



(12) 发明专利申请

(10) 申请公布号 CN 113193074 A

(43) 申请公布日 2021.07.30

(21) 申请号 202110322400.4

(22) 申请日 2021.03.25

(71) 申请人 泰州中来光电科技有限公司

地址 225500 江苏省泰州市姜堰经济开发区开阳路

(72) 发明人 杜哲仁 崔义乾 黄健 乔振聪
陈嘉 刘荣林

(74) 专利代理机构 北京金之桥知识产权代理有限公司 11137

代理人 徐李娜 邓俊勇

(51) Int. Cl.

H01L 31/18 (2006.01)

H01L 31/0216 (2014.01)

H01L 31/068 (2012.01)

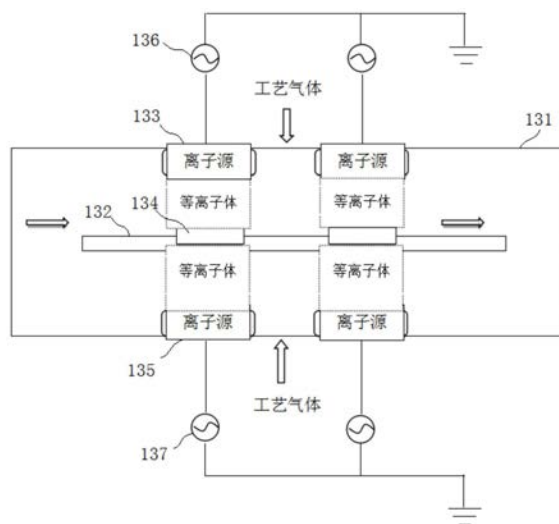
权利要求书1页 说明书6页 附图5页

(54) 发明名称

N-TOPCon太阳能电池、组件、系统及电池中制备双面氧化硅的方法、设备

(57) 摘要

本发明涉及一种N-TOPCon太阳能电池、组件、系统及电池中制备双面氧化硅的方法、设备，其中方法包括：步骤S1.以N型硅作为衬底，在N型硅的正面制备p+掺杂区域；步骤S2.在N型硅的正面制备氧化硅薄膜，同时在N型硅的背面制备隧穿氧化层；步骤S3.在N型硅的背面制备掺磷多晶硅；步骤S4.在N型硅的正面和背面制备钝化膜后印刷金属电极。本发明在保证洁净度的同时，减少工序，解决N-TOPCon工序多的问题，增强N-TOPCon的核心竞争力。



1. N-TOPCon太阳能电池中制备双面氧化硅的方法,其特征在于,包括依序执行的以下步骤:

步骤S1. 以N型硅作为衬底,在N型硅的正面制备p+掺杂区域;

步骤S2. 在N型硅的正面制备氧化硅薄膜,同时在N型硅的背面制备隧穿氧化层;

步骤S3. 在N型硅的背面制备掺磷多晶硅;

步骤S4. 在N型硅的正面和背面制备钝化膜后印刷金属电极。

2. 根据权利要求1所述的方法,其特征在于,步骤S1在N型硅的正面制备完成p+掺杂区域之后直接执行所述步骤S2。

3. 根据权利要求1所述的方法,其特征在于,步骤S2进一步包括:采用PECVD的方法在N型硅背面和正面分别制备隧穿氧化层和氧化硅薄膜。

4. 根据权利要求3所述的方法,其特征在于,步骤S2进一步包括:在氧化硅工艺腔上下分别安装离子源来实现隧穿氧化层和氧化硅薄膜的同时制备。

5. 根据权利要求4所述的方法,其特征在于,在纯氧或者硅烷/氧气混合气体、压强为0.01-50Pa、沉积温度为200-500℃条件下,通过分别控制上下离子源功率来分别控制隧穿氧化层以及氧化硅薄膜的厚度。

6. 根据权利要求1所述的方法,其特征在于,步骤S4进一步包括:在N型硅正面沉积钝化膜后在该钝化膜沉积钝化减反射膜。

7. N-TOPCon太阳能电池,其特征在于,该电池乃是由权利要求1-6任一项所述的方法所制造出的电池。

8. N-TOPCon太阳能电池组件,包括由上至下依次设置的前层材料、封装材料、N-TOPCon太阳能电池、封装材料、背层材料,其特征在于:所述N-TOPCon太阳能电池是权利要求7所述的N-TOPCon太阳能电池。

9. N-TOPCon太阳能电池系统,包括至少一个串联的N-TOPCon太阳能电池组件,其特征在于:所述N-TOPCon太阳能电池组件是权利要求8所述的N-TOPCon太阳能电池组件。

10. N-TOPCon太阳能电池中制备双面氧化硅的设备,包括填充有工艺气体的氧化硅工艺腔,该氧化硅工艺腔中的载板的上方安装有第一离子源,所述第一离子源用于在载板上的N型硅的正面产生氧离子,其特征在于,氧化硅工艺腔中的载板的下方安装有第二离子源,所述第二离子源用于在第一离子源工作时同步在N型硅的背面产生氧离子。

11. 根据权利要求10所述的设备,其特征在于,还包括用于驱动第一离子源工作的第一高频射频电源,以及用于驱动第二离子源工作的第二高频射频电源。

12. 根据权利要求10所述的设备,其特征在于,还包括气体输入口,所述工艺气体经气体输入口输入至氧化硅工艺腔内,其中气体输入口具有至少两个,分别位于腔体的顶部和底部。

13. 根据权利要求10所述的设备,其特征在于,还包括装载腔、加热腔、隔离腔、非晶硅制备腔、冷却腔、卸载腔,装载腔、加热腔、氧化硅工艺腔、隔离腔、非晶硅制备腔、冷却腔、卸载腔依序接通。

N-TOPCon太阳能电池、组件、系统及电池中制备双面氧化硅的方法、设备

技术领域

[0001] 本发明涉及太阳能电池技术领域,具体涉及一种N-TOPCon太阳能电池、组件、系统及电池制备双面氧化硅的方法、设备。

背景技术

[0002] 隧穿氧化层钝化接触(TOPCon)太阳电池是近几年发展迅速的一种N型太阳电池。该电池特点是采用高质量的超薄氧化硅加掺杂多晶硅层实现电池全背面高效钝化和载流子选择性收集,可以大幅度提高开路电压,提升转换效率,其中超薄氧化硅是很关键的一层薄膜,提供载流子选择性。另一方面,在电池正面氧化铝之前制备一层氧化硅既可以对P+面进行化学钝化,又可以增多氧化铝中的负电荷量,增强场钝化,总体增强正面的钝化效果,提升开路电压。此外,氧化硅还可以起到降低硅表面污染的作用,也就是说,无论是N-TOPCon电池的正面还是背面,都需要氧化硅的存在。

[0003] 目前沉积氧化硅的方法有热氧化法与硝酸氧化,热氧化法具有工艺时间长、能耗大,成本高等缺点,硝酸氧化会造成含N物排放,不利于环保。此外,通常情况下如专利文献CN201911262690.7所示,N-TOPCon电池的正面和背面的氧化硅是分别制备的,在刻蚀之后进行背面隧穿氧化硅和多晶硅层掺杂,考虑到正面的污染问题,要加一步清洗工艺再进行正面氧化硅的制备,工序较多。另有学者采用热氧化的方式同时在两面沉积氧化硅,但是这样的制备方法无法对两面的厚度分别进行调整,缩小了工艺调试窗口。

发明内容

[0004] 本发明要保证洁净度的同时,减少工序,解决N-TOPCon工序多的问题,增强N-TOPCon 的核心竞争力。

[0005] 本发明通过以下技术方案实现:

[0006] 提供一种N-TOPCon太阳能电池中制备双面氧化硅的方法,包括依序执行的以下步骤:

[0007] 步骤S1.以N型硅作为衬底,在N型硅的正面制备p+掺杂区域;

[0008] 步骤S2.在N型硅的正面制备氧化硅薄膜,同时在N型硅的背面制备隧穿氧化层;

[0009] 步骤S3.在N型硅的背面制备掺磷多晶硅;

[0010] 步骤S4.在N型硅的正面和背面制备钝化膜后印刷金属电极。

[0011] 其中,步骤S1进一步包括:N型硅正面的p+掺杂区域是通过在N型硅的正面进行硼扩散后,用湿法刻蚀方式去除N型硅背面的硼绕扩而制得,在湿法刻蚀之后立即执行所述步骤 S2。

[0012] 其中,硼扩散后进行湿法刻蚀的方式进一步包括:对N型硅进行双面制绒后采用三溴化硼作为硼源在N型硅的正面进行硼扩散,对经过硼扩散的N型硅,取其背面放入HF、HN03、H2S04混合溶液中进行刻蚀处理以去除背面硼绕扩并获得平缓的金字塔表面。

[0013] 其中,步骤S2进一步包括:采用PECVD的方法在N型硅背面和正面分别制备隧穿氧化层和氧化硅薄膜,且在氧化硅工艺腔上下分别安装离子源来实现隧穿氧化层和氧化硅薄膜的同时制备,具体地,在纯氧或者硅烷/氧气混合气体、压强为0.01-50Pa、沉积温度为200-500℃条件下,通过分别控制上下离子源功率来分别控制隧穿氧化层以及氧化硅薄膜的厚度。

[0014] 其中,步骤S4进一步包括:在N型硅正面沉积钝化膜后在该钝化膜沉积钝化减反射膜。

[0015] 还提供一种N-TOPCon太阳能电池,该电池乃是由上述的方法所制造出的电池。

[0016] 还提供一种N-TOPCon太阳能电池组件,包括由上至下依次设置的前层材料、封装材料、N-TOPCon太阳能电池、封装材料、背层材料,所述N-TOPCon太阳能电池是上述的N-TOPCon 太阳能电池。

[0017] 还提供一种N-TOPCon太阳能电池系统,包括至少一个串联的N-TOPCon太阳能电池组件,所述N-TOPCon太阳能电池组件是上述的N-TOPCon太阳能电池组件。

[0018] 还提供一种N-TOPCon太阳能电池中制备双面氧化硅的设备,包括填充有工艺气体的氧化硅工艺腔,该氧化硅工艺腔中的载板的上方安装有第一离子源,所述第一离子源用于在载板上的N型硅的正面产生氧离子,产生的氧离子和硅片正表面进行反应形成氧化硅;氧化硅工艺腔中的下方安装有第二离子源,所述第二离子源用于在第一离子源工作时同步在N型硅的背面产生氧离子。

[0019] 其中,载板用于放置N型硅的位置镂空处理以使N型硅得以两面同时镀膜。

[0020] 其中,所述第一离子源朝下对准N型硅的正面以在该正面上制备氧化硅薄膜,所述第二离子源朝上对准N型硅的背面以在该正面上制备隧穿氧化层。当然,也可以使N型硅正背面相反放置,从而使第一离子源朝下制备隧穿氧化层,第二离子源朝上氧化硅薄膜。

[0021] 其中,所述第一离子源的功率控制在使氧化硅薄膜的厚度为0.3-3nm,和/或所述第二离子源的功率控制在使隧穿氧化层的厚度为0.5-2nm。

[0022] 其中,所述N型硅的厚度为150-170μm,电阻率为0.3-2Ω·cm。

[0023] 其中,还包括用于驱动第一离子源工作的第一高频射频电源,以及用于驱动第二离子源工作的第二高频射频电源。

[0024] 其中,还包括气体输入口,所述工艺气体经气体输入口输入至氧化硅工艺腔内,进一步地,气体输入口具有至少两个,分别位于腔体的顶部和底部。

[0025] 其中,还包括装载腔、加热腔、隔离腔、非晶硅制备腔、冷却腔、卸载腔,装载腔、加热腔、氧化硅工艺腔、隔离腔、非晶硅制备腔、冷却腔、卸载腔依序接通。

[0026] 本发明的技术优点包括:(1)能耗低,污染小,大幅度降低工艺成本;(2)在p+掺杂区域制备之后立即进行双面氧化硅的制备,氧化硅对硅片表面起到保护作用,可以降低工艺污染;(3)同时进行双面氧化层的制备,可以减少工序,降低设备和人工成本;(4)均匀性良好,保证硅片整体的钝化效果;(5)可以分别控制双面氧化硅的厚度,保证了的工艺调试窗口;(6)实现该工艺技术,在设备上升级改造比较简单,容易实现。

[0027] 所述说明仅是本发明技术方案的概述,为了能够更清楚了解本发明的技术手段,而可依照说明书的内容予以实施,并且为了让本发明的所述和其它目的、特征和优点能够更明显易懂,以下特举本发明的具体实施方式。

附图说明

[0028] 通过阅读下文优选实施方式的详细描述,各种其他的优点和益处对于本领域普通技术人员将变得清楚明了。附图仅用于示出优选实施方式的目的,而并不认为是对本发明的限制。而且在整个附图中,用相同的参考符号表示相同的构件。

[0029] 图1为本发明实施例所述方法中步骤(1)制绒后的电池结构截面示意图。

[0030] 图2为本发明实施例所述方法中步骤(2)双面硼扩后的电池结构截面示意图。

[0031] 图3为本发明实施例所述方法中步骤(3)背面刻蚀、正面HF清洗后的电池结构截面示意图。

[0032] 图4为本发明实施例所述方法中步骤(4)沉积双面氧化硅后的电池结构截面示意图。

[0033] 图5为本发明实施例所述方法中步骤(5)沉积非晶硅的电池结构截面示意图。

[0034] 图6为本发明实施例所述方法中步骤(6)退火后形成多晶硅薄膜的电池结构截面示意图。

[0035] 图7为本发明实施例所述方法中步骤(7)正面Al₂O₃后的电池结构示意图。

[0036] 图8为本发明实施例所述方法中步骤(8)正面SiN_x钝化减反射膜后的电池结构示意图。

[0037] 图9为本发明实施例所述方法中步骤(9)背面SiN_x钝化膜后的电池结构示意图。

[0038] 图10为本发明实施例所述方法中步骤(10)金属化后的电池结构示意图。

[0039] 图11为本发明制备双面氧化硅的整体设备示意图。

[0040] 图12为传统的单面氧化硅制备工艺腔的示意图。

[0041] 图13为本发明的双面氧化硅制备工艺腔示意图。

具体实施方式

[0042] 下面将参照附图更详细地描述本公开的示例性实施例。虽然附图中显示了本公开的示例性实施例,然而应当理解,可以以各种形式实现本公开而不应被这里阐述的实施例所限制。相反,提供这些实施例是为了能够更透彻地理解本公开,并且能够将本公开的范围完整的传达给本领域的技术人员。

[0043] 本发明的一种N-TOPCon太阳能电池中制备双面氧化硅的方法,包括依序执行的以下步骤:

[0044] 步骤S1.以N型硅作为衬底,在N型硅的正面制备p+掺杂区域;

[0045] 步骤S2.在N型硅的正面制备氧化硅薄膜,同时在N型硅的背面制备隧穿氧化层;

[0046] 步骤S3.在N型硅的背面制备掺磷多晶硅;

[0047] 步骤S4.在N型硅的正面和背面制备钝化膜后印刷金属电极。

[0048] 本发明通过在制备p+掺杂区域后同时进行双面氧化硅的沉积,工艺时间短,能耗低,且可以减少N排放,具有良好的均匀性。此外,这样制备出来的电池,无需在制备多晶硅层后再增加清洗工序,因为氧化层会对正面起到很好的保护作用、减少污染。

