



US010431688B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.:** **US 10,431,688 B2**
(45) **Date of Patent:** **Oct. 1, 2019**

(54) **THIN-FILM TRANSISTOR STRUCTURE WITH THREE-DIMENSIONAL FIN-SHAPE CHANNEL AND PREPARATION METHOD THEREOF**

(71) Applicants: **Sun Yat-Sen University**, Guangzhou (CN); **SUN YAT-SEN UNIVERSITY CARNEGIE MELLON UNIVERSITY SHUNDE INTERNATIONAL JOINT RESEARCH INSTITUTE**, Guangdong (CN)

(72) Inventors: **Kai Wang**, Guangzhou (CN); **Hai Ou**, Guangzhou (CN); **Jun Chen**, Guangzhou (CN)

(73) Assignees: **SUN YAT-SEN UNIVERSITY**, Guangdong (CN); **SUN YAT-SEN UNIVERSITY CARNEGIE MELLON UNIVERSITY SHUNDE INTERNATIONAL JOINT RESEARCH INSTITUTE**, Guangdong (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/749,969**

(22) PCT Filed: **Jul. 30, 2016**

(86) PCT No.: **PCT/CN2016/092450**

§ 371 (c)(1),

(2) Date: **Feb. 2, 2018**

(87) PCT Pub. No.: **WO2017/020796**

PCT Pub. Date: **Feb. 9, 2017**

(65) **Prior Publication Data**

US 2018/0233599 A1 Aug. 16, 2018

(30) **Foreign Application Priority Data**

Aug. 4, 2015 (CN) 2015 1 0472392

(51) **Int. Cl.**

H01L 29/66 (2006.01)

H01L 29/786 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC .. **H01L 29/78603** (2013.01); **H01L 29/42384**

(2013.01); **H01L 29/66** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01L 29/78603; H01L 29/66; H01L 29/66477; H01L 29/7848; H01L 29/785;

H01L 31/022408

See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

8,928,080 B2 * 1/2015 Sun H01L 29/785

257/347

2009/0073334 A1 * 3/2009 Honda G09G 3/3685

349/38

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101789398 A 7/2010

CN 103730512 A 4/2014

(Continued)

OTHER PUBLICATIONS

International Search report dated Nov. 4, 2016 from PCT/CN2016/092450, 4 pgs.

Primary Examiner — Kyoung Lee

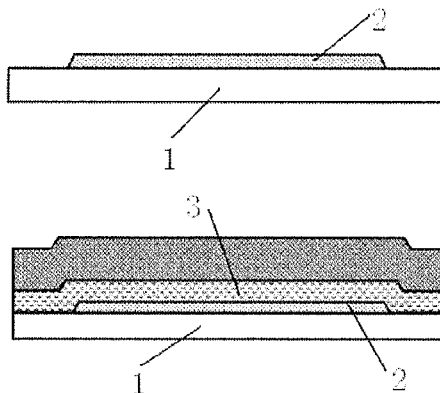
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57)

ABSTRACT

The present invention discloses a thin-film transistor structure with a three-dimensional fin-shape channel and a prepa-

(Continued)



ration method thereof. The preparation method includes following steps: (a) depositing and etching a bottom gate electrode on a substrate; (b) depositing a bottom dielectric layer at an upper part of a structure obtained from the step (a), and sequentially depositing a semiconductor film on the bottom dielectric layer; (c) etching the semiconductor film to obtain a fin-type channel; (d) respectively depositing an ohmic contact layer, a source electrode and a drain electrode on the semiconductor film located at both sides of the fin-shape channel, and etching; (e) depositing a top dielectric layer and a top gate electrode at an upper part of a structure obtained from the step (d); and (f) etching the top gate electrode, an completing a preparation of a thin-film transistor with a dual-gate three-dimensional fin-shape channel.

