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Datasheet for the decision of 14 December 2012

Case Number: T 2412/09 - 3.3.09

Application Number: 05709076.3

Publication Number: 1922773

IPC: H01L 51/05

Language of the proceedings: EN

Title of invention:
Perylene imide/diimide based organic field effect Transistors-Ofets and a method of producing the same

Applicant:
Türkiye Sise Ve Cam Fabrikalari A.S.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 84, 123(2)

Keyword:
"Third auxiliary request: Clarity (yes); added subject-matter (no)"
"Remittal"

Decisions cited:
-

Catchword:
-

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Case Number: T 2412/09 - 3.3.09

D E C I S I O N
of the Technical Board of Appeal 3.3.09
of 14 December 2012

Appellant: (Applicant)
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Decision under appeal:
Decision of the Examining Division of the European Patent Office posted 29 June 2009 refusing European patent application No. 05709076.3 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman: W. Ehrenreich
Members: M. O. Müller
F. Blumer

Summary of Facts and Submissions

I. European patent application No. 05 709 076.3, filed on 23 March 2005 as international application PCT/IB2005/050997 in the name of *Turkiye Sise Ve Cam Fabrikalari A.S.*, was refused by the examining division with its decision issued in writing on 29 June 2009.

II. Basis for the decision were the following documents:

Description
page 1 as originally filed;
pages 2 to 5 enclosed with the international preliminary examination report issued on 25 September 2007;

Claims
claims 1 to 4 submitted with the applicant's letter dated 18 April 2009;

Drawings
Sheets 1/5 to 5/5 as originally filed.

Claim 1 read as follows:

"1. An Organic filed [sic] effect transistor (OFET) comprising of n-type semiconductors selected from a group comprising of perylene imide (perylene monoimide) derivatives; N-cyclohexyl-perylene-3,4,9,10-tetracarboxylic-3,4-anhydride-9,10-imide, N-ethylhexyl-perylene-3,4,9,10-tetracarboxylic-3,4,9,10-tetracarboxylic-3,4-anhydride-9,10-imide."

Concerning the amended description pages 2 to 5, the examining division found that a number of amendments did not comply with Article 123(2) EPC (points 2.2 to 2.6 in the reasons for the decision).

In assessing inventive step, the document

D1 WO 03/052841 A1

was referred to. In this connection the examining division held that "In the theoretical case claim 1 complies with the provision of Article 123(2) EPC", the subject-matter of claims 1 to 4 was not inventive. Reasons were given in points 2.7 to 2.10 of the decision and reference was made to the International Report on patentability and the official communication sent to the applicant in the European phase.

III. On 27 August 2009 the applicant (hereinafter: the appellant) filed a notice of appeal against the decision of the examining division and paid the appeal fee on the same day. The grounds of appeal were received on 28 October 2009.

With the statement of the grounds of appeal the appellant filed a new set of claims 1 to 5 and new description pages 1 to 5, replacing the claims and description on which the decision of the examining division was based. The appellant also gave reasons why the amendments to the claims complied with Article 123(2) EPC and the subject-matter of the claims was novel and inventive in view of D1.

Claim 1 reads as follows:

"1. A method of constructing a solution processed, ambipolar, air stable organic field effect transistor (OFET) comprising the steps of:

(a) patterning of electrically conductive indium tin oxide (ITO) on a glass substrate and cleaning of the patterned ITO;

(b) spin coating a transparent film of PVA (poly-vinyl alcohol) having an average molecular weight of 127.000 as a dielectric layer on top of the ITO or spin coating a transparent film of divinyltetramethyldisiloxane-bis(benzocyclobutene) BCB as the dielectric layer on top of the ITO, wherein the dielectric layer has a thickness in the range of 1 to 3 µm;

(c) spin coating N,N'-bis(dehydroabietyl)-3,4,9,10-perylenebis(dicarboximide), N-(cyclohexyl)perylene-3,4,9,10-tetracarboxylic-3,4-anhydride-9,10-imide, or N,N'-bis-(butyl)-1,4,5,8-naphthalenebis(dicarboximide) as a semiconductor layer on the dielectric layer; and

(d) evaporating LiF/Al source and drain electrodes on top of the semiconductor layer under vacuum through a shadow mask."

