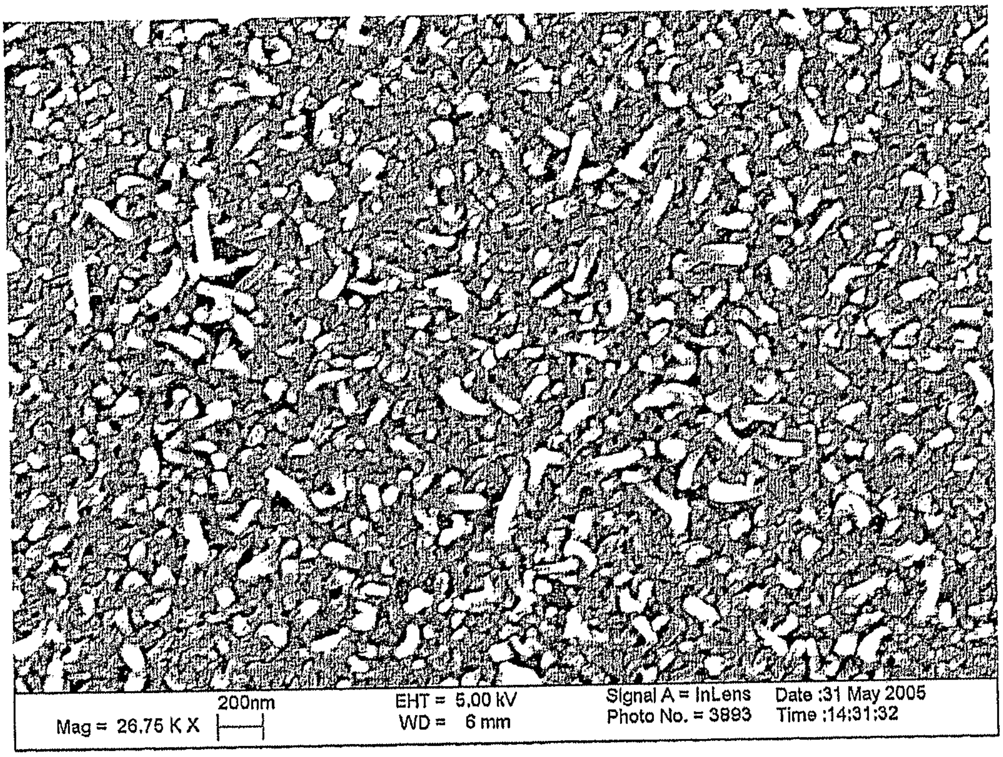

200nm
Mag = 26.75 K X
EHT = 5.00 kV
WD = 6 mm
Signal A = InLens
Photo No. = 3893
Date :31 May 2005
Time :14:31:32