3 Claims, 4 Drawing Sheets

(51) **Int. Cl.**
H01L 29/78 (2006.01)
H01L 31/0224 (2006.01)
H01L 29/423 (2006.01)

(52) **U.S. Cl.**
CPC *H01L 29/66477* (2013.01); *H01L 29/785*
(2013.01); *H01L 29/7848* (2013.01); *H01L*
29/78618 (2013.01); *H01L 29/78648*
(2013.01); *H01L 29/78696* (2013.01); *H01L*
31/022408 (2013.01)

(56) References Cited

U.S. PATENT DOCUMENTS

2014/0008647	A1 *	1/2014	Yamazaki	.....	H01L 29/7869 257/43
2014/0326992	A1 *	11/2014	Hondo	.....	H01L 29/78696 257/43
2016/0035865	A1 *	2/2016	Nagamatsu	.....	H01L 21/8221 438/104
2016/0111545	A1 *	4/2016	Tanaka	.....	H01L 29/7869 257/43
2016/0172500	A1 *	6/2016	Yamazaki	.....	H01L 29/7869 257/43

FOREIGN PATENT DOCUMENTS

CN	103762251	A	4/2014
CN	105261638	A	1/2016

* cited by examiner



Formalities Officer
Name: Cornudet, Véronique
Tel: +49 30 25901 - 712
or call
+31 (0)70 340 45 00

Bergmeier, Werner
Canzler & Bergmeier
Patentanwälte Partnerschaft mbB
Friedrich-Ebert-Straße 84
85055 Ingolstadt
ALLEMAGNE

Application No. 16 832 284.0 - 1230	Ref. SUN-7393-15	Date 12.03.2020
Applicant Sun Yat-Sen University, et al		

Communication under Rule 71(3) EPC

1. Intention to grant

You are informed that the examining division intends to grant a European patent on the basis of the above application, with the text and drawings and the related bibliographic data as indicated below.

A copy of the relevant documents is enclosed.

1.1 In the text for the Contracting States:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT
RO RS SE SI SK SM TR

Description, Pages

1-6 filed with entry into the regional phase before the EPO

Claims, Numbers

1-3 filed in electronic form on 18-07-2019

Drawings, Sheets

1/4-4/4 filed with entry into the regional phase before the EPO

With the following amendments to the above-mentioned documents proposed by the division

Description, Pages 1, 2
Delete Previous: 7
Claims, Numbers 1, 3

Comments

Applicant's arguments relating to D3 and D5 have been accepted.

DESCRIPTION

Page 1: Mention of relevant prior art in the description (Rule 42(1) EPC)

Page 2: Description adapted to amended claims (Art. 84 EPC)

Page 7: (PAGE DELETED) -Scope of claim unclear - clarified (Art. 84 EPC)

CLAIMS

Page 1, Claim 1: Scope of claim unclear - clarified (Art. 84 EPC). Direction specified since otherwise the channel length would not be increased, see description page 3, lines 23-27.

Page 2, Claim 3: Scope of claim unclear - clarified (Art. 84 EPC)

1.2 Bibliographic data

The title of the invention in the three official languages of the European Patent Office, the international patent classification, the designated contracting states, the registered name(s) of the applicant(s) and the other bibliographic data are shown on **EPO Form 2056** (enclosed).

2. Invitation

You are invited, **within a non-extendable period of four months** of notification of this communication,

2.1 to EITHER approve the text communicated above and verify the bibliographic data (Rule 71(5) EPC)

(1) by filing a translation of the claim(s) in the other two official languages of the EPO

	Fee code	EUR
(2a) by paying the fee for grant including the fee for publication:	007	925.00
minus any amount already paid (Rule 71a(5) EPC):		0.00
Total amount:		925.00
(3) by paying additional claims fees under Rule 71(4) EPC;		
number of claims fees payable: 0	016	0.00
minus any amount already paid (Rule 71a(5) EPC):		0.00
Total amount:		0.00

Important: If the translations of the claims and fees have already been filed and paid respectively in reply to a previous communication under Rule 71(3) EPC, e.g. in the case of resumption of examination after approval (see Guidelines C-V, 6), **agreement as to the text to be granted** (Rule 71a(1) EPC) must be expressed within the same time limit (e.g. by approving the text and verifying the bibliographic data, by confirming that grant proceedings can go ahead with the documents on file and/or by stating which translations of the claims already on file are to be used).

Note 1: See "Notes concerning fee payments" below.

Note 2: Any overpaid "minus" amounts will be refunded when the decision to grant (EPO Form 2006A) has been issued.