Claims 2 to 4 are dependent claims wherein

- in claim 2 the thickness of the dielectric layer is limited to a preferred range of from 1.5 to 2.5 µm;
- in claim 3 the roughness of the semiconductor layer is defined to be <5 nm;
- in claim 4 further data for the LiF/Al source and drain electrodes are given, namely the thickness of

0.6 nm/60 nm, the channel length of 35 µm and the channel width of 1.4 mm.

Claim 5 is an independent product claim relating to an n-channel organic field effect transistor.

IV. On 8 October 2012 the board, in preparation of the oral proceedings scheduled for 14 December 2012, issued a communication in which it expressed its preliminary views on essential issues of the case.

(a) Concerning the amended claims the board, in respect of Article 123(2) EPC, in particular raised the following points:

Claim 1

- it was questionable whether paragraph [026] of the original description provided a basis for PVA or BCB being coated on top of the ITO as an alternative;
- with respect to the application as filed, doubts existed that the thickness in the range of 1 to 3 µm for the dielectric layer could be related to both PVA and BCB;
- it was questionable whether there was sufficient basis in paragraphs [013 to 016] of the original description for the three single semiconductor components in feature c) being coated onto the dielectric layer which was either PVA or BCB;
- concerning the LiF/Al source and drain electrodes according to feature d), it appeared that data from original claim 6 and paragraph [027] were missing.

Claim 3

The question should be discussed whether the roughness feature, which was originally more generally disclosed, could be transferred to the specific semiconductor components of claim 3.

Claim 5

Product claim 5 had no basis in the application as filed. Original claim 7 was a product-by-process claim referring back to claims 1 to 6. It was questionable whether its conversion to an independent product claim was allowable.

(b) Under the provisions of Article 84 EPC the following objections were raised:

- it was not clear whether the "average molecular weight" (relating to the value 127.000 for PVA in feature b) of claim 1) referred to a weight average, number average or viscosity average;
- the method for measuring the roughness cited in claim 3 was not clear.

(c) Finally, the board informed the appellant that remittal of the case to the examining division was intended if claims could be elaborated in the oral proceedings which were formally allowable under Articles 123(2) and 84 EPC.

V. With its letter of response dated 28 November 2012 the appellant submitted three sets of claims as a new main request and first and second auxiliary requests.

(a) The claims of the new main request essentially correspond to the claims of the old main request, except that in claim 3 the word "dielectric" has been replaced by "semiconductor".

(b) The first auxiliary request consists of four claims with the following amendments vis-à-vis the claims of the old main request:

- incorporation into claim 1 of the feature that the perylene diimide/imide derivatives absorb in the visible region;
- incorporation into claim 1 of the features of claim 4 concerning the data of the LiF/Al source and drain electrodes and, additionally, definition of the value for the vacuum as being $2x10^{-6}$ mbar;
- correction of claim 3 by replacing "dielectric" with "semiconductor";
- deletion of claims 4 and 5;
- introduction of a new claim 4 as a product-by-process claim.

(c) The second auxiliary request consists of two claims, wherein claim 1 is partly based on original claims 1, 3, 4 and 6 and claim 2 corresponds to original claim 6 with back-reference to claim 1. The wording of claim 1 is given in the reasons, point 3 below.

VI. During the oral proceedings the amendments to the claims of all requests were discussed with a view to Articles 123(2) and 84 EPC. After the board had informed the appellant that none of the requests was allowable, the appellant was given the opportunity to file a new request in order to take account of the deficiencies identified during the discussion. The appellant filed, as third auxiliary request, a set of two claims. The wording of the claims is given in the reasons, point 4 below.

VII. The appellant requested that the decision under appeal be set aside and that the case be remitted to the examining division on the basis of the main request or, subsidiarily, on the basis of any of the first auxiliary request, the second auxiliary request and the third auxiliary request, the main request, first and second auxiliary request filed with the letter dated 28 November 2012, the third auxiliary request as filed during the oral proceedings before the board.

