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- (71) **Applicant:** UNIVERSITY OF CENTRAL FLORIDA RESEARCH FOUNDATION INC. [US/US]; 12201 Research Parkway, Suite 501, Orlando, Florida 32826-3246 (US).
- (72) **Inventors:** DAVIS, Kristopher O.; 14525 Stonebriar Way, Orlando, Florida 32826 (US). SCHOENFELD, Winston V.; 2830 Regal Pine Trail, Oviedo, Florida 32766 (US). JIANG, Kaiyun; Robert-Bosch-Str. 32-36, 72250 Freudenstadt (DE). ZUNFT, Heiko; Robert-Bosch-Str. 32-36, 72250 Freudenstadt (DE). SCHMID, Christian; Robert-Bosch-Str. 32-36, 72250 Freudenstadt (DE).
- (74) **Agents:** GREENER, William et al.; Bond, Schoeneck & King, PLLC, 10 Brown Road, Suite 102, Ithaca, New York 14850 (US).

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(54) **Title:** DOUBLE LAYER ANTI-REFLECTIVE COATINGS, METHODS AND APPLICATIONS

14 – second ARC layer

12 – first ARC layer

10 – substrate

FIG. 1

(57) **Abstract:** Embodiments which provide an optically active component, a method for fabricating the optically active component and a method for operating a photovoltaic cell that may comprise the optically active component all use a dual layer anti-reflective coating. The dual layer anti-reflective coating in turn includes as a second and upper anti-reflective coating layer an aluminum oxide material. By using such an aluminum oxide material for forming the second and upper anti-reflective coating layer the embodiments exhibit enhanced barrier resistance to chemical and moisture intrusion, and thus enhanced performance of the optically active component.



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DOUBLE LAYER ANTI-REFLECTIVE COATINGS, METHODS AND APPLICATIONS

STATEMENT OF GOVERNMENT INTEREST

N/A

BACKGROUND

Field of the Invention

Embodiments relate generally to optical components. More particularly, embodiments relate to anti-reflective coating (ARC) compositions within the context of optical components.

Description of the Related Art

ARC coating compositions when used within the context of optical components and optical apparatus generally provide enhanced optical properties to those optical components and optical apparatus by attenuating surface reflections within those optical components and optical apparatus. The attenuated surface reflections typically provide superior optical transmission properties and optical absorbance properties to those ARC coated optical components and optical apparatus.

Insofar as optical component and optical apparatus design considerations and performance considerations are likely to become increasingly more stringent, desirable are methods and materials that may assist in providing optical components and optical apparatus with enhanced optical performance properties.

SUMMARY

Embodiments provide an optical component, a method for fabricating the optical component and a method for operating a photovoltaic (PV) cell that may comprise the optical component. The optical component, the method for fabricating the optical component and the method for operating the PV cell that may comprise the optical component each use as a dual layer ARC (DLARC) located and formed over a substrate that comprises the optical component: (1) a first ARC layer located and formed over and closer to (and possibly upon) the substrate and comprising at least one dielectric material selected from the group consisting of silicon

containing dielectric materials and titanium containing dielectric materials; and (2) a second ARC layer located and formed over (and possibly upon) the first ARC layer (i.e., and further from the substrate) and comprising an aluminum containing dielectric material.

By using within the context of the embodiments the second ARC layer located and formed over (and possibly upon) the first ARC layer and comprising the aluminum containing dielectric material, the optical component in accordance with the embodiments is simultaneously provided with enhanced barrier properties with respect to chemical intrusion and moisture intrusion, and otherwise enhanced optical properties (i.e., such as but not limited to optical transmission and optical absorption) in comparison with a single layer ARC (SLARC) that comprises a single ARC material.

Within the context of the embodiments as disclosed and the invention as claimed, use of the terminology “over” with respect to a vertical overlay of a second layer or structure relative to a first layer or structure is intended that the second layer or structure is vertically aligned with respect to the first layer or structure, but not necessarily contacting.