Note 3: For the calculation of the grant fee under Article 2(2), No. 7, RFees (old fee structure), the number of pages is determined on the basis of a clean copy of the application documents, in

which text deleted as a result of any amendments by the examining division is not shown.
Such clean copy is made available via on-line file inspection only.

2.2 OR, in the case of disapproval, to request reasoned amendments or corrections to the text communicated above or keep to the latest text submitted by you (Rule 71(6) EPC).

In this case the translations of the claims and fee payments mentioned under point 2.1 above are NOT due.

The terms "amendment(s)" and "correction(s)" refer only to amendments or corrections of the application documents and not of other documents (e.g. bibliographic data, the designation of the inventor, etc.).

If filing amendments, you must identify them and indicate the basis for them in the application as filed. Failure to meet either requirement may lead to a communication from the examining division requesting that you correct this deficiency (Rule 137(4) EPC).

2.3 Bibliographic data

Where you request a change or correction of bibliographic data in response to the Rule 71(3) communication, this will **not** cause the sending of a further communication under Rule 71(3) EPC. You will still have to pay the fees and file translations in reply to the Rule 71(3) communication in the case of 2.1 above, unless you also file a reasoned request for amendments or corrections in response to the Rule 71(3) communication (see case 2.2 above).

3. Loss of rights

If neither of the two possible actions above (see points 2.1 or 2.2) is performed in due time, the European patent application will be deemed to be withdrawn (Rule 71(7) EPC).

4. Further procedure

4.1 In the case of point 2.1 above

- 4.1.1** The decision to grant the European patent will be issued, and the **mention of the grant** of the patent will be published in the European Patent Bulletin, if the requirements concerning the translation of the claims and the payment of all fees are fulfilled and there is agreement as to the text to be granted (Rule 71a(1) EPC).

Note on payment of the renewal fee:

If a renewal fee becomes due before the next possible date for publication of the mention of the grant of the European patent, publication will be effected only after the renewal fee and any additional fee have been paid (Rule 71a(4) EPC).

Under Article 86(2) EPC, the obligation to pay renewal fees to the European Patent Office terminates with the payment of the renewal fee due in respect of the year in which the mention of the grant of the European patent is published.

Note on payment of the designation fee(s):

If the designation fee(s) become(s) due after the communication under Rule 71(3) EPC, the mention of the grant of the European patent will not be published until these fees have been paid (Rule 71a(3) EPC).

- 4.1.2** After publication, the **European patent specification** can be downloaded free of charge from the EPO publication server <https://data.epo.org/publication-server>.

4.1.3 Filing of translations in the contracting states

As regards translation requirements prescribed by the contracting states under Article 65(1) EPC, please consult the website of the European Patent Office

www.epo.org → Law & practice → Legal texts, National law relating to the EPC

www.epo.org → Law & practice → All Legal texts → London Agreement

In the case of a valid extension or validation

As regards translation requirements prescribed by the extension or validation states, please consult the website of the European Patent Office

www.epo.org → Law & practice → Legal texts, National law relating to the EPC

Failure to supply a prescribed translation in a contracting state, or in an extension or validation state may result in the patent being deemed to be void *ab initio* in the state concerned (Art. 65(3) EPC).

4.2 In the case of 2.2 above

If the present communication under Rule 71(3) EPC is based on an auxiliary request and, within the time limit, you maintain the main request or a higher ranking request which is not allowable, the application will be refused (Art. 97(2) EPC).

If the examining division gives its consent to the requested amendments or corrections, it will issue a new communication under Rule 71(3) EPC; otherwise, it shall resume the examination proceedings (Rule 71(6) EPC).

5. Filing of a divisional application

Any divisional application relating to this European patent application must be filed directly with the European Patent Office in Munich, The Hague or Berlin and will be in the language of the proceedings for the present application, or if the latter was not in an official language of the EPO, the divisional application may be filed in the language of the present application as filed (see Article 76(1) and Rule 36(2) EPC). Any such divisional application must be filed while the present application is still pending (Rule 36(1) EPC; Guidelines A-IV, 1.1.1).

6. Notes concerning fee payments

6.1 Making payments

For payments made via deposit account, please note that as from 1 December 2017 debit orders will only be carried out if filed in an electronically processable format (xml), using an accepted means of filing as laid down in the Arrangements for deposit accounts (ADA), published in the Supplementary publication in the Official Journal.