[0049] 在一个实施例中,步骤S1进一步包括N型硅正面的p+掺杂区域是通过在N型硅的正面进行硼扩散后,用湿法刻蚀方式去除N型硅背面的硼扩而制得,在湿法刻蚀之后立即执行所述步骤S2。由于在湿法刻蚀后立即进行双面氧化硅的制备,氧化硅对硅片表面起到保

护作用,可以降低工艺污染。

[0050] 优选地,硼扩散后进行湿法刻蚀的方式进一步包括:对N型硅进行双面制绒后采用三氯化硼作为硼源在N型硅的正面进行硼扩散,对经过硼扩散的N型硅,取其背面放入HF、HNO₃、H₂SO₄混合溶液中进行刻蚀处理以去除背面硼绕扩并获得平缓的金字塔表面。

[0051] 在一个实施例中,步骤S2进一步包括:采用PECVD的方法在N型硅背面和正面分别制备隧穿氧化层和氧化硅薄膜。

[0052] 进一步地,为简化制备流程,进行双面氧化硅沉积的方法为:在氧化硅工艺腔上下分别安装离子源来实现隧穿氧化层和氧化硅薄膜的同时制备,具体地,在纯氧或者硅烷/氧气混合气体、压强为0.01-50Pa、沉积温度为200-500℃条件下,通过分别控制上下离子源功率来分别控制隧穿氧化层以及氧化硅薄膜的厚度,如此可以对两面氧化硅的厚度进行分别控制,不会影响工艺调试窗口。

[0053] 在一个实施例中,步骤S4进一步包括:在N型硅正面沉积钝化膜后在该钝化膜沉积钝化减反射膜。

[0054] 本发明还提供一种N-TOPCon太阳能电池,该电池乃是由上述的方法所制造出的电池。

[0055] 本发明还提供一种N-TOPCon太阳能电池组件,包括由上至下连接的前层材料、封装材料、N-TOPCon太阳能电池、封装材料、背层材料,N-TOPCon太阳能电池是上述的N-TOPCon 太阳能电池。本实施例的N-TOPCon太阳能电池组件的结构及工作原理使用本领域公知的技术,且本发明提供的组件的改进仅涉及上述的N-TOPCon太阳能电池,不对其他部分进行改动。故本说明书仅对N-TOPCon太阳能电池及其制备方法进行详述,对N-TOPCon太阳能电池组件的其他部件及工作原理这里不再赘述。本领域技术人员在本说明书描述的内容基础上,即可实现本发明的N-TOPCon太阳能电池组件。

[0056] 本发明还提供一种N-TOPCon太阳能电池系统,包括一个或多个串联的N-TOPCon 太阳能电池组件,N-TOPCon太阳能电池组件是上述的一种N-TOPCon太阳能电池组件。本实施例的N-TOPCon太阳能电池系统的结构及工作原理使用本领域公知的技术,且本发明提供的N-TOPCon太阳能电池系统的改进仅涉及上述的N-TOPCon太阳能电池,不对其他部分进行改动。故本说明书仅对N-TOPCon太阳能电池及其制备方法进行详述,对N-TOPCon太阳能电池系统的其他部件及工作原理这里不再赘述。本领域技术人员在本说明书描述的内容基础上,即可实现本发明的N-TOPCon太阳能电池系统。

[0057] 图12为传统的单面氧化硅制备工艺腔的示意图,其只能在硅片上表面镀膜,只能沉积一层氧化层。为制备双面氧化硅,本发明还对传统的单面氧化硅制备工艺腔进行升级改造,进而提供一种N-TOPCon太阳能电池中制备双面氧化硅的设备,如图11、图13所示,包括填充有工艺气体的氧化硅工艺腔131,该氧化硅工艺腔131中的载板132的上方安装有第一离子源133,第一离子源133用于在载板132上的N型硅134的正面产生氧离子,载板132下方安装有第二离子源135,第二离子源135用于在第一离子源133工作时同步在载板132上的N型硅134的背面产生氧离子。

[0058] 本发明的制备双面氧化硅的设备,改造方法较简单、容易实现,只需要在制备氧化硅工艺腔的腔体两面均安装离子源并保证腔体内气体均匀即可。

[0059] 在一个实施例中,载板132用于放置N型硅134的位置除有支架遮挡外,全部作镂空

处理以使N型硅得以两面同时镀膜。

[0060] 在一个实施例中,第一离子源133朝下对准N型硅134的正面,以在该正面上制备氧化硅薄膜,第二离子源135朝上对准N型硅的背面,以在该正面上制备隧穿氧化层,其中,第一离子源132的功率控制在使氧化硅薄膜的厚度为0.3-3nm,第二离子源135的功率控制在使隧穿氧化层的厚度为0.5-2nm,N型硅134的厚度为150-170 μm ,电阻率为0.3-2 $\Omega \cdot \text{cm}$ 。当然,也可以使N型硅正背面相反放置,从而使第一离子源133朝下制备隧穿氧化层,第二离子源135朝上氧化硅薄膜。

[0061] 进一步地,设备还包括用于驱动第一离子源133工作的第一高频射频电源136,以及用于驱动第二离子源135工作的第二高频射频电源137,通过设置两个电源分别驱动两个离子源,来实现两个离子源功率的分别控制,从而分别对上下氧化硅膜层的厚度进行调整。

[0062] 在一个实施例中,还包括气体输入口,所述工艺气体经气体输入口输入至氧化硅工艺腔内,实际中,可通过外部设备控制对腔内输入工艺气体。

[0063] 进一步地,气体输入口具有两个或多个,各气体输入口均匀分布于腔体的顶部和底部,以使得整个腔室气体均匀。

[0064] 见图11,在一个实施例中,通过将装载腔、加热腔、氧化硅工艺腔、隔离腔、非晶硅制备腔、冷却腔、卸载腔依序接通,使双面氧化硅制备设备结合链式多晶硅制备设备成为二合一设备,进一步扩大设备优势。

[0065] 下面将以具体的实施例对发明的制备方法进行详细地说明。

[0066] 实施例1

[0067] 本实施例的一种N型钝化接触结构太阳能电池,如图10所示,从上往下包括正面p+金属电极10、正面SiNx钝化减反射膜8、正面Al₂O₃钝化膜7、正面氧化硅薄膜3、p+掺杂区域2、n型硅基体1、隧穿氧化层2、背面n+掺杂区域6、背面SiNx钝化膜9、背面n+金属电极11。

[0068] 本实施例的一种N型钝化接触结构太阳能电池的制备方法,包括以下步骤:

[0069] (1)、选择厚度150-170 μm ,电阻率0.3-2 $\Omega \cdot \text{cm}$,尺寸156.75mm $\times$ 156.75mm的N型硅1作为衬底进行双面制绒处理,完成本步骤之后的电池结构如图1所示。

[0070] (2)、在经过制绒处理后的N型硅表面采用三溴化硼在N型硅的正面进行硼扩散,扩散温度850-1000 $^{\circ}\text{C}$,时间50-80min,方阻80-100 Ω/sqr ,完成本步骤之后的电池结构如图2所示。

[0071] (3)、将经过硼扩散的N型硅,取其背面放入HF与HNO₃、以及H₂SO₄混合溶液中进行刻蚀处理,以去除背面p+掺杂区域2,得到刻蚀后平缓的金字塔表面,其中, HF:HNO₃:H₂SO₄:H₂O=1:4:0.6:3, HF质量分数20%,完成本步骤之后的电池结构如图3所示。

