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[Continued on next page]

(54) Title: METHODS AND APPARATUSES FOR FORMING SEMICONDUCTOR FILMS

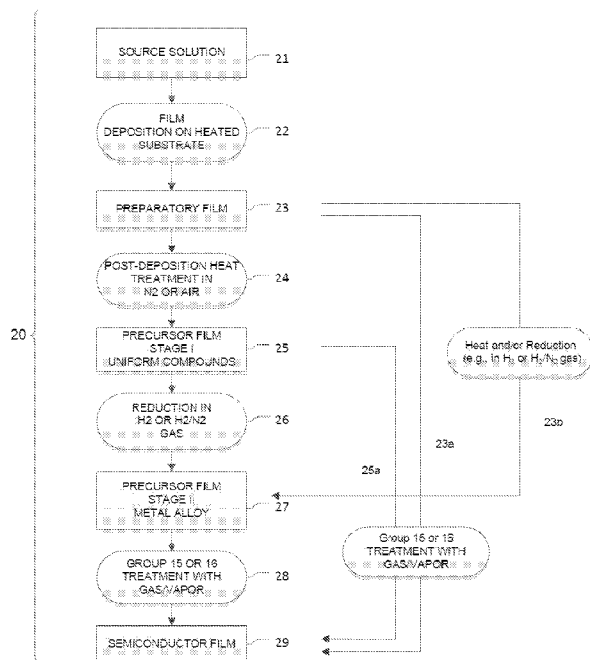


Fig 2

(57) Abstract: Described herein are systems and methods method for forming semiconductor films. In some embodiment, the methods comprising depositing the source solution containing a solvent and plurality of types of metal ionic species and a second type on a substrate heated to a temperature at or above the boiling point of the solvent. In some embodiments, methods and apparatus for exposing a substrate to a gas are also provided.

WO 2014/011674 A3



EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/049781

<p>A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - H01L 21/00 (2014.01) USPC - 438/46 According to International Patent Classification (IPC) or to both national classification and IPC</p>																										
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols) IPC(8) - H01L 21/00, 21/20, 21/36 (2014.01) USPC - 438/46, 47, 478, 483, 509; 118/724, 725</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched CPC - H01L 33/007, 21/0254, 21/0262 (2013.01)</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Orbit, Google Patents, ProQuest</p>																										
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>US 6,127,202 A (KAPUR et al) 03 October 2000 (03.10.2000) entire document</td> <td>1-10, 17, 37, 44-54</td> </tr> <tr> <td>Y</td> <td>US 2011/0139071 A1 (OLADEJI) 16 June 2011 (16.06.2011) entire document</td> <td>1-10, 17, 37, 39-41, 44-56</td> </tr> <tr> <td>Y</td> <td>US 2011/0206842 A1 (REVANKAR et al) 25 August 2011 (25.08.2011) entire document</td> <td>4-7, 37, 39-41, 54-56</td> </tr> <tr> <td>Y</td> <td>US 2010/0132891 A1 (NOZAWA) 03 June 2010 (03.06.2010) entire document</td> <td>41</td> </tr> <tr> <td>A</td> <td>US 2008/0078325 A1 (MATSUDA et al) 03 April 2008 (03.04.2008) abstract, para. 0065-0069</td> <td>1-10, 17, 37, 39-41, 44-56</td> </tr> <tr> <td>A</td> <td>US 2009/0280624 A1 (CURTIS et al) 12 November 2009 (12.11.2009) entire document</td> <td>1-10, 17, 37, 39-41, 44-56</td> </tr> <tr> <td>A</td> <td>US 2010/0059385 A1 (LI) 11 March 2010 (11.03.2010) entire document</td> <td>1-10, 17, 37, 39-41, 44-56</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	US 6,127,202 A (KAPUR et al) 03 October 2000 (03.10.2000) entire document	1-10, 17, 37, 44-54	Y	US 2011/0139071 A1 (OLADEJI) 16 June 2011 (16.06.2011) entire document	1-10, 17, 37, 39-41, 44-56	Y	US 2011/0206842 A1 (REVANKAR et al) 25 August 2011 (25.08.2011) entire document	4-7, 37, 39-41, 54-56	Y	US 2010/0132891 A1 (NOZAWA) 03 June 2010 (03.06.2010) entire document	41	A	US 2008/0078325 A1 (MATSUDA et al) 03 April 2008 (03.04.2008) abstract, para. 0065-0069	1-10, 17, 37, 39-41, 44-56	A	US 2009/0280624 A1 (CURTIS et al) 12 November 2009 (12.11.2009) entire document	1-10, 17, 37, 39-41, 44-56	A	US 2010/0059385 A1 (LI) 11 March 2010 (11.03.2010) entire document	1-10, 17, 37, 39-41, 44-56
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<p><input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/></p>																										
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<p>Date of the actual completion of the international search 03 February 2014</p>		<p>Date of mailing of the international search report 20 FEB 2014</p>																								
<p>Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No: 571-273-3201</p>		<p>Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774</p>																								