All relevant information related to the modes of payment of fees to the EPO can be retrieved from the EPO website at "**Making Payments**".

6.2 Information concerning fee amounts

Procedural fees are usually adjusted every two years, on even years, with effect from 1 April. Therefore, before making a payment, parties should verify the amounts actually due on the date of payment using the applicable version of the Schedule of fees and expenses, published as a Supplement to the Official Journal of the EPO, available on the EPO website (www.epo.org) at www.epo.org/schedule-of-fees. The "Schedule of fees" table allows the viewing, downloading and searching of individual fee amounts, both current and previous.

6.3 Note to users of the automatic debiting procedure

The fee for grant, including the fee for publication, and any additional claims fees due under Rule 71(4) EPC will be debited automatically on the date of filing of the translations of the claims, or on the last day of the period of this communication. However, if the designation fee(s) become(s) due as set out in Rule 71a(3) EPC and/or a renewal fee becomes due as set out in Rule 71a(4) EPC, these should be paid separately by another permitted way of payment in order not to delay the publication of the mention of the grant. The same applies in these circumstances to the payment of extension and validation fees. The same applies in these circumstances to the payment of extension and validation fees.

Note: If a waiver is expressed in response to a Rule 71(3) communication (see OJ EPO 2015, A52), the fee for grant, including the fee for publication/printing, and any additional claims fees will not be debited automatically. These fees must be paid separately by another means of payment allowed under the Rules relating to Fees.

Examining Division:

Chairman:	Stirn, Jean-Pierre
2nd Examiner:	Ekoué, Adamah
1st Examiner:	Juhl, Andreas



Cornudet, Véronique
For the Examining Division
Tel. No.: +49 30 25901 - 712

Berlin sub-office

Enclosures: Text intended for grant
 EPO Form 2056

Annex to EPO Form 2004, Communication pursuant to Rule 71(3) EPC

Bibliographical data of European patent application No. 16 832 284.0

For the intended grant of the European patent, the bibliographical data are set out below, for information:

Title of invention:

- DÜNNSCHICHTTRANSISTORSTRUKTUR MIT DREIDIMENSIONALEM RIPPENFÖRMIGEM KANAL UND HERSTELLUNGSVERFAHREN DAFÜR
- THIN-FILM TRANSISTOR STRUCTURE HAVING THREE-DIMENSIONAL FIN-SHAPED CHANNEL AND MANUFACTURING METHOD THEREOF
- STRUCTURE DE TRANSISTOR À COUCHES MINCES À CANAL EN FORME D'AILETTE EN TROIS DIMENSIONS ET SON PROCÉDÉ DE FABRICATION

Classification: INV. H01L29/66 H01L29/423 H01L29/786 H01L31/0224

Date of filing: 30.07.2016

Priority claimed: CN / 04.08.2015 / CNA201510472392

Contracting States*
for which fees have
been paid:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU
LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

Extension States*
for which fees have
been paid:

Validation States*
for which fees have
been paid:

Applicant(s):** Sun Yat-Sen University
Cai, Ming
No. 135 Xingang Xi Road
Haizhu
Guangdong, Guangdong 510275
CN

Sun Yat-Sen University Carnegie Mellon University
WANG, Kai
International Joint Research Institute
No.9 in Eastern Nanguo Road
Shunde
Foshan, Guangdong 528300
CN

Inventor(s):

WANG, Kai
c/o SUN YAT-SEN UNIVERSITY
No. 135 Xingang West Road
Haizhu Guangzhou,
Guangdong 510275
CN

OU, Hai
c/o SUN YAT-SEN UNIVERSITY
No. 135 Xingang West Road
Haizhu Guangzhou,
Guangdong 510275
CN

CHEN, Jun
c/o SUN YAT-SEN UNIVERSITY
No. 135 Xingang West Road
Haizhu Guangzhou,
Guangdong 510275
CN

- *) If the time limit for the payment of designation fees according to Rule 39(1) EPC has not yet expired and the applicant has not withdrawn any designation, **all Contracting States/Extension States/Validation States** are currently still deemed to be designated. See also Rule 71a(3) EPC and, if applicable, the above Note to users of the automatic debiting procedure.
- **) If two or more applicants have designated different Contracting States, this is indicated here.