[0072] (4)、采用PECVD的方法在经过步骤(3)刻蚀后的N型硅背面和正面分别制备一层超薄隧穿氧化层3和正面氧化硅薄膜4。该设备示意图如图11所示。具体地,在氧化硅工艺腔上下分别安装离子源。工艺时整个腔体气体相同,温度相同,可以通过分别控制上下离子源功率来分别控制氧化硅厚度。在纯氧或者硅烷/氧气混合气体、压强为0.01-50Pa,沉积温度为200-500 $^{\circ}\text{C}$ 条件下,离子源功率为在5-500W范围内可调,反应时间3-200s,得到隧穿氧化层3厚度为0.5-2nm和正面氧化硅薄膜4厚度为0.3-3nm,完成本步骤之后的电池结构如图4所示。

[0073] (5)、采用PVD法制备掺磷非晶硅膜5。将经过步骤(4)处理后的N型硅进入到PVD工

艺腔进行掺磷非晶硅层制备时,所述靶材为旋转式纯硅柱靶材或掺磷硅靶材,使用氩气和磷烷在磁场中经过等离子激发产生氩离子并溅射硅靶材,从而制作掺磷非晶硅薄膜;具体地,功率为1000-30000W,压强为0.1-50Pa,温度为100-700℃,反应时间3-400s。完成本步骤之后的电池结构如图5所示。

[0074] 需要说明的是,还可以采用板式PECVD法制备掺磷非晶硅层。具体地,功率为50-40000W,压强为0.1-200Pa,温度为100-600℃,反应时间为3-400s。

[0075] (6)、将经过步骤(5)的N型硅片进行快速退火处理,掺磷非晶硅5将转化为掺磷多晶硅6。首先将退火炉抽真空至 10^{-4} pa以下,然后充氮气作为保护气。退火过程中退火炉的真空度500-950mbar,退火时间20-60min,退火温度800-900℃。完成本步骤之后的电池结构如图6所示。

[0076] (7)、对退火后的N型硅进行表面钝化处理,在正面氧化硅膜上沉积一层 Al_2O_3 钝化膜 7。

[0077] (8)、在经过步骤(7)的N型硅片, Al_2O_3 钝化膜7上面沉积一层SiNx钝化减反射膜8。

[0078] (9)、在经过步骤(8)的N型硅片,在N型硅背面的n+掺杂区域采用SiNx钝化膜9 的钝化结构。

[0079] (10)、在经过步骤(9)的N型硅片,N型硅正面的p+掺杂区域2采用银铝浆印刷正面p+金属电极10,并高温烧结,N型硅背面的n+掺杂区域6采用银浆印刷背面n+金属电极11,并高温烧结。

[0080] 最后应当说明的是,以上实施例仅用以说明本发明的技术方案,而非对本发明保护范围的限制,尽管参照较佳实施例对本发明作了详细地说明,本领域的普通技术人员应当理解,可以对本发明的技术方案进行修改或者等同替换,而不脱离本发明技术方案的实质和范围。

