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Datasheet for the decision of 28 January 2018

Case Number: T 2399/13 - 3.4.03

Application Number: 06744335.8

Publication Number: 1897157

IPC: H01L51/05

Language of the proceedings: EN

Title of invention:
LAYER-SELECTIVE LASER ABLATION PATTERNING

Applicant:
Flexenable Limited

Headword:

Relevant legal provisions:
EPC 1973 Art. 56

Keyword:
Inventive step - (yes)

Decisions cited:

Catchword:

Europäisches Patentamt
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Beschwerdekammern

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Case Number: T 2399/13 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 28 January 2018

Appellant: (Applicant)	Flexenable Limited 34 Cambridge Science Park Milton Road Cambridge Cambridgeshire CB4 0FX (GB)
Representative:	Martin, Philip John Marks & Clerk LLP 62-68 Hills Road Cambridge CB2 1LA (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 16 July 2013 refusing European patent application No. 06744335.8 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Eliasson
Members:	M. Papastefanou
	C. Heath

Summary of Facts and Submissions

I. The appeal is against the decision of the Examining Division refusing the European patent application No. 06 744 335.8 (published as WO 2006/129126 A2) on the grounds that neither the Main request nor the Auxiliary requests before it involved an inventive step within the meaning of Article 56 EPC and, additionally, that claim 1 of the Fifth Auxiliary request did not comply with the requirements of Article 84 EPC.

II. Reference is made to the following document:

D1: US 2005/0106507 A1.

III. In the statement setting out the grounds of appeal, the Appellant (Applicant) requested that the decision of the Examining Division be set aside and that a patent be granted based on the Main request or according to one of the First to Fifth Auxiliary requests. All the requests were filed with the statement of the grounds of appeal.

IV. The Board issued summons to oral proceedings accompanied with its preliminary opinion. After receiving the Appellant's reply to the preliminary opinion, the Board, in a telephone communication with the Appellant, indicated that the claims of the Third Auxiliary request appeared to be new and to involve an inventive step.

V. Thereafter, the Appellant withdrew the Main request as well the First and Second Auxiliary requests and named the Third Auxiliary as the Main request. In response to this, the Board cancelled the oral proceedings.

VI. The Appellant's final Main request is to set the decision under appeal aside and to grant a European patent based on the following documents:

- Claims 1-22, of the Third Auxiliary request filed with the statement of grounds of the appeal;
- Description:
  1-3, 5, 12-17, 19-22, 25, 27, 28, 32-36 as published;
  4, 6-11, 18, 23, 24, 26, 29, 30, 31, filed with letter dated 16 November 2018;
- Drawings: Sheets 1-13 as published.

VII. The sole independent claim of the Third Auxiliary request is worded as follows:

A method of fabricating an organic electronic device, said organic electronic device having a structure including an upper conductive layer (7) comprising an inorganic metal with a resistivity of less than lOOμΩcm, an underlying layer (4) immediately beneath said upper conductive layer (7) and at least one solution processable semiconducting layer (3), wherein said underlying layer (4) comprises a layer of organic dielectric material; the method comprising

patterning said upper conductive layer (7) of said structure by:

laser ablating said upper conductive layer using a pulsed laser (6) to remove regions of upper conductive layer (7) from said underlying layer (4) for said patterning; and

wherein said laser ablating uses a single pulse of said laser (6) to substantially completely remove a said

region of said upper conductive layer (7) to expose said underlying layer (4) beneath,

wherein said fluence of said laser pulse is greater than an ablation threshold of said underlying layer (4), and

wherein said underlying layer (4) is substantially undamaged by said ablating.

Reasons for the Decision

1. The appeal is admissible.

2. Amendments

2.1 Claim 1 of the Third Auxiliary request is a combination of original claims 1, 7, 8, 9 and 14.

2.2 Regarding the dependent claims:

- Dependent claims 2-6 correspond to original claims 2-6 respectively.
- Claims 7-10 correspond to original claims 10-13 respectively.
- Claims 11, 12 and 13 correspond to original claims 15, 16, 17 respectively.
- Claims 14-18 correspond to original claims 28-32 respectively.
- Claim 19 finds basis in original claim 49.
- Claims 20 and 21 correspond to original claims 50 and 51 respectively.
- Claim 22 finds basis in the original description, page 5, first and last paragraph and/or page 21, last paragraph.