Reasons for the Decision

1. The appeal is admissible.

2. The amended claims according to the main request and first auxiliary request submitted with the letter of 28 November 2012 in the light of the provisions of Article 123(2) EPC

2.1 To analyse the requirements of Article 123(2) EPC, an interpretation of the essential features of the

subject-matter disclosed in the application as filed is needed.

2.1.1 Original claim 1 is directed to the preparation of an organic field effect transistor (OFET). The claimed process includes the following steps:

(a) a step relating to cleaning and patterning the ITO coated glass substrate;
(b) a step relating to the spin coating of a transparent PVA dielectric film having average molecular weight of 127.000 (Mowiol® 40-88) on top of ITO;
(c) a step relating to the spin coating of a transparent dielectric BCB film on top of ITO, the film having a thickness of from 1 to 3 µm.

2.1.2 Step (a) of claim 1 relates to "cleaning and patterning" the ITO coated glass substrate. According to paragraph [026] of the description as filed, the process of manufacturing the device (i.e. the OFET) "starts with etching" the ITO on the glass substrate. Etching creates a certain pattern on the ITO, and thus corresponds to the "patterning" in claim 1. The definition of step (a) "cleaning and patterning" in claim 1 in conjunction with paragraph [0026] as filed therefore implies a certain order in that patterning is the first measure and cleaning follows patterning (in order to remove by-products formed during the patterning).

2.1.3 Steps (b) and (c) of claim 1 are formulated as follows:

"b) spin coating ... PVA ...dielectric layer ...; c) spin coating ...BCB as a dielectric layer".

This implies that b) and c) are consecutive steps.

2.1.4 According to claims 3 to 5, referring back to claim 1, the PVA/BCB covered ITO/glass substrate is coated with the specific semiconductor layers dehydroabietyl perylene diimide having a roughness of <5 nm (claim 3), cyclohexyl perylene anhydride-imide having a roughness of <5 nm (claim 4) or n-butyl naphthalene diimide (claim 5) "instead of step c)". The wording "instead of step (c)", unambiguously implies that step c) of claim 1, i.e. the spin coating step of BCB, is replaced by the spin coating step of the semiconductor layers. This means that the semiconductor layers are directly coated onto the PVA layer applied in step (b) of claim 1. This is also in accordance with paragraphs [018] and [021/022] of the original description wherein specific naphthalene diimide or dehydroabietyl perylene diimide semiconductor layers, coated onto a PVA film, are disclosed.

2.1.5 Original claim 1 defines the thickness of the BCB layer applied in step (c) as being in the range of 1 to 3 µm, with a preferred range of 1.5 to 2.5 µm according to claim 2. A thickness range for the PVA layer applied in step (b) is not expressly defined.

2.2 In contrast to claim 1 as originally filed, wherein two consecutive steps (b) and (c) are defined for the spin coating of the PVA and BCB dielectric layers, both the

main and first auxiliary request now define in claim 1 the spin coating of the dielectric layers PVA and BCB in one step (b) as an alternative, and a new step (c) has been included relating to the spin coating of the semiconductor layer. This amendment now includes the embodiment where the semiconductor layer can be applied alternatively either onto the PVA or the BCB dielectric layer. In this connection the appellant referred to paragraph [026] of the description as filed wherein the following disclosure can be found:

"A highly viscous PVA solution gives a transparent film by spin coating ... forming the dielectric layer. Same experiment was conducted with ... BCB as dielectric layer".

Under Article 123(2) EPC the board cannot, however, accept this amendment, because it contravenes the disclosure in claims 3 to 5 in conjunction with claim 1 as originally filed, according to which exclusively the BCB spin coating step (c) is replaced by spin coating of the semiconductor layer. This disclosure exclusively relates to the embodiment that the semiconductor layer is directly applied onto the PVA dielectric layer. No explicit disclosure of an alternative is found in the application as filed, wherein the semiconductor layer is directly coated onto a BCB dielectric layer.

The above amendment therefore contravenes Article 123(2) EPC.