Figure 4

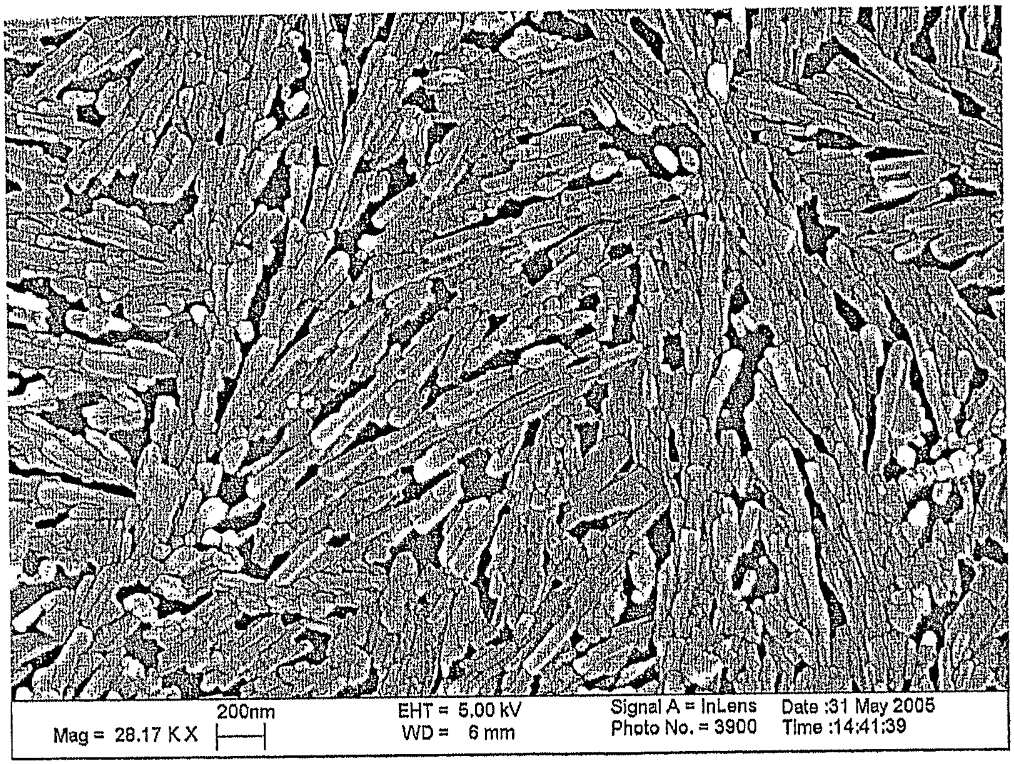
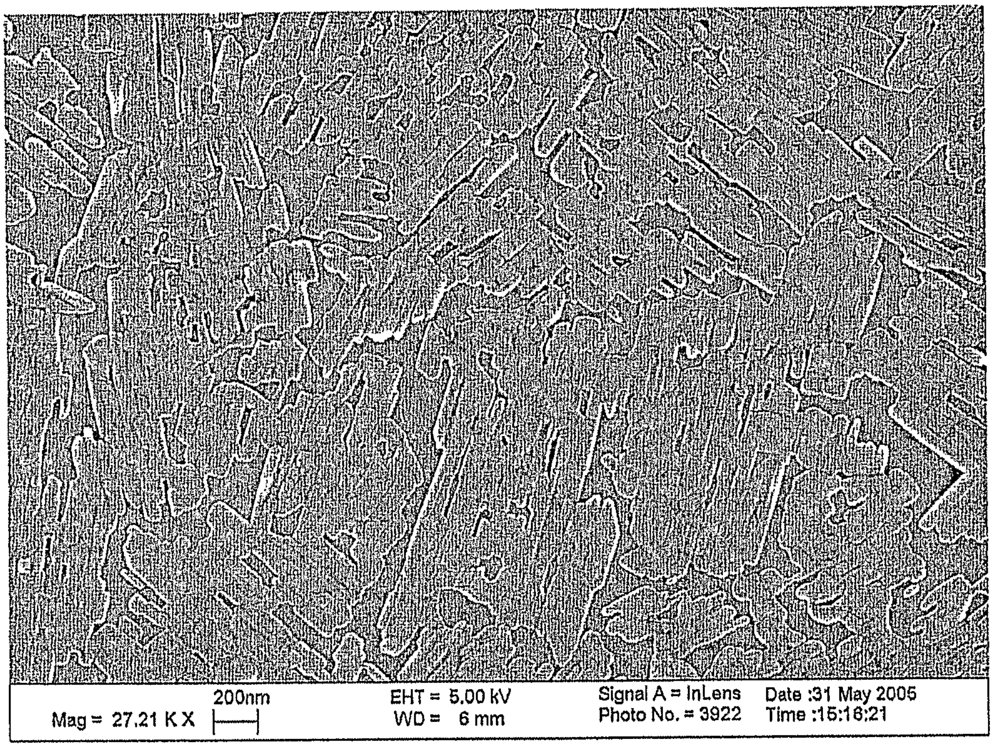

200nm
Mag = 28.17 K X
EHT = 5.00 kV
WD = 6 mm
Signal A = InLens
Photo No. = 3900
Date :31 May 2005
Time :14:41:39

Figure 5


Mag = 27.21 K X
200nm
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WD = 6 mm
Signal A = InLens
Photo No. = 3922
Date :31 May 2005
Time :15:16:21