2.3 The amendments of the description consist in adapting it to the claims of the Third Auxiliary request.

2.4 The Board is, thus, satisfied that the application meets the requirements of Article 123(2) EPC.

3. The invention

3.1 The invention relates to a method for fabricating an organic electronic device (like thin film transistors or diode structures) using laser ablation for selective patterning (page 1, first paragraph of the published application).

The organic electronic device has a layer structure (see Figure 1, for example) and includes an upper conductive layer (5) comprising an inorganic metal with a resistivity of less than 100 µΩcm. Immediately beneath this upper conductive layer there is an underlying layer (4) comprising organic dielectric material. The organic electronic device comprises further at least one solution processable semiconducting layer (3) (page 17, last paragraph - page 18, 3rd paragraph).

3.2 Normally, the upper conductive layer is patterned selectively in order to form electric conductors on it. The use of laser ablation in carrying out this selective patterning has been known in the art.

One issue that has to be addressed in the use of laser ablation is how to protect the underlying layer(s) from being damaged during the ablation of the upper layer. A common solution has been to adjust the fluence of the laser pulses so that it would be under the ablation threshold of the underlying layers. In such cases,

there may be a need for several laser pulses to achieve the desired patterning. The more laser pulses are used for the ablation of the upper layer, the higher is the risk for inaccuracies and damages in the obtained patterning (see pages 2 and 3 of the description).

This solution becomes difficult to apply when the upper conductive layer is an inorganic metal and the underlying layer is an organic dielectric material because the inorganic metal has normally a higher ablation threshold than the organic material of the underlying layer. For the laser pulse(s) to be able to ablate the upper conductive layer the fluence must be high enough to be over the ablation threshold of the inorganic metal. In such a case the fluence would be over the ablation threshold of the underlying inorganic dielectric material.

3.3 The solution proposed by the invention is to use a single laser pulse for the ablation of the upper conductive layer. If the pulse is strong enough (i. e. its fluence is over the ablation threshold of the inorganic metal of the upper layer), it would achieve the desired ablation. At the same time, the intense laser pulse creates a plasma which does not penetrate the underlying layer and which protects the underlying layer from any residual laser energy (see page 5, first and last paragraphs, page 21, last paragraph).

4. The state of the art

4.1 It is uncontested that D1 represents the closest prior art.

4.2 D1 describes a process for laser structuring in the production of semiconductors (paragraph [0001]). The

semiconductors consist of layers and comprise a solution processable semiconductor and and organic insulator (dielectric) layer (paragraph [0022]).

4.3 The upper layer is a conductive layer (electrode) and it is patterned (structured) using laser ablation. As with the claimed invention, it is desired to pattern the upper conductive layer without damaging the underlying organic insulator layer, which lies immediately beneath the electrode (paragraph [0021]).

4.4 As with the claimed invention, the ablation of the upper conductive layer is carried out by a single laser pulse (paragraph [0012] and claim 7).

4.5 The upper conductive layer comprises a functional conductive polymer (see paragraph [0007]). There is disclosure that the upper conductive layer (electrode) can comprise inorganic metals (first lines of paragraph [0019]). The Board is, however, of the opinion that the method described in D1 relates to patterning of semiconductors with upper conductive layer (electrode) comprising a functional polymer.

This is corroborated by the declaration of the invention of D1 (paragraph [0005]) according to which "[t]he present invention relates to a device for structuring a functional polymer...." and "[a]nother object of the invention is to provide a process for structuring functional polymers...". Corresponding definitions of the device and the process are to be found in claims 1 and 5 respectively.

The Board further notes that the use of laser ablation for the structuring of the upper electrode is described only in connection with the electrode comprising a

functional polymer (paragraphs [0019], [0027] and [0028]).

4.6 There is no disclosure in D1 of the fluence of the laser pulsed with respect to the ablation threshold of the underlying layer. There is mention that the power of the laser pulse can be adjusted (paragraph [0021]) but no further details are given.

