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INTERNATIONAL SEARCHING AUTHORITY

To:

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PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB2015/051478	20.05.2015	20.05.2014

International Patent Classification (IPC) or both national classification and IPC
INV. H01L51/05 H01L51/30

Applicant
THE UNIVERSITY OF MANCHESTER

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
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WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/GB2015/051478

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	2, 3, 5, 15, 16, 18, 22, 24, 26, 27, 33, 37-40, 42-44
	No:	Claims	1, 4, 6-14, 17, 19-21, 23, 25, 28-32, 34-36, 41
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-44
Industrial applicability (IA)	Yes:	Claims	1-44
	No:	Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reference is made to the following documents:

D1 JANG YUNSEOK ET AL: "High field-effect mobility pentacene thin-film transistors with nanoparticle polymer composite/polymer bilayer insulators", APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS, US, vol. 94, no. 18, 5 May 2009, pages 183301-183301, XP012121184, ISSN: 0003-6951, DOI: 10.1063/1.3124660
cited in the application

D2 ONOUE T ET AL: "LOW-OPERATING-VOLTAGE ORGANIC FIELD-EFFECT TRANSISTORS WITH POLY-P-XYLYLENE/HIGH-K POLYMER BILAYER GATE DIELECTRIC", JAPANESE JOURNAL OF APPLIED PHYSICS, JAPAN SOCIETY OF APPLIED PHYSICS, JP, vol. 45, no. 29, 1 August 2006, pages L770-L772, XP001246307, ISSN: 0021-4922, DOI: 10.1143/JJAP.45.L770

D3 YUNSANG KIM ET AL: "Enhancement of breakdown strength and energy density in BaTiO3 ferroelectric polymer nanocomposites via processing-induced matrix crystallinity and uniformity", RSC ADV., vol. 4, no. 38, 1 January 2014, pages 19668-19673, XP055202397, DOI: 10.1039/C4RA00987H

D4 US 2010/276754 A1 (OHE TAKAHIRO [JP] ET AL) 4 November 2010

D5 WO 2013/131130 A1 (NEWCASTLE INNOVATION LTD [AU]) 12 September 2013

D6 US 2007/215957 A1 (CHEN FANG-CHUNG [TW] ET AL) 20 September 2007

1 The present application does not meet the criteria of Article 33(2) PCT, because the subject-matter of claim 1 is not new.

D1 discloses an organic thin film transistor comprising a semiconductor layer (p. 183301-1, col. 2, l. 32: "pentacene") and a gate dielectric layer, and a continuous intermediate layer disposed therebetween (p. 183301-1, col. 2, l. 4: "nanocomposite/PS double dielectric layers"), wherein

a) the gate dielectric layer has a thickness of 50 nm - 1 µm and comprises 2 - 11 wt.% of nanoparticles dispersed in a polymer matrix, the nanoparticles having an average particle size of 20 - 200 nm and a high dielectric constant, and the polymer matrix having a high dielectric constant (p. 183301-1, col. 2, l. 7-10: "BST nanoparticles", "diameter < 50 nm", "k = 16", "PVP"; table 1: "8 wt %", dielectric constant "3.9"); and
b) the intermediate layer has a thickness of 10 - 55 nm and comprises a polymeric material having a low dielectric constant (p. 183301-3, col. 1, l. 25-30: "PS layer", "k = 2.6", "20 nm").

2 The subject-matter of the independent method claim 29 also lacks novelty:

D1 discloses a process for the preparation of an organic thin film transistor as claimed in claim 1, the process comprising the steps of:
a) providing a gate electrode (p. 183301-1, col. 2, l. 28-32, "n-type Si wafer"),
b) applying the dielectric layer to an exposed surface of the gate electrode ("insulator films were fabricated by spin-coating..."),
c) applying the intermediate layer to the exposed surface of the dielectric layer (p. 183301-3, col. 1, l. 25-30: "PS layer onto the nanoparticle-filled PVP insulators"), and
d) applying the semiconductor layer to the exposed surface of the intermediate layer p. 183301-1, col. 2, l. 28-32, "pentacene").

3 Dependent claims 4, 6-14, 17, 19-21, 23, 25, 28, 30-32, 34-36, 41 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty.

Claim 4:	The gate dielectric layer comprises 8 wt.% of nanoparticles dispersed in a polymer matrix (D1: table 1).
Claim 6:	The nanoparticles in D1 are identical.
Claims 7 and 8:	The nanoparticles have a dielectric constant of greater than 15 (p. 183301-1, col. 2, l. 9: "k=16").
Claim 9:	The nanoparticles are formed from inorganic material ("$Ba_{0.35}Sr_{0.35}TiO_3$").