Within the context of the embodiments as disclosed and the invention as claimed, use of the terminology “upon” with respect to a vertical overlay of a second layer or structure relative to a first layer or structure is intended that the second layer or structure is vertically aligned with respect to the first layer or structure, and necessarily contacting.

Within the context of the embodiments as disclosed and the invention as claimed, stoichiometric and non-stoichiometric compositions are intended for materials that are described in a general manner or general composition, such as but not limited to aluminum oxide dielectric materials, silicon oxide dielectric materials, silicon nitride dielectric materials, silicon oxynitride dielectric materials and titanium oxide dielectric materials, as well as doped (i.e., p doped, n doped and p and n doped) versions of the aluminum oxide dielectric materials, silicon oxide dielectric materials, silicon nitride dielectric materials, silicon oxynitride dielectric materials and titanium oxide dielectric materials.

A particular optical component in accordance with the embodiments includes an optically active substrate. The particular optical component also includes a dual layer anti-reflective coating located over the optically active substrate. Within this particular embodiment, the dual layer anti-reflective coating comprises: (1) a first anti-reflective coating layer located over, and closer to, the substrate; and (2) a second anti-reflective coating layer comprising an aluminum oxide dielectric material located over the first anti-reflective coating layer, and further from the substrate.

Another particular optical component in accordance with the embodiments includes an optically active substrate comprising a photovoltaic cell. This other particular embodiment also includes a dual layer anti-reflective coating located over the optically active substrate. The dual layer anti-reflective coating comprises: (1) a first anti-reflective coating layer located over and closer to the substrate and comprising at least one dielectric material selected from the group consisting of silicon containing dielectric materials and titanium containing dielectric materials; and (2) a second anti-reflective coating layer comprising an aluminum containing dielectric material located over the first anti-reflective coating layer, and further from the substrate.

A particular method for fabricating an optical component in accordance with the embodiments includes forming over a substrate a first anti-reflective coating layer comprising a dielectric material selected from the group consisting of silicon containing dielectric materials and titanium containing dielectric materials. This particular method also includes forming over the substrate and the first anti-reflective coating layer a second anti-reflective coating layer comprising an aluminum containing dielectric material.

A particular method for operating an optical component in accordance with the embodiments includes illuminating with a photon source an optically active semiconductor substrate having formed thereover a dual layer anti-reflective coating comprising: (1) a first anti-reflective coating layer formed closer to the optically active semiconductor substrate and comprising at least one dielectric material selected from the group consisting of silicon containing dielectric materials and titanium containing dielectric materials; and (2) a second anti-reflective coating layer located over the first anti-reflective coating and further from the optically active semiconductor

substrate, and comprising an aluminum containing dielectric material. The method also includes collecting an electrical output from the photovoltaic cell.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the embodiments are understood within the context of the Detailed Description of the non-Limiting Embodiments, as set forth below. The Detailed Description of the non-Limiting Embodiments is understood within the context of the accompanying drawings, that form a material part of this disclosure, wherein:

FIG. 1 shows a schematic cross-sectional diagram of an optical component in accordance with the embodiments.

FIG. 2 shows: (a) standard SiN_x emitter passivation and ARC structure used in most c-Si solar cells currently manufactured; and (b) a modeled reflectance of textured monocrystalline Si wafers with the industry standard SiN_x SLARC (75 nm with $n = 2.0$ at 600 nm) and with a $\text{SiN}_x/\text{AlO}_x$ DLARC in accordance with the embodiments.

FIG. 3 shows experimentally measured front surface reflectance of textured monocrystalline Si wafers with: (a) an industry standard SiN_x SLARC (≈ 78 nm); and (b) two passivation + DLARC structures featuring AlO_x and SiO_2 as the intermediate passivation films. The spike in the measured reflectance spectra occurring for $\lambda > 1 \mu\text{m}$ is due to light travelling through the wafer and being internally reflected back up at the c-Si/air interface at the rear. Thus, this particular feature of the drawing figures should be disregarded.