Figure 6

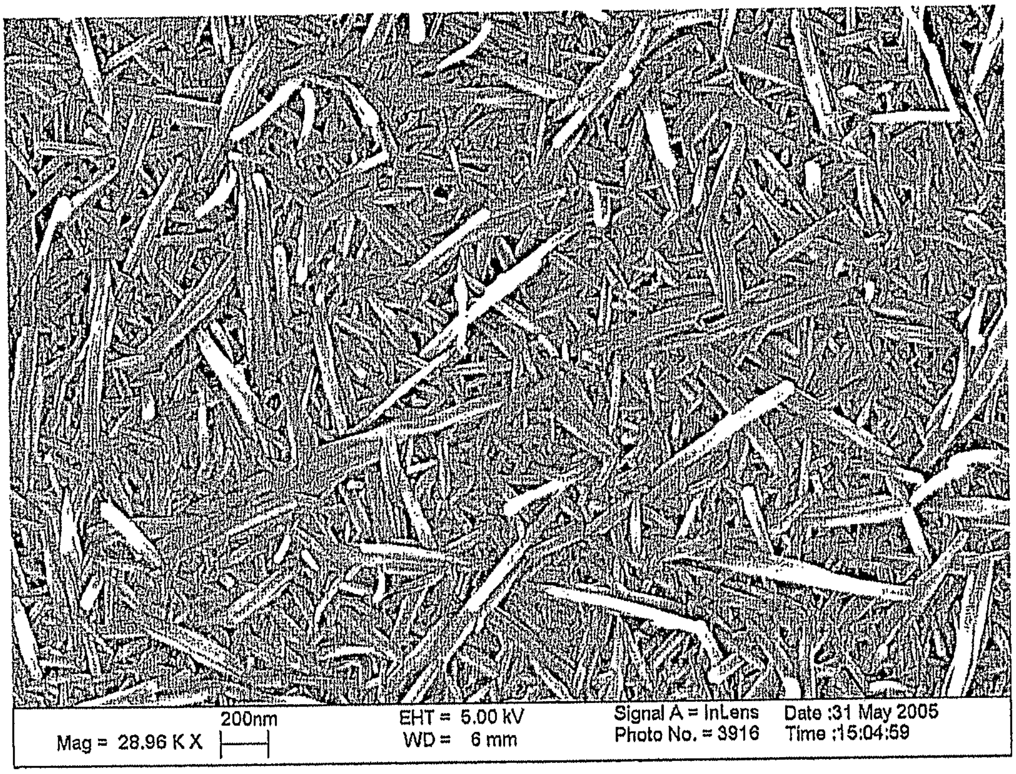
Mag = 28.96 K X
200nm
EHT = 5.00 kV
WD = 6 mm
Signal A = InLens
Photo No. = 3916
Date :31 May 2005
Time :15:04:59

Figure 7

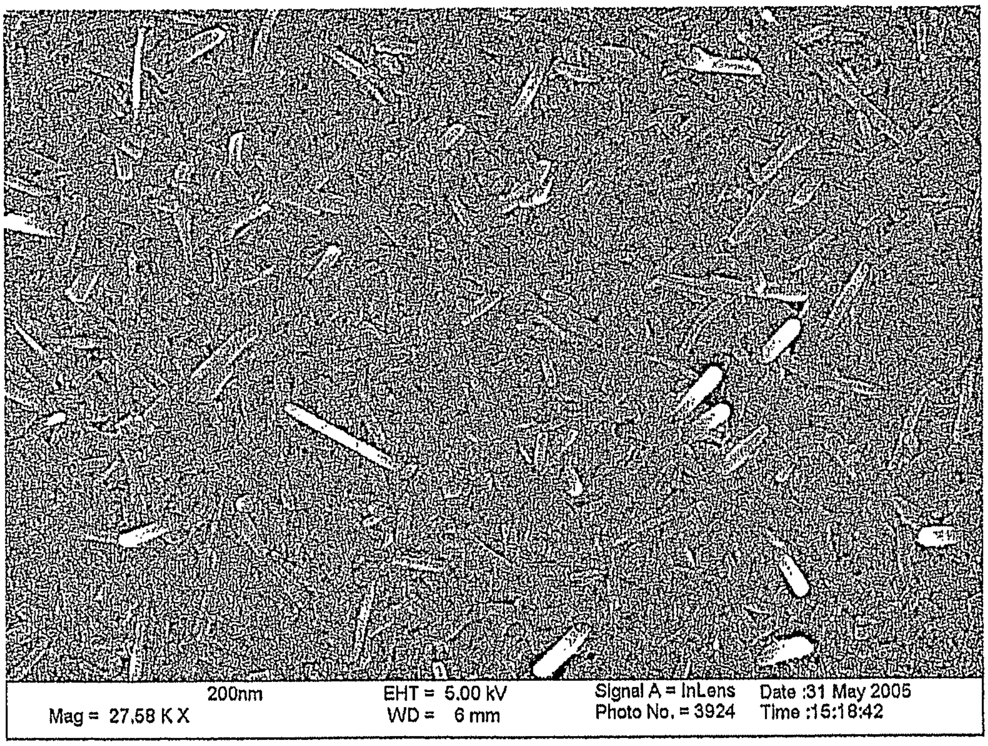
200nm
Mag = 27.58 K X
EHT = 5.00 kV
WD = 6 mm
Signal A = InLens
Photo No. = 3924
Date :31 May 2005
Time :15:18:42