2.3 With regard to the further amendment in claim 1, according to which the range of 1 to 3 µm for the thickness of the dielectric layer now relates to both

the PVA and the BCB dielectric layer, the appellant refers to the preferred thickness range of 1.5 to 2.5 µm in original claim 2 and the thickness value of 2 µm disclosed in paragraph [026] as a basis. The board, however, notes that the range of 1 to 3 µm and the preferred range of 1.5 to 2 µm are exclusively linked to the thickness of the BCB layer by the wording of original claims 1 and 2. By analogy, the single value of 2 µm disclosed in paragraph [026] relates solely to a PVA dielectric layer. A generalisation of the thickness range of 1 to 3 µm so that it relates to both the PVA and the BCB dielectric layer is thus also not in compliance with Article 123(2) EPC.

2.4 The main request and first auxiliary request are thus not allowable because of non-compliance with Article 123(2) EPC.

3. Amended claim 1 of the second auxiliary request in the light of the provisions of Article 84 EPC

Claim 1 reads as follows:

"1. A method of constructing a solution processed, ambipolar, air stable organic field effect transistor (OFET) based on perylene dimide [sic]/imide derivatives that absorb in the visible region comprising the steps of:

(a) patterning of electrically conductive indium tin oxide (ITO) on a glass substrate and cleaning of the patterned ITO;

(b) spin coating a transparent film of PVA (poly-vinyl alcohol) having an average molecular weight of 127.000 as a dielectric layer on top of the ITO

(c) spin coating a transparent film of divinyltetramethyldisiloxane-bis(benzocyclobutene) BCB as the dielectric layer on top of the ITO having a thickness in the range of 1 to 3 µm;

(d) spin coating the PVA/BCB covered ITO/glass subtrate [sic] with a semiconductor layer of dehydroabietyl perylene diimide having a roughness of <5 nm or spin coating the PVA/BCB covered ITO/glass subtrate [sic] with a semiconductor layer of cyclohexyl perylene anyhdride-imide [sic] having a roughness of <5 nm; and

(e) evaporating LiF/Al source and drain electrodes on top of the semiconductor layer under a vacuum of $2x10^{-6}$ mbar through a shadow mask, in which the LiF/Al layer has a thickness in source and drain electrodes of 0.6 nm/60 nm, respectively and a channel length of 35 µm and a channel width of 1.4 mm."

3.1 For the PVA dielectric layer, a PVA average molecular weight of 127.000 is given in step (b). The term "average molecular weight" without disclosure of a method for measuring the average molecular weight is unclear because claim 1 lacks an indication whether the term represents a weight average molecular weight, Mw, a number average molecular weight, Mn, or a viscosity average molecular weight, Mη and as specific methods for measuring Mn, Mw and Mη lead to different results.

3.2 Also the roughness values "<5 nm" in step (d) lack any further definition. It is known in the prior art that different kinds of roughness exist, for example an arithmetic average roughness, Ra, a root mean squared roughness, Rq, or a maximum peak height roughness, Rp,

which all define a different profile of the surface of a layer and are all expressed by different formulae. In the absence of any indication in claim 1 as to whether the roughness cited therein refers to an arithmetic average roughness, Ra, a root mean squared roughness, Rq, or a maximum peak height roughness, Rp, this feature also lacks clarity.

3.3 Consequently, the second auxiliary request is also not allowable.

4. The claims of the third auxiliary request in the light of the provisions of Articles 84 and 123(2) EPC

The claims of the third auxiliary request read as follows:

"1. A method of constructing a solution processed, ambipolar, air stable organic field effect transistor (OFET) comprising the steps of:

(a) patterning of electrically conductive indium tin oxide (ITO) on a glass substrate and cleaning of the patterned ITO;

(b) spin coating a transparent film of PVA (poly-vinyl alcohol) as a dielectric layer on top of the ITO;

(c) spin coating the PVA covered ITO/glass substrate with a semiconductor layer of N,N'-bis-(dehydroabietyl)-3,4,9,10-perylenebis(dicarboximide); or
spin coating the PVA covered ITO/glass substrate with a semiconductor layer of N-(cyclohexyl)perylene-3,4,9,10-tetracarboxylic-3,4,-anhydride-9,10-imide; or

spin coating the glass substrate with a semiconductor layer of N,N'-bis-(butyl)-1,4,5,8-naphthalenebis(dicarboximide);

(d) evaporating LiF/Al source and drain electrodes on top of the semiconductor layer under vacuum through a shadow mask, wherein the LiF/Al source and drain electrodes have a thickness of 0.6 nm/60 nm, respectively, a channel length of 35 µm and a channel width of 1.4 mm."