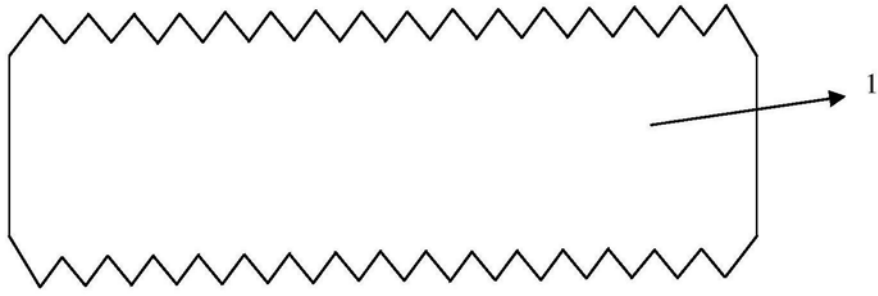


图1

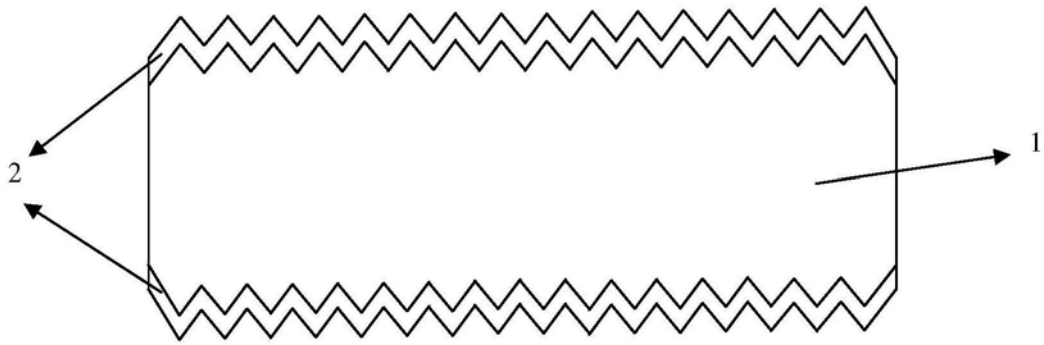


图2

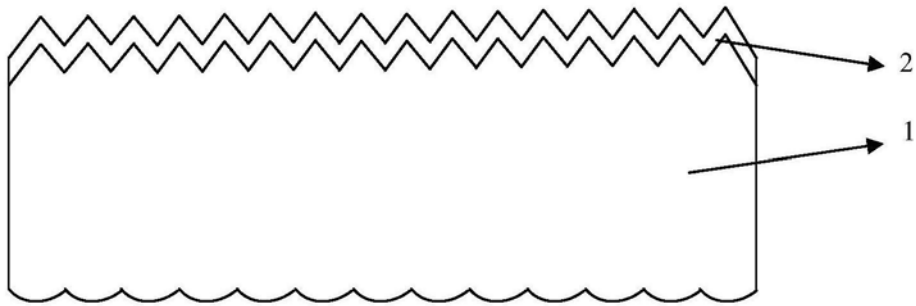


图3

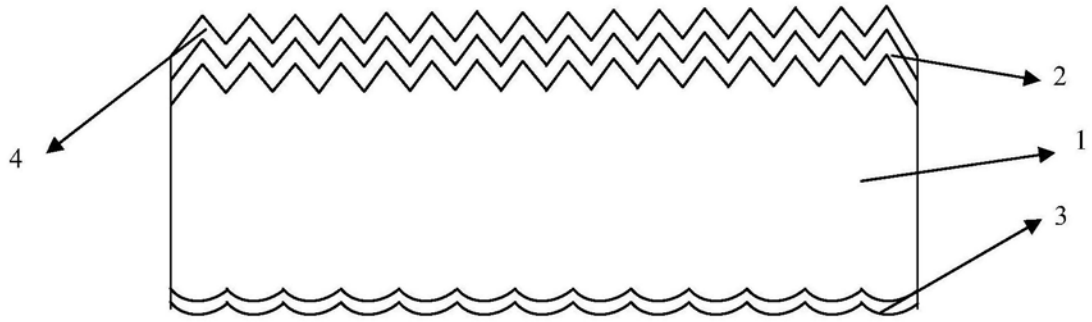


图4

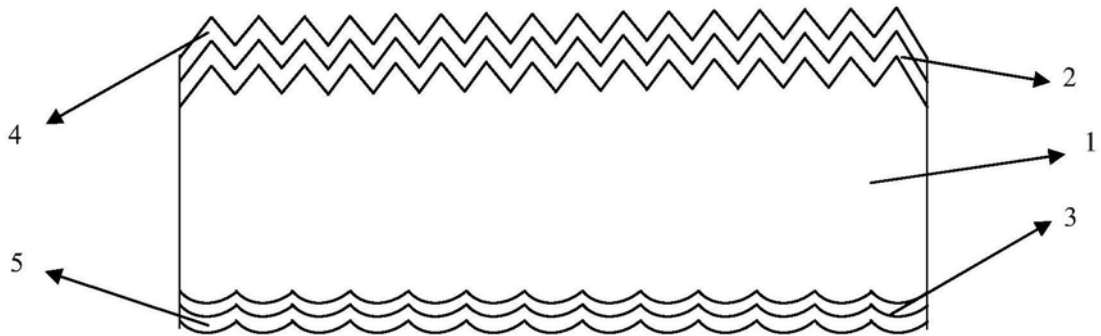


图5

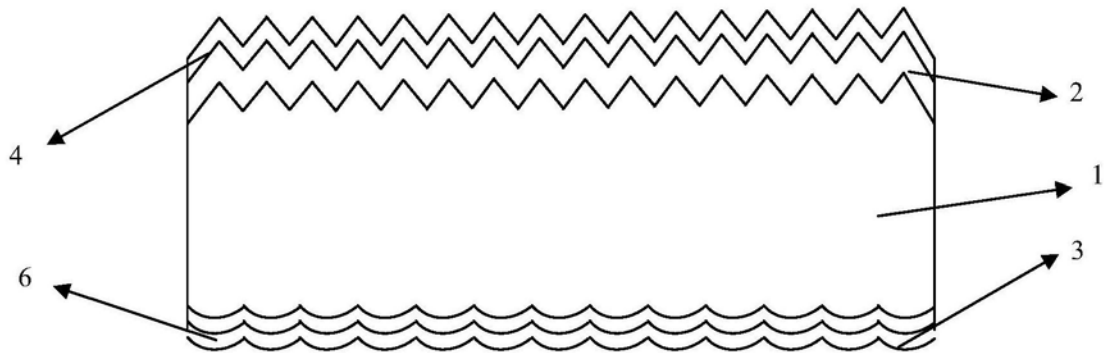


图6

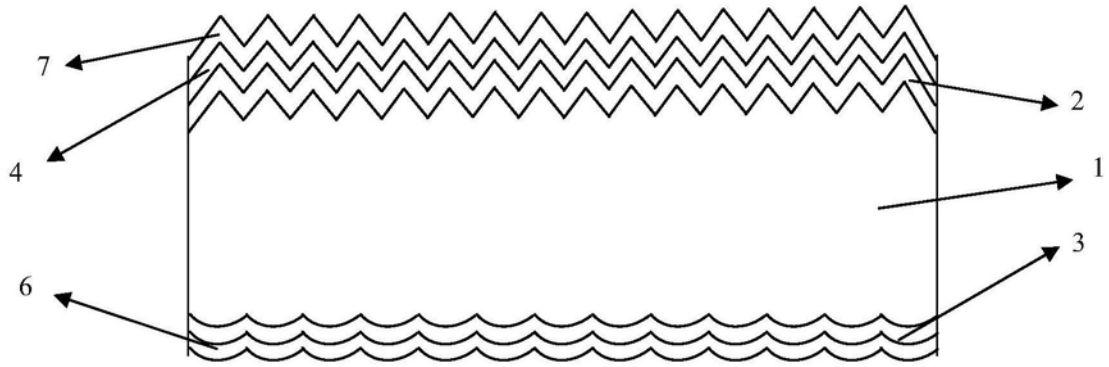


图7

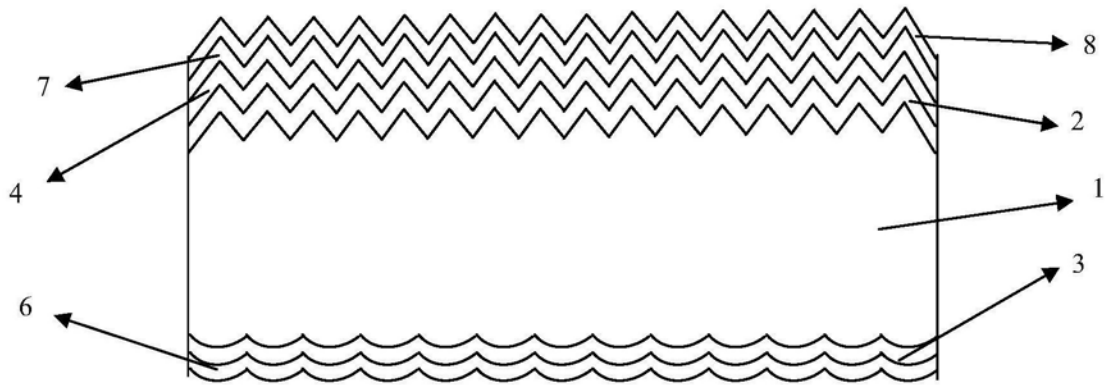


图8

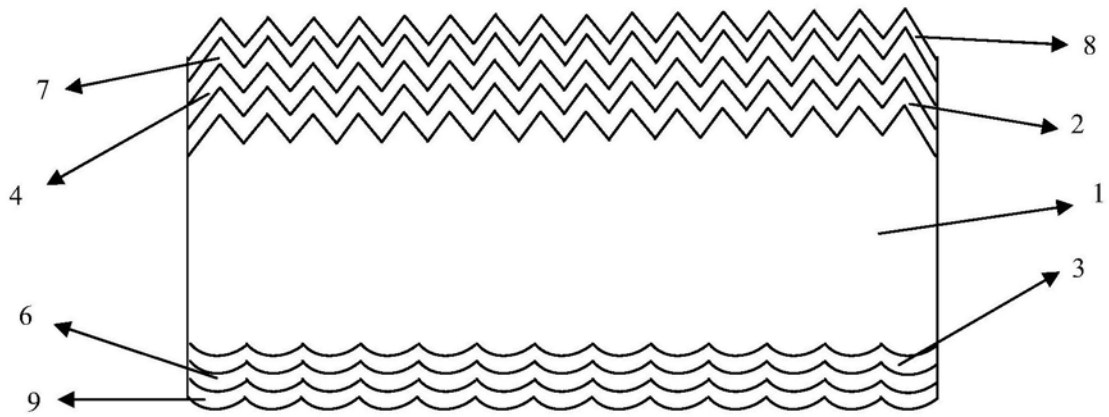


图9

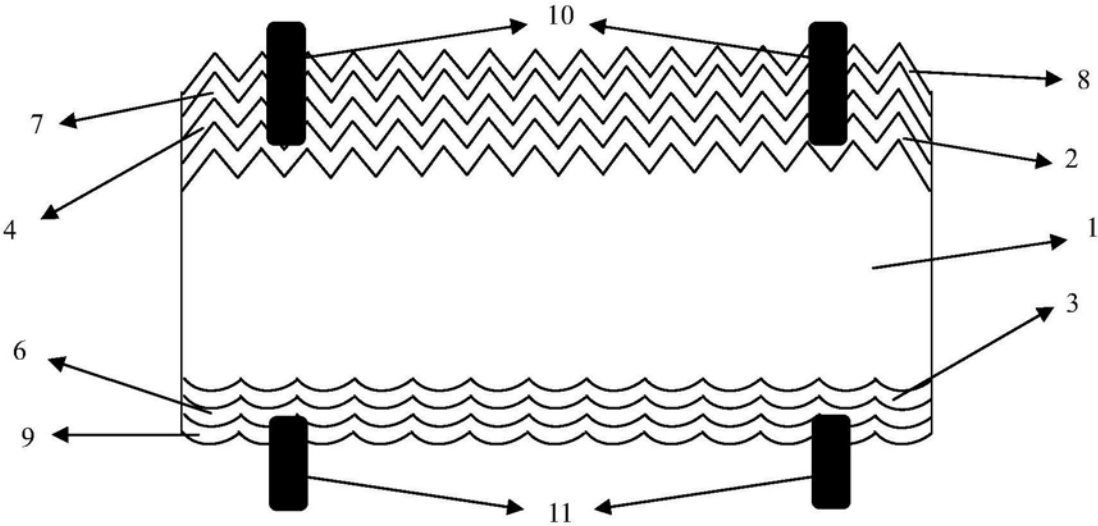


图10

装载腔	加热腔	离子源 氧化硅工艺腔	隔离腔	非晶硅制备腔	冷却腔	卸载腔
载板运行位置						
		离子源				

图11

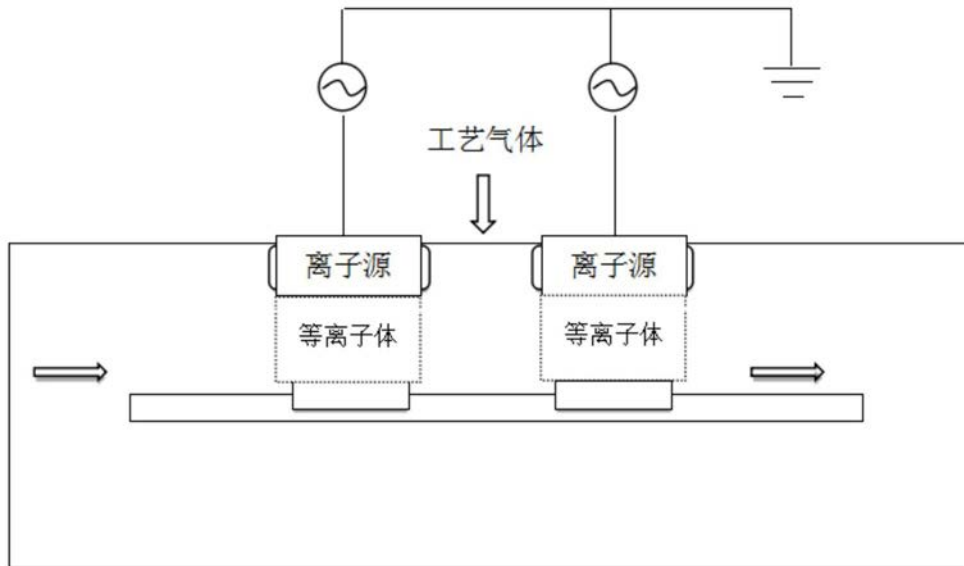


图12

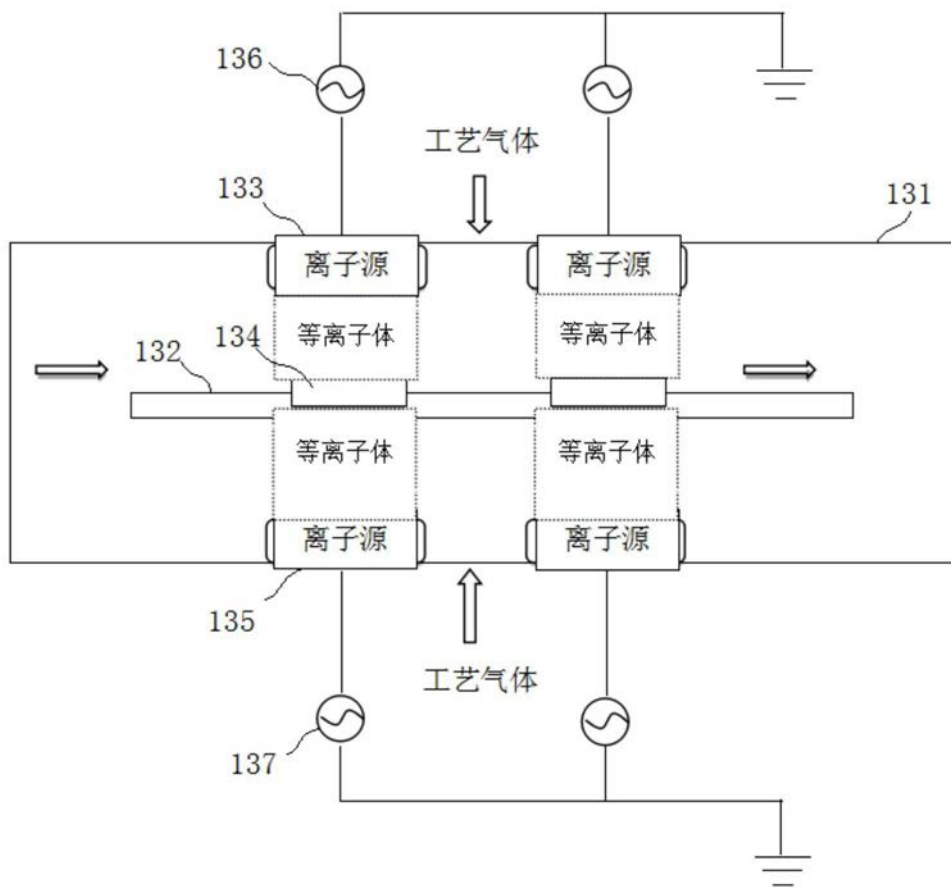


图13

(19) China National Intellectual Property Administration



(12) Invention Patent Application

(10) Publication No. CN 113193074 A

(43) Publication Date July 30, 2021

(21) Application No. 202110322400.4

(22) Filing Date March 25, 2021

(71) Applicant Taizhou Zhonglai
Photovoltaic Technology Co., Ltd.Address 225500 Kaiyang Road, Jiangyan
Economic Development Zone, Taizhou
City, Jiangsu Province(72) Inventors Zheren DU Yiqian CUI Jian
HUANG Zhencong QIAO Jia CHEN
Ronglin LIU(74) Patent Agency Beijing Jinzhijiao
Intellectual Property Agency Co., Ltd.
11137

Agent Lina Xu Junyong Deng