DETAILED DESCRIPTION OF THE NON-LIMITING EMBODIMENTS

Embodiments provide an optical component, a method for fabricating the optical component and a method for operating a PV cell that may comprise the optical component. The optical component, the method for fabricating the optical component and the method for operating the PV cell that may comprise the optical component each use as a DLARC: (1) a first ARC layer located over and closer to (and possibly upon) a substrate that comprises the optical component and comprising at least one dielectric material selected from the group consisting of silicon

containing dielectric materials and titanium containing dielectric materials; and (2) a second ARC layer located over (and possibly upon) the first ARC layer and further from the substrate that comprises the optical component, and comprising an aluminum oxide dielectric material.

By using within the context of the embodiments the second ARC layer located over (and possibly upon) the first ARC layer and comprising the aluminum oxide dielectric material, the optical component in accordance with the embodiments is simultaneously provided with enhanced barrier properties with respect to chemical intrusion and moisture intrusion, and otherwise enhanced optical properties (i.e., such as but not limited to optical transmission and optical absorption) in comparison with a SLARC that comprises a single ARC material.

1. General Considerations for Fabricating an Embodied ARC Coated Optical Component

FIG. 1 shows a schematic cross-sectional diagram illustrating an optical component in accordance with the embodiments. To that end, FIG. 1 shows a substrate 10. The substrate 10 may comprise any of several substrate materials, including but not limited to conductor substrate materials, semiconductor substrate materials and dielectric substrate materials. Typically the substrate 10 comprises a semiconductor substrate material or a dielectric substrate material, either having a thickness from about 1 to about 200 microns.

As is understood by a person skilled in the art, although the substrate 10 within the schematic cross-sectional diagram of FIG. 1 is illustrated as a flat substrate, the substrate 10 is not strictly limited to being a flat substrate. Rather, the substrate 10 may comprise any of several alternative surface topographic substrates. Under such circumstances when the substrate 10 comprises a topographic substrate, the embodiments intend that each of the first ARC layer 12 and the second ARC layer 14 comprises a conformal layer of a uniform thickness to provide the DLARC of the embodiments as a conformal DLARC of uniform thickness.

Also shown in FIG. 1 located and formed upon the substrate 10 is a first ARC layer 12. Within the embodiments, the first ARC layer 12 comprises a dielectric material selected from the group including but not limited to silicon containing dielectric materials (i.e., such as but not limited to silicon oxide dielectric materials, silicon nitride dielectric materials and silicon oxynitride

dielectric materials) and titanium containing dielectric materials (i.e. such as but not limited to titanium oxide dielectric materials). Within the context of the embodiments, the first ARC layer 12 typically comprises at least one of a silicon oxide dielectric material and a titanium oxide dielectric material located and formed upon the substrate 10 to a thickness from about 35 to about 80 nanometers. If the first ARC layer 12 provides adequate surface passivation by itself (e.g., silicon nitride), then no additional intermediate dielectric passivation layer is required. In this instance, a thickness from 50 to 80 nm is preferred for the first ARC layer 12, depending on the refractive index of the dielectric material from which is comprised the first ARC layer 12. However, if the first ARC layer 12 material does not provide adequate passivation (e.g., as-deposited titanium oxide), then an intermediate passivation material layer may be, and generally is, required, which can be a thin thermally grown silicon oxide material layer or an aluminum oxide material layer, for example, preferably less than about 20 nm thick. In this instance, a thinner first ARC layer 12 would be needed, (preferably from about 35 to about 55 nanometers, the particular thickness of the first ARC layer depending on the thickness and the refractive index of the dielectric material from which is comprised the intermediate passivation material layer. Additional details regarding methods for fabricating the foregoing dielectric materials, and dielectric material layers, are found below.

Finally also shown in FIG. 1 located and formed upon the first ARC layer 12 is a second ARC layer 14. Within the embodiments, the second ARC layer 14 comprises an aluminum containing dielectric material and more particularly an aluminum oxide dielectric material. Within the context of the embodiments, the second ARC layer 14 typically comprises an aluminum oxide dielectric material located and formed to a thickness from about 75 to about 100 nanometers over, and more particularly upon, the first ARC layer 12. As is further understood by a person skilled in the art, the first ARC layer 12 and the second ARC layer 14 comprise a DLARC in accordance with the embodiments.