Figure 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2006/003320

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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: H01L 51/00, H01L 29/786, C09K 11/06, C09K 11/00, H01L 29/417, H01L 51/30, H01L 21/00

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 practicable, search terms used)

WPI, EPODOC, PAJ, Chinese Patent Database, Chinese journal net: transistor, field, effect, organic, film, thin, quinacridone, derivative, hole, channel, active, OTFT, adhesive

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-146430 A (KONICA CORPORATION (JP)) 20May.2004 (20. 05. 2004) the paragraph [0022] to [0052] and the paragraph [0057] to [0065], figures 1(b), 2-9	1-19
Y	US6376107B1 (BAYER AKTIENGESELLSCHAFT(DE))23Apr.2002 (23. 04. 2002) specification col.11.line66-col.16.line10, the general formulae IIIa and C1-C28	1-19

☒ Further documents are listed in the continuation of Box C. ☒ 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 application or patent 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
7 Mar. 2007 (07. 03. 2007)	22 · MAR 2007 (22 · 03 · 2007)

Name and mailing address of the ISA/CN
The State Intellectual Property Office, the P.R.China
6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China
100088
Facsimile No. 86-10-62019451

Authorized officer
WANG Yan
Telephone No. (86-10)62086359

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2006/003320

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US6821811B2 (SEMICONDUCTOR ENERGY LABORATORY Co., LTD. (JP)) 23Nov.2004 (23. 11. 2004) specification col.11.line18-col.12.line16, figure 8	1-19
Y	JP11-121175A (MITSUI CHEM INC (JP)) 30 Apr. 1999 (30. 04. 1999) The whole document	1-19
Y	JP 2003-96191 A (RICOH KK (JP)) 03 Apr.2003 (03. 04. 2003) The whole document	1-19
A	CN 1409417 A (CHANGCHUN INSTITUTE OF APPLIED CHEMISTRY CHINESE ACADEMY OF SCIENCE (CN)) 09 Apr.2003 (09. 04. 2003) The whole document	1-19
A	CN 1639884 A (3M INNOVATIVE PROPERTIES CO (US)) 13 Jul. 2005 (13. 07. 2005) The whole document	1-19

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2006/003320

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP2004-146430A	20 May. 2004	EP1361619A2	12 Nov. 2003
		US2003211649A1	13 Nov. 2003
		JP2004031933A	29 Jan. 2004
		JP2004064059A	26 Feb. 2004
		US7018872B2	28 Mar. 2006
US6376107B1	23 Apr. 2002	EP0933972A2	04 Aug. 1999
		DE19803889A1	05 Aug. 1999
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US6821811B2	23 Nov. 2004	US2004023447A1	05 Feb. 2004
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		US6847048B2	25 Jan. 2005
		CN1186822C	26 Jan. 2005
CN1639884A	13 Jul. 2005	US2003175551A1	18 Sep. 2003
		WO03077327A1	18 Sep. 2003
		AU2003209087A1	22 Sep. 2003
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		TW200306027 A	01 Nov. 2003

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2006/003320

CLASSIFICATION OF SUBJECT MATTER

H01L 51/00 (2007.01) i

H01L 29/786 (2007.01) i

C09K 11/06 (2007.01) i