Claims 10-12:	The nanoparticles are formed from an ABO_3 - type perovskite, a barium strontium titanate ("$Ba_{0.35}Sr_{0.35}TiO_3$").
Claims 13 and 14:	The nanoparticles have an average particle size of 20 - 50 nm (p. 183301-1, col. 2, l. 8: "diameter < 50 nm").
Claim 17:	The polymer matrix is formed from a homopolymer ("PVP").
Claim 19:	The intermediate layer has a thickness of 15 - 35 nm (D1: 183301-3, col. 1, l. 30: "20 nm").
Claim 20:	The intermediate layer has a dielectric constant of less than 4 (D1: 183301-3, col. 1, l. 28: "k = 2.6").
Claim 21, 23:	The intermediate layer is formed from a homopolymer, polystyrene ("PS")
Claim 25:	The semiconductor layer comprises a small molecule material (D1: "pentacene").
Claim 28:	The transistor in D1 is a bottom-gate top-contact transistor.
Claim 30:	The dielectric layer is applied to the gate electrode as a dispersion (D1: 183301-1, col. 2, l. 28-29).
Claim 31:	The dielectric layer dispersion contains at least one organic solvent (D1: 183301-1, col. 2, l. 11-12: "PGMEA").
Claim 32.	Step b) comprises spin coating an exposed surface of the gate electrode with the dielectric layer (D1: 183301-1, col. 2, l. 28-29).
Claims 34 and 35:	The intermediate layer is applied to the dielectric layer as a solution (D1: 183301-3, col. 1, l. 25-26: "spin cast").
Claim 36:	Step c) comprises spin coating the exposed surface of the dielectric layer with the intermediate layer (D1: 183301-3, col. 1, l. 25-26: "spin cast").
Claim 41:	A step of providing source and drain electrodes (D1: 183301-1, col. 2, l. 35-36: "Gold source and drain electrodes").

4 The present application does not meet the criteria of Article 33(3) PCT, because the subject-matter of claims 2, 3, 5, 15, 16, 18, 22, 24, 26, 27, 33, 37-40, 42-44 does not involve an inventive step.

Claims 2 and 3: The skilled person would always try to reduce the thickness of the dielectric layer in order to increase the capacitance per unit area, thereby minimising the driving voltage of the transistor.

Claim 5: The dielectric constant of the dielectric layer increases with the concentration of the nanoparticles (see e.g. D6: § 34). However, the leakage current also increases with the concentration of the nanoparticles (§ 36). According to table 1 of D6, a TFT having a relatively high dielectric constant and a high mobility can be produced with a nanoparticle concentration of 5 wt%.

Claims 15 and 16: The skilled person is well aware of the fact that the dielectric constant of the dielectric layer can be improved if a polymer matrix material having a higher dielectric constant is used (see e.g. D2: p. L771, col. 2, last 4 lines - p. L772, col. 1, l. 3, "CyEPL (k = 15.4)").

Claim 18: D3 discloses a dielectric layer containing nanoparticles in a polymer matrix, wherein the polymer matrix is formed from poly(vinylidene fluoride-co-hexafluoropropylene) [P(VDF-HFP)] (see abstract).

Claim 22: Cross-linking of homopolymers or copolymers represents a standard technique in the fabrication of dielectric layers.

Claim 24: The dielectric layer in D1 is formed from poly(4-vinylphenol) cross-linked with poly(melamine-co-formaldehyde). The skilled person would use this material also for fabricating the intermediate layer.

Claims 26 and 27: Organic thin film transistors comprising a blend of 6,13-Bis (triisopropylsilylethynyl)pentacene and poly(a-methylstyrene) in the semiconductor layer are well known (see e.g. D4: § 69).

Claim 33: The spin-coated dielectric layer in D2 is heated at a temperature of 110°C (p. L770, col. 2, l. 12-14).

Claim 37: Spin-coated polystyrene layers (see D1) are usually heated in order to evaporate the solvent.

Claims 38-40:	The semiconductor layer in D4 is spin-coated on the dielectric layer and then heated at 60°C (§ 69).
Claims 42 and 43:	Organic thin film transistors are used in electronic devices such as displays in portable computers (see e.g. D4: § 2).
Claim 44:	D5 describes the use of an organic thin film transistor for water sensing applications (p. 1, third paragraph, p. 15, l. 5-6).

Re Item VII

Independent claims 1 and 29 are not in the two-part form in accordance with Rule 6.3 (b) PCT, which in the present case would be appropriate.

Re Item VIII

The application does not meet the requirements of Article 6 PCT, because claim 1 is not clear.

The relative terms "high dielectric constant" and "low dielectric constant" used in claim 1 have no well-recognized meaning and leaves the reader in doubt as to the meaning of the technical feature to which they refer, thereby rendering the definition of the subject-matter of said claim unclear, Article 6 PCT.