(51) Int.Cl.

H01L 31/18 (2006 .01)*H01L 31/0216* (2014 .01)*H01L 31/068* (2012 .01)

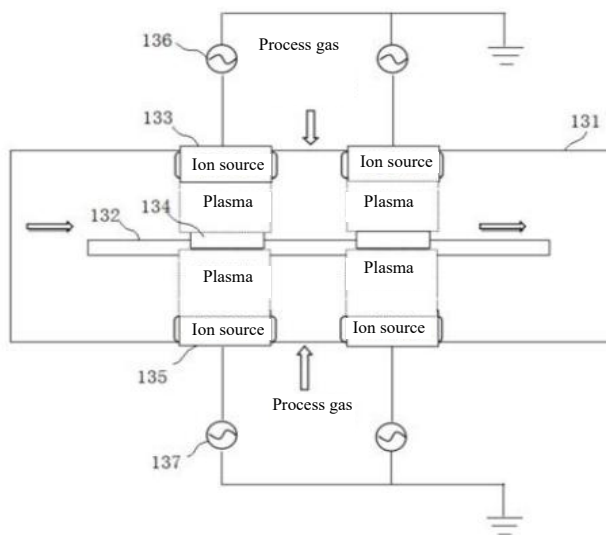
Claims 1 page Specification 6 pages Drawings 5 pages

(54) Title of Invention

N-TOPCon solar cell, module, system,
and method and equipment for preparing
double-sided silicon oxide in a cell

(57) Abstract

The present invention relates to an N-TOPCon solar cell, module, system, and method and equipment for preparing double-sided silicon oxide in a cell, wherein the method includes: Step S1. of using N-type silicon as a substrate to prepare a p⁺ doped region on the front side of the N-type silicon; Step S2. of preparing a silicon oxide thin film on the front side of the N-type silicon, and simultaneously preparing a tunneling oxide layer on the back side of the N-type silicon; Step S3. of preparing phosphorus-doped polysilicon on the back side of the N-type silicon; Step S4. of printing metal electrodes after preparing passivation films on the front side and the back side of the N-type silicon. The present invention reduces process steps while ensuring cleanliness, solves the problem of a high number of N-TOPCon process steps, and enhances the core competitiveness of N-TOPCon.



1. A method for preparing double-sided silicon oxide in an N-TOPCon solar cell, characterized in that it includes the following steps to be performed in sequence:

Step S1. of using N-type silicon as a substrate to prepare a p⁺ doped region on a front side of the N-type silicon;

Step S2. of preparing a silicon oxide thin film on the front side of the N-type silicon, and simultaneously preparing a tunneling oxide layer on a back side of the N-type silicon;

Step S3. of preparing phosphorus-doped polysilicon on the back side of the N-type silicon;

Step S4. of printing metal electrodes after preparing passivation films on the front side and the back side of the N-type silicon.

2. The method according to claim 1, characterized in that step S2 is performed directly after completion of the p⁺ doped region on the front side of the N-type silicon in step S1.

3. The method according to claim 1, characterized in that step S2 further includes: using a PECVD method to prepare the tunneling oxide layer and the silicon oxide thin film on the back side and the front side of the N-type silicon, respectively.

4. The method according to claim 3, characterized in that step S2 further includes: respectively installing ion sources above and below a silicon oxide process chamber to achieve simultaneous preparation of the tunneling oxide layer and the silicon oxide thin film.

5. The method according to claim 4, characterized in that under conditions of pure oxygen or a silane/oxygen mixed gas, a pressure of 0.01-50 Pa, and a deposition temperature of 200-500°C, the thicknesses of the tunneling oxide layer and the silicon oxide thin film are respectively controlled by respectively controlling the power of upper and lower ion sources.

6. The method according to claim 1, characterized in that step S4 further includes: depositing a passivation antireflection film on the passivation film after depositing a passivation film on the front side of the N-type silicon.

7. An N-TOPCon solar cell, characterized in that the solar cell is a solar cell manufactured by the method according to any one of claims 1-6.

8. An N-TOPCon solar cell module, comprising a front layer material, an encapsulation material, an N-TOPCon solar cell, an encapsulation material, and a back layer material that are sequentially arranged from top to bottom, characterized in that: the N-TOPCon solar cell is the N-TOPCon solar cell according to claim 7.

9. An N-TOPCon solar cell system, comprising at least one N-TOPCon solar cell module connected in series, characterized in that: the N-TOPCon solar cell module is the N-TOPCon solar cell module according to claim 8.

10. Equipment for preparing double-sided silicon oxide in an N-TOPCon solar cell, comprising a silicon oxide process chamber filled with a process gas, wherein a first ion source is installed above a carrier plate in the silicon oxide process chamber, the first ion source being used to generate oxygen ions on the front side of N-type silicon on the carrier plate, characterized in that a second ion source is installed below the carrier plate in the silicon oxide process chamber, the second ion source being used to synchronously generate oxygen ions on the back side of the N-type silicon while the first ion source is operating.

11. The equipment according to claim 10, characterized in that it further comprises a first high-frequency radio frequency power supply for driving the first ion source to operate, and a second high-frequency radio frequency power supply for driving the second ion source to operate.

12. The equipment according to claim 10, characterized in that it further comprises gas inlets, the process gas being input into the silicon oxide process chamber through the gas inlets, wherein there are at least two gas inlets, respectively located at the top and the bottom of the chamber.

13. The equipment according to claim 10, characterized in that it further comprises a loading chamber, a heating chamber, an isolation chamber, an amorphous silicon preparation chamber, a cooling chamber, and an unloading chamber, wherein the loading chamber, the heating chamber, the silicon oxide process chamber, the isolation chamber, the amorphous silicon preparation chamber, the cooling chamber, and the unloading chamber are connected in sequence.

N-TOPCon Solar Cell, Module, System, and Method and Equipment for Preparing Double-sided Silicon Oxide in a Cell

Technical Field

[0001] The present invention relates to the technical field of solar cells and in particular to an N-TOPCon solar cell, module, system, and method and equipment for preparing double-sided silicon oxide in a cell.

Background Art

[0002] A tunneling oxide passivated contact (TOPCon) solar cell is an N-type solar cell that has developed rapidly in recent years. A key feature of this solar cell is that it achieves high-efficiency full-backside passivation and selective carrier collection by using an ultrathin silicon oxide layer together with a doped polysilicon layer, which can greatly increase the open-circuit voltage and improve the conversion efficiency, wherein the ultrathin silicon oxide is a very key thin film layer and provides carrier selectivity. On the other hand, preparing a silicon oxide layer before depositing the front-side aluminum oxide (Al_2O_3) film can both chemically passivate the P+ surface and increase the amount of negative charge in the aluminum oxide, enhancing field passivation, overall enhancing the front-side passivation effect, and increasing the open-circuit voltage. In addition, silicon oxide can also play a role in reducing contamination on the silicon surface, that is, whether on the front side or the back side of an N-TOPCon cell, the presence of silicon oxide is required.

[0003] At present, methods for depositing silicon oxide include a thermal oxidation method and nitric acid oxidation; the thermal oxidation method has disadvantages such as long process time, high energy consumption, and high cost, and nitric acid oxidation will cause emission of N-containing substances, which is not conducive to environmental protection. In addition, under normal circumstances, as shown in patent document CN201911262690.7, the silicon oxide on the front side and the back side of an N-TOPCon cell is prepared separately; after etching, backside tunneling silicon oxide and polysilicon layer doping are performed, and considering the front-side contamination problem, a cleaning process step must be added and then the front-side silicon oxide is prepared, resulting in additional process steps. Other researchers use thermal oxidation to deposit silicon oxide on both sides at the same time, but such a preparation method cannot separately adjust the thicknesses of the two sides, which narrows the process tuning window.

Summary of the Invention

[0004] The present invention, while ensuring cleanliness, reduces process steps, solves the problem of a high number of N-TOPCon process steps, and enhances the core competitiveness of N-TOPCon.

[0005] The present invention is implemented through the following technical solutions:

[0006] Provided is a method for preparing double-sided silicon oxide in an N-TOPCon solar cell, including the following steps to be performed in sequence:

[0007] Step S1. of using N-type silicon as a substrate to prepare a p+ doped region on the front side of the N-type silicon;

[0008] Step S2. of preparing a silicon oxide thin film on the front side of the N-type silicon, and simultaneously preparing a tunneling oxide layer on the back side of the N-type silicon;

[0009] Step S3. of preparing phosphorus-doped polysilicon on the back side of the N-type silicon;

[0010] Step S4. printing metal electrodes after preparing passivation films on the front side and the back side of the N-type silicon.

[0011] In the method, step S1 further includes: the p+ doped region on the front side of the N-type silicon is obtained by performing boron diffusion on the front side of the N-type silicon and then removing boron wrap-around diffusion on the back side of the N-type silicon by a wet etching method, and step S2 is performed immediately after the wet etching.

[0012] In the method, the wet etching method after boron diffusion further includes: after double-sided texturing of the N-type silicon, using boron tribromide as a boron source to perform boron diffusion on the front side of the N-type silicon; for the N-type silicon that has undergone boron diffusion, taking its back side and placing it into a mixed solution of HF, HNO_3 , and H_2SO_4 for etching treatment to remove back-side boron wrap-around diffusion and obtain a gentle pyramid surface.

[0013] In the method, step S2 further includes: using a PECVD method to respectively prepare the tunneling oxide layer and the silicon oxide thin film on the back side and the front side of the N-type silicon, and respectively installing ion sources above and below a silicon oxide process chamber to achieve simultaneous preparation of the tunneling oxide layer and the silicon oxide thin film; specifically, under conditions of pure oxygen or a silane/oxygen mixed gas, a pressure of 0.01-50 Pa, and a deposition temperature of 200-500°C, the thicknesses of the tunneling oxide layer and the silicon oxide thin film being respectively controlled by respectively controlling the power of the upper and lower ion sources.