While the embodiments in general do not discriminate with respect to a method for fabrication of the first ARC layer 12 and the second ARC layer 14, an atmospheric pressure chemical vapor deposition (APCVD) method is generally preferred. The APCVD method is generally preferred insofar as desirable performance of a DLARC may be realized in accordance with an APCVD

method. As well such an APCVD method does not in general require an expense of vacuum equipment as is required for alternative chemical vapor deposition methods, such as but not limited to low pressure chemical vapor deposition (LPCVD) methods and plasma enhanced chemical vapor deposition (PECVD) methods.

Generally, within the context of an APCVD method for forming a first ARC layer 12 and a second ARC layer 14 as is illustrated in FIG. 1, the APCVD method typically uses: (1) a reactor chamber pressure of approximately 760 torr; (2) a substrate 10 temperature from about 250 to about 500 degrees centigrade; (3) an aluminum, silicon or titanium containing dielectric material source material flow rate from about 10 to about 30 cubic centimeters per minute within an optional appropriate inert carrier gas flow, if present; and (4) an oxidant source material flow rate from about 0.5 to about 1.5 standard cubic centimeters per minute. Suitable aluminum, silicon or titanium containing dielectric material source materials generally include, but are not limited to alkoxides, halides and hydrides of aluminum, silicon and/or titanium.

Desirably within the context of the above deposition conditions there is formed in particular an aluminum oxide dielectric material that provides suitable moisture barrier properties to withstand over 1,000 hours of exposure to 85% relative humidity at 85 degrees centigrade without encapsulation of a solar cell, with minimal impact to the final construction of the solar cell. Additionally, also desirable is the ability of such solar cells to withstand potential induced degradation testing due to Na barrier properties of the aluminum oxide ARC material within the second ARC layer.

2. Specific Considerations for Exemplary Non-Limiting Embodiments

The embodiments in general attempt to combine technologies from two different industries, photovoltaics (PV) and optical displays. In the case of the PV industry, dual layer anti-reflection coatings (DLARC) are desirable. The advantage of a DLARC composition over a single layer anti-reflective coating (SLARC) composition is that for DLARC compositions reflectance minima at two wavelengths may be obtained, as opposed to only one wavelength. This provides a broadband reduction in front surface reflectance PV cells. In the display industry, aluminum oxide (and other oxide films) are desirable as a moisture barrier to prevent intrusion of water

vapor into a semiconductor device. Similarly, silicon oxide (SiO_x) passivated solar cells also face degradation due to moisture intrusion, thus requiring a moisture barrier. While this is typically accommodated using a SiN_x film as a SLARC, in the embodiments, an aluminum oxide (AlO_x) top layer can act as a moisture barrier eliminating the need to use SiN_x . There is also a potential for AlO_x to act as a Na diffusion barrier in solar cells, which is of particular importance for crystalline silicon (c-Si) solar cells. This has additional value due to a commonly known degradation and failure mode called potential induced degradation (PID).

In concert with the above, a goal of the embodiments is thus to provide a low cost, easily implementable way to improve the optical performance, reliability and durability of solar cells. By combining elements from different R&D sectors in an intended non-intuitive manner, the embodied multi-functional coating technology is intended to provide a useful and non-obvious approach.

3. Applications and Specific Experimental Results

One application of the DLARC technology in accordance with the embodiments as described above would be to simply deposit AlO_x on top of an existing SiN_x layer. This applies to the emitter passivation and ARC structure used for most c-Si cells manufactured today, as shown in **Error! Reference source not found..** For optimized optical performance (i.e. reduced reflectance), the existing SiN_x film should be slightly reduced in thickness (e.g. from ≈ 75 nm down to ≈ 55 -60 nm) and a higher refractive index (n) should be used (≈ 2.3 -2.4 at 600 nm). Care must be taken to prevent significant optical absorption in these high index SiN_x films. The key benefits of this implementation are the reduced front surface reflectance (R_{fe}) (**Error! Reference source not found.b**) in a relevant spectral range of from about 500 to about 700 nm, as well as a reduced susceptibility to PID for modules made from these cells when operating in the field.