"2. An n-channel organic field effect transistor (OFET) with a solution spin coated aromatic imide/diimide semiconductor layer that absorbs in the visible region produced by the method as claimed in claim 1."

4.1 Clarity - Article 84 EPC

The average molecular weight of the PVA dielectric layer and the roughness of the semiconductor layers have been deleted from claim 1. These deletions remove the clarity problems mentioned above in points 3.1 and 3.2.

4.2 Amendments - Article 123(2) EPC

4.2.1 In comparison with original claim 1, the feature that the perylene diimide/imide derivatives absorb in the visible region has been omitted. However, in respect of the incorporation of the specific single semiconductor components in feature (c) which inherently possess an absorption in the visible region, omission of this feature does not violate Article 123(2).

4.2.2 The order "patterning ... ITO ... and cleaning the patterned ITO" in feature (a) is directly and unambiguously derivable from original claim 1 in conjunction with the passage in paragraph [026] of the original description, as already mentioned under point 2.1.2 above.

4.2.3 Step (c) is now limited in that the spin coating of the semiconductor layers is solely applied onto the PVA covered ITO/glass substrate rather than a BCB covered substrate. This corresponds to a combination of original claims 1, 3, 4 and 5 disclosing that the spin coating of the semiconductor layers is performed instead of the spin coating of the BCB dielectric layer (point 2.1.4 above).

4.2.4 The three specific semiconductor components spin coated onto the PVA covered ITO/glass substrate according to feature (c) are disclosed in paragraphs [018] to [024] of the original description.

4.2.5 Step (d) is based on original claim 6.

4.2.6 The deletion of the PVA average molecular weight is allowable in view of the passage in paragraph [013] of the original description disclosing, in conjunction with the general formula in Figure 2, a "PVA (MOWIOL) dielectric polymer" without any indication of a specific molecular weight and a number range of the index "n" in the formula. The index "n" therefore expresses the variability of the polymer chain length. The term "MOWIOL" in brackets is considered to represent the trade name for a preferred product.

4.2.7 While original claims 3 and 4 required a certain roughness in conjunction with the specific semiconductor components, this roughness has been omitted in step (c) of present claim 1. This omission is based on paragraphs [018] to [024] of the original description, wherein these semiconductor components are disclosed without any link to a certain roughness. Furthermore, original product-by-process claim 7 is directed to a semiconductor-coated OFET and neither itself, nor by its reference to the method of claim 1, contains any restriction with regard to roughness. It is thus clearly and unambiguously derivable from the application as filed that the roughness of the semiconductor is not a mandatory feature of the OFET.

4.2.8 Claim 2 corresponds to original claim 7.

4.3 In view of points 4.1 and 4.2 above, the claims of the third auxiliary request meet the requirements of Articles 84 and 123(2) EPC.

5. Remittal

According to Article 111(1) EPC it is at the board's discretion to remit the case to the first instance. During the appeal proceedings the circumstances of the case have changed vis-à-vis the situation leading to the appealed decision, insofar as formally allowable claims have been presented during the oral proceedings before the board, which considerably differ from the claims on which the decision of the examining division was based. The board, therefore, considers it appropriate that the subject-matter of these claims be examined by the first instance for novelty and

inventive step. The appellant's request that the case be remitted to the examining division is therefore granted.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance for further prosecution on the basis of the third auxiliary request as filed during the oral proceedings before the board.

The Registrar The Chairman

M. Cañueto Carbajo W. Ehrenreich