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/049781

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

- 1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

- 2. Claims nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

- 3. Claims Nos.: 11-16, 18-36, 38, 42-43
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet

- 1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
- 2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
- 3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

- 4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

Continuation of Box III.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-3, 8-10, 17, 44-53, drawn to a method for forming a semiconductor film on at least a portion of a substrate, comprising: (a) depositing a source solution containing a solvent and at least a first type of metal ionic species and a second type of metal ionic species dissolved therein on at least a portion of the substrate to form a preparatory film comprising the first type of metal ionic species and the second type of metal ionic species, wherein the substrate onto which the source solution is deposited is at a temperature at or above the boiling point of the solvent; and (b) exposing the preparatory film to a material comprising a Group 15 or Group element to form a semiconductor film.

Group II, claims 4-7, 37, 39-41, 54-56, drawn to a method and an apparatus for exposing a substrate to a gas, comprising: a chamber comprising a substrate holder, a gas inlet, and a gas outlet, wherein the substrate holder is configured to be operatively coupled to a substrate; a gas supply system in fluid communication with the gas inlet and configured to supply gas to the chamber and distribute gas onto at least one surface of a substrate associated with the substrate holder; a heater configured to heat the chamber and/or substrate coupled to the substrate holder; and a gas treatment and recirculation system configured to recirculate gas from the gas outlet back to the gas inlet wherein the gas handling system comprises a moisture removal system configured to remove moisture from the gas being recirculated.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: forming a semiconductor film on at least a portion of a substrate, comprising: (a) depositing a source solution containing a solvent and at least a first type of metal ionic species and a second type of metal ionic species dissolved therein on at least a portion of the substrate to form a preparatory film comprising the first type of metal ionic species and the second type of metal ionic species, wherein the substrate onto which the source solution is deposited is at a temperature at or above the boiling point of the solvent; and (b) exposing the preparatory film to a material comprising a Group 15 or Group element to form a semiconductor film as claimed therein is not present in the invention of Group II. The special technical feature of the Group II invention: exposing a substrate to a gas, comprising: a chamber comprising a substrate holder, a gas inlet, and a gas outlet, wherein the substrate holder is configured to be operatively coupled to a substrate; a gas supply system in fluid communication with the gas inlet and configured to supply gas to the chamber and distribute gas onto at least one surface of a substrate associated with the substrate holder; a heater configured to heat the chamber and/or substrate coupled to the substrate holder; and a gas treatment and recirculation system configured to recirculate gas from the gas outlet back to the gas inlet wherein the gas handling system comprises a moisture removal system configured to remove moisture from the gas being recirculated as claimed therein is not present in the invention of Group I.

Groups I and II lack unity of invention because even though the inventions of these groups require the technical feature of forming a semiconductor film on at least a portion of a substrate, and exposing a substrate to a gas containing a reactive material in order to form a reaction, this technical feature is not a special technical feature as it does not make a contribution over the prior art in view of US2008/0078325 A1 (MATSUDA et al) 03 April 2008 (03.04.2008), abstract, para. 0065-0069.

Since none of the special technical features of the Group I or II inventions are found in more than one of the inventions, unity of invention is lacking.