Another important application of the particular technology in accordance with the embodiments is for SiO_2 passivated solar cells, which applies to both p - and n -type wafers and a wide variety of cell architectures (both standard and advanced, including cells with ion implanted emitters, back contact cells, bifacial n -type cells, etc. and cells featuring a wide variety of SiO_2 films, including thermal, chemical, CVD deposited or diffused doped SiO_2). As is understood by a

person skilled in the art, both the R_{fe} is reduced and the PID resiliency improved for SiO_2 passivated cells. Another key benefit of a PV cell in accordance with the embodiments is that it enables the use of a high index titanium oxide (TiO_2) intermediate ARC layer instead of SiN_x , which has significant cost reduction potential. TiO_2 cannot be currently used with SiO_2 passivation due to the permeability of both TiO_2 and SiO_2 . Utilizing the multi-functional AlO_x layer on the top alleviates this issue while also providing the improved optical performance, particular in the blue part of the spectrum ($\lambda > 500 \text{ nm}$). The TiO_2 - AlO_x DLARC structure can also be applied to AlO_x passivated solar cells, which is of particular interest in n -type wafers with p^+ emitters. Experimental reflectance measurements for SiO_2 and AlO_x passivated wafers with the TiO_2 - AlO_x DLARC are shown in **Error! Reference source not found.** in comparison to the standard SiN_x SLARC, where curves at the left hand side of FIG. 3 correspond with structures at the right hand side of FIG. 3.

All references, including publications, patent applications, and patents cited herein are hereby incorporated by reference in their entireties to the extent allowed, and as if each reference was individually and specifically indicated to be incorporated by reference and was set forth in its entirety herein.

The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) is to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. The term "connected" is to be construed as partly or wholly contained within, attached to, or joined together, even if there is something intervening.

The recitation of ranges of values herein is merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it was individually recited herein.

All methods described herein may be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate embodiments of the invention and does not impose a limitation on the scope of the invention unless otherwise claimed.

No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the invention. There is no intention to limit the invention to the specific form or forms disclosed, but on the contrary, the intention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention, as defined in the appended claims. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

CLAIMS

What is claimed is:

1. An optical component comprising:

an optically active substrate; and

a dual layer anti-reflective coating located over the optically active substrate, where the dual layer anti-reflective coating comprises:

a first anti-reflective coating layer located over, and closer to, the substrate; and

a second anti-reflective coating layer comprising an aluminum oxide dielectric material located over the first anti-reflective coating layer and further from the substrate.

2. The optical component of claim 1 wherein the optically active substrate is selected from the group consisting of optically active conductor substrates, optically active semiconductor substrates and optically active dielectric substrates.

3. The optical component of claim 1 wherein the first anti-reflective coating layer comprises a dielectric material selected from the group consisting of silicon containing dielectric materials and titanium containing dielectric materials.

4. The optical component of claim 3 wherein the silicon containing dielectric materials and titanium containing dielectric materials are selected from the group consisting of silicon oxide dielectric materials, silicon nitride dielectric materials, silicon oxynitride dielectric materials and titanium oxide dielectric materials.

5. The optical component of claim 1 wherein:

the first anti-reflective coating layer comprises a silicon oxide dielectric material having a thickness from about 35 to about 80 nanometers; and

the second anti-reflective coating layer comprises an aluminum oxide dielectric material having a thickness from about 75 to about 100 nanometers.