5. Difference and technical problem

5.1 Accordingly, the method of claim 1 differs from the method in D1 in that the semiconductor fabricated by it has an upper conductive layer (electrode) comprising an inorganic metal with a resistivity of less than 100 μΩcm and that the fluence of the laser pulse is greater than the ablation threshold of the underlying layer.

In the method of D1, the upper conductive layer comprises a functional polymer (i. e. organic material) and there are no details about the fluence of the laser pulse.

5.2 As a technical effect of this differentiating features, the Board sees the possibility of using a metal of low resistivity as electrode for the semiconductor, which yields a semiconductor of improved performance. The use of a laser pulse with fluence greater than the ablation threshold of the underlying layer would thus be necessary, since the underlying layer comprises organic material (which normally has a lower ablation threshold than the inorganic metal) and the ablation is carried out with a single laser pulse.

The technical problem the skilled person starting with the method of D1 will be faced with would thus be, how

to use this method to fabricate organic semiconductors with improved performance.

6. Solution and inventive step

6.1 In the claimed method, this problem is solved by the use of a single laser pulse of sufficient fluence so that the upper conductive layer of the semiconductor device is ablated and the desired pattern formed.

As explained in the description, it has been discovered that the pulse creates a plasma during the ablation process that protects the underlying layer from any residual laser energy.

This allows the use of low resistivity inorganic metal in the upper conductive layer and the fabrication of semiconductors with improved performance.

6.2 In D1, the use of a single laser pulse for the ablation of the upper layer (electrode) is preferred in order to achieve a high speed of production and it is not motivated by any consideration of protecting the underlying layer. As it is explained in D1, the semiconductor layers are in a form of a moving web that is transported (roll-to-roll process) before a mask which is used to form the desired patterning (structuring) of the electrode using laser pulse (claim 1, paragraph [0027] and Figure 1). The idea is to achieve this structuring with a single laser pulse so that the speed of the process is as high as possible (paragraph [0030]).

Although the protection of the underlying layer is also considered in D1, there are other means to achieve this like adjusting the energy of the layer pulse, the

wavelength of the laser light and the number of laser pulses (paragraph [0021]).

Since the electrode (upper conductive layer) of the semiconductor in D1 comprises a functional polymer, its ablation threshold would not be very different from the ablation threshold of the underlying insulation (dielectric) layer, which comprises also organic material. The Board is, hence, of the opinion that the skilled person would opt for a conventional way to protect the underlying layer from damage, like adjusting the energy (fluence) of the lase pulse in order to be under the ablation threshold of the underlying layer.

6.3 In any case, given the information in D1 and the common general knowledge at the time (on the priority date of the application), the skilled person would not contemplate the idea of using an inorganic metal of low resistivity for the electrode layer, since this would necessitate either a laser pulse with fluence greater than the ablation threshold of the underlying layer or carrying out the ablation with more than one laser pulses with fluence (energy) under the ablation threshold of the underlying layer.

The former solution would go against the general knowledge and practice at the time, since it would mean increasing the risk of damaging the underlying layer. The latter would be against the intention of the method in D1, which is to achieve a quick and reliable process for structuring electrodes for organic semiconductors and, in any case, would lead away from the claimed method.

6.4 The conclusion of the Board is that the skilled person starting from D1 would not be able to arrive at the claimed method in an obvious way. The subject-matter of claim 1 involves, therefore, an inventive step in the sense of Article 56 EPC 1973.

7. The description has been adapted to the claims and D1 is cited in the application (last paragraph on page 1 of the description).

The Board is, thus, satisfied that the patent application and the invention to which it relates meet the requirements of the EPC and the EPC 1973 and that a patent is to be granted according to Article 97(1) EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance department with the order to grant a European patent based on the following application documents:

   - Claims 1-22 of the Third Auxiliary request, filed with the statement of the grounds of appeal;

   - Description:
     1-3, 5, 12-17, 19-22, 25, 27, 28, 32-36 as published;
     4, 6-11, 18, 23, 24, 26, 29, 30, 31 filed with letter dated 16 November 2018;

   - Drawings: Sheets 1-13 as published.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated