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Datasheet for the decision of 7 October 2016

Case Number: T 2298/13 - 3.3.09

Application Number: 09154334.8

Publication Number: 2109161

IPC: H01L51/05

Language of the proceedings: EN

Title of invention:
Thin-film transistors

Applicant:
Samsung Electronics Co., Ltd.

Headword:

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step (yes, after amendment)

Decisions cited:

Catchword:

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Case Number: T 2298/13 - 3.3.09

D E C I S I O N
of Technical Board of Appeal 3.3.09
of 7 October 2016

Appellant: (Applicant)	Samsung Electronics Co., Ltd. Maetan-dong 129 Samsung-ro Yeongtong-gu Suwon-si, Gyeonggi-do 443-742 (KR)
Representative:	Greene, Simon Kenneth Elkington and Fife LLP Prospect House 8 Pembroke Road Sevenoaks, Kent TN13 1XR (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 19 June 2013 refusing European patent application No. 09154334.8 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	M. O. Müller
Members:	J. Jardón Álvarez
	E. Kossonakou

Summary of Facts and Submissions

I. This appeal lies from the decision of the examining division refusing European patent application No. 09 154 334.8.

II. The decision was based on four sets of claims, namely a main request filed with letter dated 19 November 2010 and three auxiliary requests filed with letter dated 3 April 2013.

III. The examining division refused the application on the grounds that the subject-matter of the claims of all requests lacked inventive step in view of the disclosure of documents D1 and D2:

D1: US 2003/0227014 A1; and

D2: B. S. Ong *et al.*, "Thiophene Polymer Semiconductors for Organic Thin-Film Transistors" Chem. Eur. J. 2008, 14, pages 4766 to 4778.

Starting from D2 as closest prior art the examining division saw the problem to be solved by the application as filed as being to improve the mobility and current on/off ratio of the field-effect transistors by further improving the uniformity of the deposited organic semiconductor film. The claimed solution was obvious for the skilled person in view of the disclosure of D1.

Alternatively, the claimed subject-matter lacked inventive step starting from D1 as closest prior art and combining it with D2, the problem now being to provide specific polythiophene derivatives. The skilled

person would consult D2 and arrive at the claimed solution.

Similar arguments applied for the subject-matter of the auxiliary requests, which lacked inventive step for the same reasons as the main request.

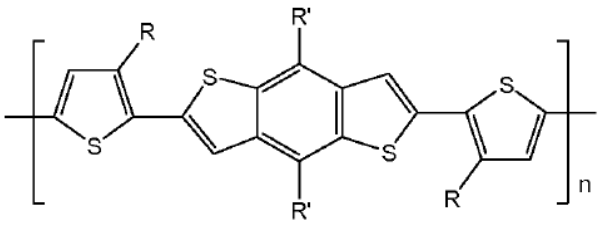
IV. On 28 August 2013 the applicant (in the following: the appellant) filed a notice of appeal. The statement setting out the grounds of appeal was filed on 29 October 2013, including a main request and a first auxiliary request which replaced its requests before the examining division. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the main request or, in the alternative, on the basis of the first auxiliary request.

V. In a communication dated 15 July 2016 the board raised objections under Articles 123(2) and 84 EPC against the claims of the main request and informed the appellant that, if these objections were overcome, the board intended to remit the case to the examining division for it to grant a patent.

VI. By letter dated 13 September 2016 the appellant filed a new main request based on the previous main request, in which the observations of the board had been addressed. Independent claims 1 and 6 of the main request read as follows:

"1. A thin film transistor comprising
a gate dielectric layer; and
a homogeneous semiconducting layer, wherein the semiconducting layer comprises an insulating polymer

and a semiconducting polymer selected from the group consisting of polymers A to D:



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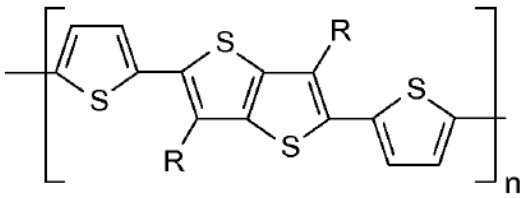

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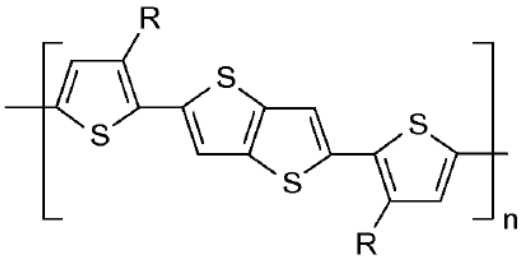

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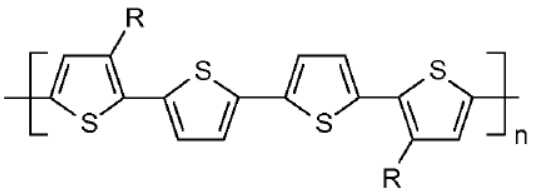


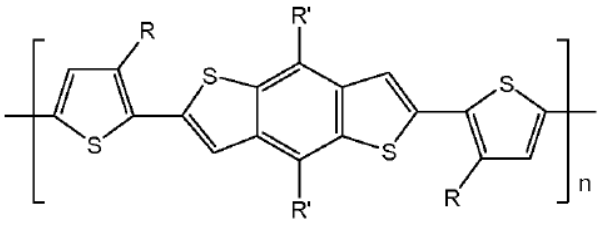
(D)

wherein R and R' are independently selected from hydrogen, alkyl or substituted alkyl containing from 1 to 20 carbon atoms, a heteroatom-comprising group, and halogen; and n is a integer from 3 to 200."

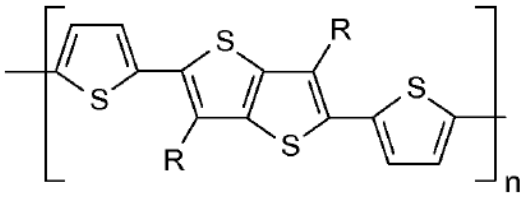
"6. A process for forming a thin-film transistor comprising:

providing a substrate, a gate electrode, a gate dielectric layer, a source electrode, and a drain electrode;

depositing a semiconductor forming composition comprising a solvent, a crystalline semiconducting polymer selected from the group consisting of polymers A to D:



(A)



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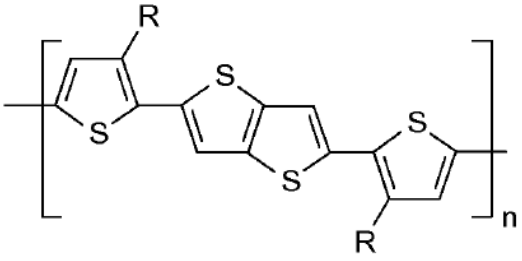

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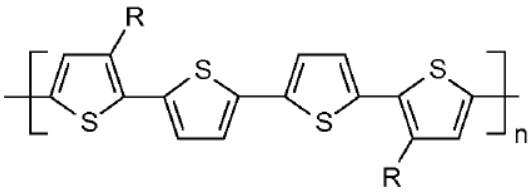

(D)

wherein R and R' are independently selected from hydrogen, alkyl or substituted alkyl containing from 1 to 20 carbons atoms, a heteroatom-comprising group, and halogen; and n is a integer from 3 to 200 and an amorphous insulating polymer upon the substrate, wherein the crystalline semiconducting polymer and the amorphous insulating polymer are dissolved in said solvent, and

drying the composition to form a homogenous semiconducting layer comprising the semiconducting polymer and the insulating polymer;

wherein the semiconducting layer and the gate electrode each directly contact the dielectric layer; and

wherein the source electrode and drain electrode each directly contact the semiconducting layer."

Claims 2 to 5, 7 and 8 are dependent claims.

VII. The relevant arguments of the appellant may be summarised as follows:

- The subject-matter of claim 1 had been limited to thin-film transistors comprising a homogeneous semiconducting layer, formed from a semiconducting polymer of formula (A) to (D) (see claim 1) and an insulating polymer.

- Document D1 was concerned with the formation of a thin-film transistor comprising a semiconducting

layer formed from a dispersion, and did not qualify as closest prior art.

- The closest prior art was D2, which belonged to the same technical field, relied on the same deposition techniques and used the same type of semiconducting polymers as the application. The problem to be solved in view of D2 was how to improve the mobility of the thin-film transistors of D2. The claimed solution would not be obvious for the skilled person given that D1 taught something entirely different, namely that a heterogeneous semiconducting layer was formed when a semiconducting polymer was dispersed in an insulating polymer matrix.

VIII. The appellant requests that the decision under appeal be set aside and that a patent be granted on the basis of claims 1 to 8 according to the main request as filed on 13 September 2016.

Reasons for the Decision

1. Amendments

1.1 Compared to claim 1 on which the appealed decision was based, claim 1 now under consideration further specifies that the semiconducting layer is a homogeneous semiconducting layer in accordance with claim 4 of the main request before the examining division.

1.2 Claim 1 results from the combination of claims 1, 3 and 6 of the application as filed, with the word "substantially" deleted.

1.3 Claim 6 is based on claim 13 as filed, but limits the semiconducting polymer to the preferred thiophene-based polymers (A) to (D) disclosed on pages 2 and 3 of the application as filed and also specifies that the semiconducting polymer and the insulating polymer are dissolved in a solvent as disclosed on page 10, lines 1 to 3 and lines 24 to 25 of the application as filed.

1.4 Dependent claims 2 to 5, 7 and 8 correspond to originally filed claims 4, 5, 7, 8, 14 and 15, respectively.

1.5 Thus, the amended claims fulfil the requirements of Article 123(2) EPC.

2. Novelty

2.1 D1 does not disclose (the formation of) a thin-film transistor with a semiconductor layer that is homogeneous.

2.2 D2 does not disclose (the formation of) a thin-film transistor with a homogeneous semiconducting layer that comprises an insulating polymer in addition to a semiconducting polymer.

2.3 The subject-matter of claims 1 and 6, and by the same token of all remaining claims 2 to 5, 7 and 8, is thus novel over D1 and D2.

3. Inventive step

3.1 The invention relates to a thin-film transistor comprising a gate dielectric layer and a homogeneous semiconducting layer, the latter comprising an

insulating polymer and a semiconducting thiophene-based polymer (claims 1 to 5), and to a process for forming said thin-film transistors (claims 6 to 8).

3.2 Closest prior art

3.2.1 The examining division started from D2 and/or D1 as closest prior art. The appellant considered D2 to represent the closest prior art.

The board agrees with the appellant that D2 is indeed the closest prior art for the subject-matter of the amended claims now under examination wherein the semiconducting layer is homogeneous:

D2 discloses printed organic thin-film transistors as a potentially low-cost alternative to silicon technology in electronic devices. Such thin-film transistors generally comprise three electrically conductive electrodes (source, drain and gate), a gate dielectric layer, and an organic or polymer semiconducting layer (see D2, page 4767, right column, second paragraph and figure 1). In D2 a review is made of the structural studies and design of thiophene-based polymer semiconductors with respect to solution processability, ambient stability, molecular self-organisation, and field-effect transistor properties for organic thin-film transistors applications (see abstract).

In order to obtain a homogeneous semiconducting layer it is necessary that the polymer can be dissolved in the solvent of the composition used to form the semiconducting layer. This is recognised in D2, which explains that solution deposition is a prerequisite for good film-forming properties (see page 4768, paragraph linking the left-hand and the right-hand columns).

Several thiophene-based polymers for the semiconducting layer are discussed in D2.

D1 in contrast is concerned with the formation of a thin-film transistor comprising a semiconducting layer formed from a dispersion (see abstract and paragraph [0040]). It is thus further away from the homogeneous semiconducting layers used in the application.

3.3 Problem and solution

3.3.1 According to the appellant, the problem to be solved by the application in view of D2 can be seen in the provision of a thin-film transistor having a homogeneous semiconducting layer with improved performance, in particular improved mobility (see application, page 1, penultimate and last paragraphs; see also statement of grounds of appeal, page 2, third paragraph from the bottom).

3.3.2 As a solution to this problem, the application proposes the thin-film transistors according to claim 1, including a homogeneous semiconducting layer in which an insulating polymer is present together with the thiophene-based semiconducting polymer. As set out above, the presence of such an insulating polymer in addition to the thiophene-based semiconducting polymer is not disclosed in D2.

3.3.3 The example in the application shows that the thin-film transistor with polystyrene (as insulating polymer) has higher mobility than the one without polystyrene. According to table 1 a thin-film transistor with addition of 10 wt% of polystyrene shows an increased

average mobility of 0.28 $cm^2/V \cdot sec$, compared to 0.22 $cm^2/V \cdot sec$ without polystyrene.

The board is therefore satisfied that the above problem is indeed solved by the claimed means.

3.4 Obviousness

3.4.1 It remains to be decided whether, in view of the available prior art, it would have been obvious for the skilled person to solve the above problem by the means claimed.

3.4.2 D2 itself does not provide any hint towards the claimed solution. D2 is completely silent about the use of any insulating polymer as a component of the semiconducting layer.

3.4.3 The skilled person would not find the required motivation in D1 either. As indicated above, D1 discloses the use of a dispersion to form the semiconducting layer, and the layer thus obtained has distinct phases, namely the insulating polymer matrix and the semiconducting polymer particles.

There is no hint at all in D1 that the use of an insulating polymer would improve mobility. The skilled person starting from D2 and confronted with the problem of increasing mobility would thus not have used the insulating polymer of D1 in the semiconducting layer of the thin-film transistor of D2. Furthermore, even if he had done so, he would not have arrived at the claimed subject-matter. More specifically, he would in this case have incorporated the insulating polymer into the thin-film transistor of D2 in the form of a distinct phase, as taught in D1, and would thus not have

obtained a homogeneous semiconducting layer as required by claim 1.

3.5 For these reasons, the board considers that the subject-matter of claim 1 and, by the same token, of dependent claims 2 to 5 involves an inventive step. The above reasoning also applies to the subject-matter of claims 6 to 8 directed to a process for forming a thin-film transistor having a homogeneous semiconducting layer.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the examining division with the order to grant a patent on the basis of claims 1 to 8 of the main request filed on 13 September 2016, after any necessary consequential amendment of the description and the figures.

The Registrar: The Chairman:

M. Cañueto Carbajo M. O. Müller

Decision electronically authenticated