6. The optical component of claim 1 wherein the optical component comprises a photovoltaic cell.
7. The optical component of claim 1 wherein the optical component comprises a glass enclosed photovoltaic cell.
8. An optical component comprising:
 - an optically active substrate comprising a photovoltaic cell; and
 - a dual layer anti-reflective coating located over the optically active substrate, where the dual layer anti-reflective coating comprises:
 - a first anti-reflective coating layer located over and closer to the substrate and comprising at least one dielectric material selected from the group consisting of silicon containing dielectric materials and titanium containing dielectric materials; and
 - a second anti-reflective coating layer located over the first anti-reflective coating layer and further from the substrate.
9. The optical component of claim 8 wherein the first anti-reflective coating layer consists of a silicon oxide dielectric material.
10. The optical component of claim 8 wherein the first anti-reflective coating layer consists of a titanium oxide dielectric material.
11. The optical component of claim 8 wherein the first anti-reflective coating material consists of both silicon oxide dielectric material and a titanium oxide dielectric material.
12. The optical component of claim 8 wherein:
 - the dual layer anti-reflective coating consists of the first anti-reflective coating layer and the second anti-reflective coating layer;
 - the first anti-reflective coating layer consists of at least one of a silicon oxide dielectric material and a titanium oxide dielectric material; and

the second anti-reflective coating layer consists of the aluminum oxide dielectric material.

13. A method for fabricating an optical component comprising:

forming over a substrate a first anti-reflective coating layer comprising a dielectric material selected from the group consisting of silicon oxide dielectric materials and titanium oxide dielectric materials; and

forming over the substrate and the first anti-reflective coating layer a second anti-reflective coating layer comprising an aluminum oxide dielectric material.

14. The method of claim 13 wherein the first anti-reflective coating layer consists of a dielectric material selected from the group consisting of silicon oxide dielectric material and titanium oxide dielectric materials.

15. The method of claim 13 wherein the second anti-reflective coating layer consists of the aluminum oxide dielectric material.

16. The method of claim 13 wherein the material from which is formed each of the first anti-reflective coating layer and the second anti-reflective coating layer is formed using an atmospheric pressure chemical vapor deposition method.

17. The method of claim 16 wherein:

the first anti-reflective coating layer has a thickness from about 35 to about 80 nanometers; and

the second anti-reflective coating layer has a thickness from about 75 to about 100 nanometers.

18. A method for operating a photovoltaic cell comprising:

illuminating with a photon source an optically active semiconductor substrate having formed thereover a dual layer anti-reflective coating comprising:

a first anti-reflective coating layer formed over the optically active semiconductor substrate and comprising at least one dielectric material selected from the group consisting of silicon containing dielectric materials and titanium containing dielectric materials; and

a second anti-reflective coating layer formed over the first anti-reflective coating and comprising an aluminum containing dielectric material; and
collecting an electrical output from the photovoltaic cell.

19. The method of claim 18 wherein the photon source provides photons in a range from about 450 to about 650 nanometers,

20. The method of claim 18 wherein:

the first anti-reflective coating layer has a thickness from about 35 to about 50 nanometers; and

the second anti-reflective coating layer has a thickness from about 75 to about 100 nanometers.

<u>14</u>	– second ARC layer
<u>12</u>	– first ARC layer
<u>10</u>	– substrate

FIG. 1

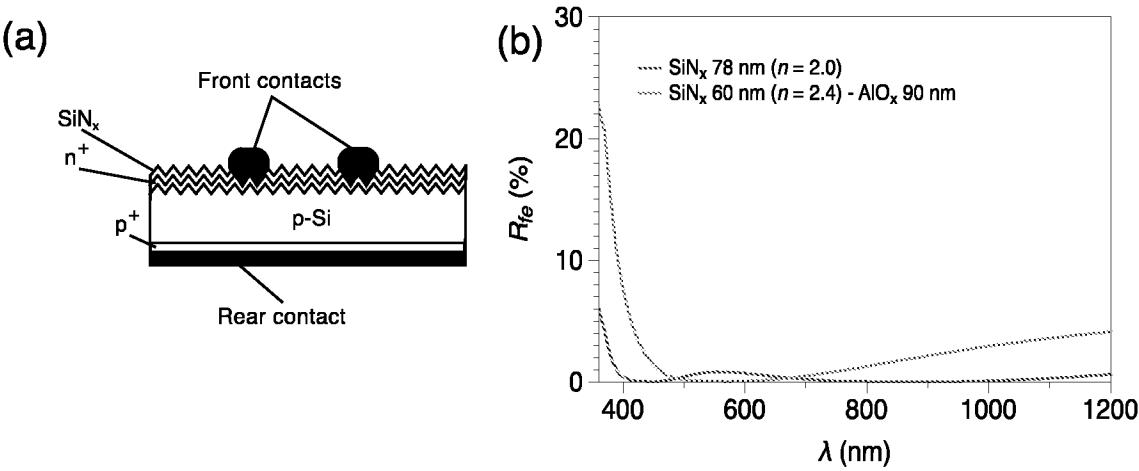


FIG. 2

2/2

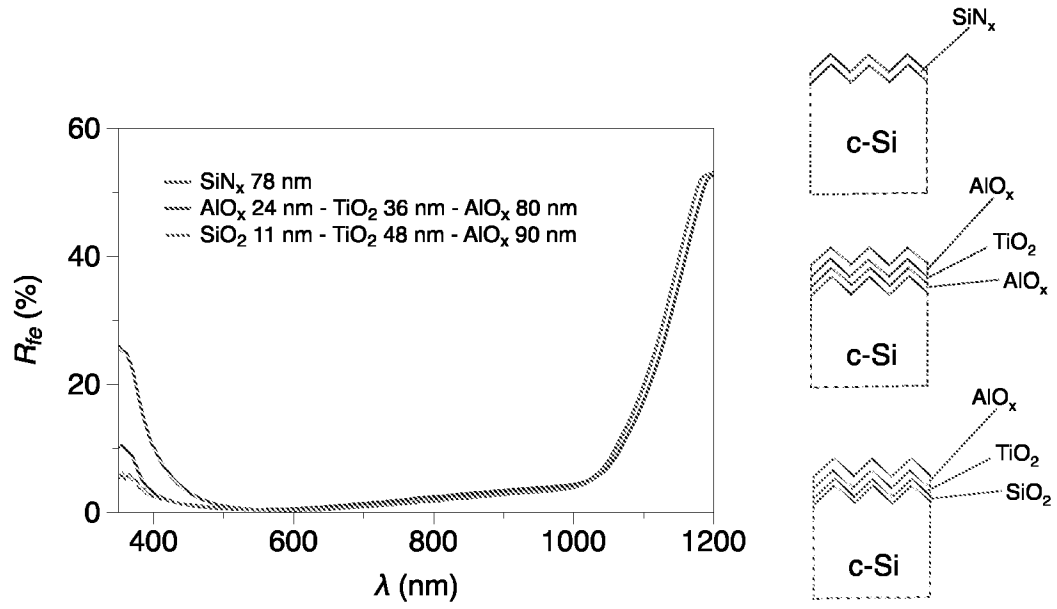


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/025373**A. CLASSIFICATION OF SUBJECT MATTER****G02B 1/11(2006.01)i, H02S 40/20(2014.01)i**

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)

G02B 1/11; H01L 31/0216; G02B 1/10; H01L 31/18; B32B 17/06; H02S 40/20

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: photovoltaic cell, dual layer, anti reflective, silicon and aluminum oxide

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1526171 A (OPTICAL COATING LABORATORY INC.) 27 September 1978 See column 2, lines 75-96, column 3, lines 5-32 and figure 1.	1-20
A	US 2007-0116966 A1 (MELLOTT, NATHAN P. et al.) 24 May 2007 See paragraphs [0015]-[0029] and figures 1-2.	1-20
A	US 2002-0051294 A1 (KATAYAMA, YOSHIHITO et al.) 02 May 2002 See paragraphs [0072]-[0107] and figures 1-5.	1-20
A	US 2013-0247972 A1 (MUNGEKAR, HEMANT P. et al.) 26 September 2013 See paragraphs [0007]-[0023] and figure 1.	1-20
A	US 2013-0167921 A1 (RATTUNDE, OLIVER) 04 July 2013 See claims 1-6 and figure 5.	1-20



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

"E" earlier application or patent but published on or after the international filing date

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"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

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

12 December 2014 (12.12.2014)

Date of mailing of the international search report

15 December 2014 (15.12.2014)

Name and mailing address of the ISA/KR

International Application Division
Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

KIM, Jin Ho

Telephone No. +82-42-481-8699



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/025373

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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