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- (71) **Applicants** (for all designated States except US): **FLI-SOM AG** [CH/CH]; Ueberlandstrasse 129, CH-8600 Dübendorf (CH). **EMPA** [CH/CH]; Ueberlandstrasse 129, CH-8600 Dübendorf (CH).
- (72) **Inventors; and**
- (75) **Inventors/Applicants** (for US only): **CHIRILA, Adrian** [CH/CH]; Gsteigstrasse 3, CH-8049 Zürich (CH). **TIWARI, Ayodhya Nath** [CH/CH]; Altwiesenstrasse 185, CH-8053 Zürich (CH). **BLOESCH, Patrick** [CH/CH]; Rebenrain 3, CH-3298 Oberwil Bei Büren (CH). **NISHIWAKI, Shiro** [JP/CH]; Vincenz / C108, Loorenstrasse 74, CH-8053 Zürich (CH). **BREMAUD, David** [CH/CH]; Bächlerstrasse 51, CH-8046 Zürich (CH).
- (74) **Agent:** **CRONIN, Brian**; Cronin Intellectual Property, Chemin de Précoissy 31, CH-1260 Nyon (CH).

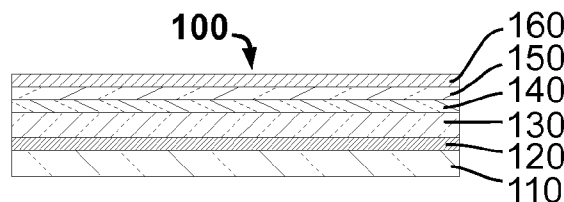
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(54) **Title:** THIN-FILM PHOTOVOLTAIC DEVICE AND FABRICATION METHOD

**FIG. 1**

(57) **Abstract:** A method to fabricate thin-film photovoltaic devices (100) comprising a photovoltaic Cu(In,Ga)Se_2 or equivalent ABC absorber layer (130), such as an ABC_2 layer, deposited onto a back-contact layer (120) characterized in that said method comprises at least five deposition steps, wherein the pair of third and fourth steps are sequentially repeatable, in the presence of at least one C element over one or more steps. In the first step at least one B element is deposited, followed in the second by deposition of A and B elements at a deposition rate ratio A_r/B_r , in the third at a ratio A_r/B_r lower than the previous, in the fourth at a ratio A_r/B_r higher than the previous, and in the fifth depositing only B elements to achieve a final ratio A/B of total deposited elements. The resulting photovoltaic devices are characterized in that, starting from the light-exposed side, the absorber layer (130) of the photovoltaic devices (100) comprises a first region (501) of decreasing Ga / (Ga + In) ratio, followed by a second region (502) of increasing Ga / (Ga + In) ratio where over the light-exposed half side of the second region (502) the value of Ga / (Ga + In) increases by less than 0.15 and contains at least one hump.

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2012/051926

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/02 H01L21/36
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010/248420 A1 (OKAMURA DAISUKE [JP] ET AL) 30 September 2010 (2010-09-30) paragraphs [0009], [0010], [0023] - [0037]; figures 2-3 -----	1-13
A	US 2011/073186 A1 (LAI CHIH-HUANG [TW] ET AL) 31 March 2011 (2011-03-31) paragraphs [0049] - [0051]; claims 1-9 -----	1-13
A	US 5 141 564 A (CHEN WEN S [US] ET AL) 25 August 1992 (1992-08-25) claims -----	1-13
A	US 4 465 575 A (LOVE ROBERT B [US] ET AL) 14 August 1984 (1984-08-14) claims ----- -/-	1-13



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

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European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Wolff, Gerhard

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2007/072023 A1 (DURHAM SCIENT CRYSTALS LTD [GB]; BASU ARNAB [GB]; ROBINSON MAX [GB]; C) 28 June 2007 (2007-06-28) claims -----	1-13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2012/051926

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.:
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 additional 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 an 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.:

1-13

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-13

A method of fabricating at least one absorber layer for thin-film photovoltaic devices, the absorber layer being made of a multinary chalcogenide material, the method comprising at least five sequential steps of which two may be repeated, the depositing steps defining specific deposition rate ratios and element ratios between the group 11 and group 13 elements.

2. claims: 14-20

A thin-film photovoltaic device comprising an absorber layer which is characterised by specific front and back grading regions each having a decreasing or increasing Ga/(Ga+In) ratio, respectively.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2012/051926

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010248420 A1	30-09-2010	JP 2010225829 A US 2010248420 A1	07-10-2010 30-09-2010
US 2011073186 A1	31-03-2011	TW 201112438 A US 2011073186 A1	01-04-2011 31-03-2011
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