[0014] In the method, step S4 further includes: after depositing a passivation film on the front side of the N-type silicon, depositing a passivation antireflection film on the passivation film.

[0015] Also provided is an N-TOPCon solar cell, the solar cell being a solar cell manufactured by the above method.

[0016] Also provided is an N-TOPCon solar cell module, comprising a front layer material, an encapsulation material, an N-TOPCon solar cell, an encapsulation material, and a back layer material that are sequentially arranged from top to bottom, wherein the N-TOPCon solar cell is the above N-TOPCon solar cell.

[0017] Also provided is an N-TOPCon solar cell system, comprising at least one N-TOPCon solar cell module connected in series, the N-TOPCon solar cell module being the above-described N-TOPCon solar cell module.

[0018] Also provided is equipment for preparing double-sided silicon oxide in an N-TOPCon solar cell, comprising a silicon oxide process chamber filled with a process gas, wherein a first ion source is installed above a carrier plate in the silicon oxide process chamber, the first ion source being used to generate oxygen ions on the front side of N-type silicon on the carrier plate, the generated oxygen ions reacting with the front surface of the silicon wafer to form silicon oxide; a second ion source is installed below the carrier plate in the silicon oxide process chamber, the second ion source being used to synchronously generate oxygen ions on the back side of the N-type silicon while the first ion source is operating.

[0019] Here, the area of the carrier plate for placing the N-type silicon is hollowed out so that the N-type silicon can be coated on both sides at the same time.

[0020] Here, the first ion source faces downward to aim at the front side of the N-type silicon to prepare a silicon oxide thin film on the front side, and the second ion source faces upward to aim at the back side of the N-type silicon to prepare a tunneling oxide layer on the back side. Of course, the N-type silicon can also be placed with the front and back sides reversed, so that the first ion source faces downward to prepare the tunneling oxide layer, and the second ion source faces upward to prepare the silicon oxide thin film.

[0021] Here, the power of the first ion source is controlled so that the thickness of the silicon oxide thin film is 0.3-3 nm, and/or the power of the second ion source is controlled so that the thickness of the tunneling oxide layer is 0.5-2 nm.

[0022] Here, the thickness of the N-type silicon is 150-170 μm , and the resistivity is 0.3-2 $\Omega\cdot\text{cm}$.

[0023] The equipment further includes a first high-frequency radio frequency power supply for driving the first ion source to operate, and a second high-frequency radio frequency power supply for driving the second ion source to operate.

[0024] The equipment further includes gas inlets, the process gas being input into the silicon oxide process chamber through the gas inlets; further, there are at least two gas inlets, respectively located at the top and the bottom of the chamber.

[0025] The equipment further includes a loading chamber, a heating chamber, an isolation chamber, an amorphous silicon preparation chamber, a cooling chamber, and an unloading chamber, wherein the loading chamber, the heating chamber, the silicon oxide process chamber, the isolation chamber, the amorphous silicon preparation chamber, the cooling chamber, and the unloading chamber are connected in sequence.

[0026] The technical advantages of the present invention include: (1) low energy consumption, low contamination, and greatly reduced process cost; (2) immediately preparing double-sided silicon oxide after preparing the p+ doped region, the silicon oxide playing a role of protecting the wafer surface and being able to reduce process contamination; (3) simultaneously preparing double-sided oxide layers, which can reduce process steps and reduce equipment and labor costs; (4) good uniformity, ensuring the overall passivation effect of the wafer; (5) being able to respectively control the thicknesses of double-sided silicon oxide, ensuring the process tuning window; (6) being able to realize the process technology so that upgrading and modification on equipment is relatively simple and easy to achieve.

[0027] The above description is only an overview of the technical solutions of the present invention; in order to be able to more clearly understand the technical means of the present invention so that the present invention can be implemented according to the contents of the specification, and in order to make the above and other objectives,

features, and advantages of the present invention more obvious and easy to understand, specific embodiments of the present invention are exemplarily given below.

Brief Description of the Drawings

[0028] By reading the detailed description of the preferred embodiments below, various other advantages and benefits will become clear to those of ordinary skill in the art. The drawings are only for the purpose of illustrating preferred embodiments, and are not considered to limit the present invention. Moreover, throughout the drawings, the same reference numerals represent the same components.

[0029] FIG. 1 is a schematic cross-sectional view of a cell structure after texturing in step (1) in the method according to an embodiment of the present invention.

[0030] FIG. 2 is a schematic cross-sectional view of a cell structure after double-sided boron diffusion in step (2) in the method according to an embodiment of the present invention.

[0031] FIG. 3 is a schematic cross-sectional view of a cell structure after back-side etching and front-side HF cleaning in step (3) in the method according to an embodiment of the present invention.

[0032] FIG. 4 is a schematic cross-sectional view of a cell structure after depositing double-sided silicon oxide in step (4) in the method according to an embodiment of the present invention.

[0033] FIG. 5 is a schematic cross-sectional view of a cell structure with amorphous silicon deposited in step (5) in the method according to an embodiment of the present invention.

[0034] FIG. 6 is a schematic cross-sectional view of a cell structure in which a polysilicon thin film is formed after annealing in step (6) in the method according to an embodiment of the present invention.

[0035] FIG. 7 is a schematic view of a cell structure after front-side Al_2O_3 in step (7) in the method according to an embodiment of the present invention.

[0036] FIG. 8 is a schematic view of a cell structure after a front-side SiNx passivation antireflection film in step (8) in the method according to an embodiment of the present invention.

[0037] FIG. 9 is a schematic view of a cell structure after a back-side SiNx passivation film in step (9) in the method according to an embodiment of the present invention.

[0038] FIG. 10 is a schematic view of a cell structure after metallization in step (10) in the method according to an embodiment of the present invention.

[0039] FIG. 11 is a schematic diagram of the overall equipment for preparing double-sided silicon oxide of the present invention.

[0040] FIG. 12 is a schematic diagram of a conventional single-sided silicon oxide preparation process chamber.

[0041] FIG. 13 is a schematic diagram of a double-sided silicon oxide preparation process chamber of the present invention.

Specific Embodiments

[0042] Exemplary embodiments of the present invention will be described in more detail below with reference to the accompanying drawings. Although exemplary embodiments of the present invention are shown in the accompanying drawings, it should be understood that the present invention can be implemented in various forms and should not be limited by the embodiments described herein. On the contrary, these embodiments are provided so as to enable a more thorough understanding of the present invention and to fully convey the scope of the present invention to those skilled in the art.

[0043] A method for preparing double-sided silicon oxide in an N-TOPCon solar cell of the present invention includes the following steps to be performed in sequence:

[0044] Step S1. of using N-type silicon as a substrate to prepare a p^+ doped region on the front side of the N-type silicon;

[0045] Step S2. of preparing a silicon oxide thin film on the front side of the N-type silicon, and simultaneously preparing a tunneling oxide layer on the back side of the N-type silicon;

[0046] Step S3. of preparing phosphorus-doped polysilicon on the back side of the N-type silicon;

[0047] Step S4. of printing metal electrodes after preparing passivation films on the front side and the back side of the N-type silicon.

[0048] In the present invention, by simultaneously depositing double-sided silicon oxide after preparing the p^+ doped region, the process time is short, the energy consumption is low, and N emissions can be reduced, and good uniformity is achieved. In addition, the cell prepared in this way does not need an additional cleaning process step after preparing the polysilicon layer, because the oxide layer will very well protect the front side and reduce contamination.

[0049] In one embodiment, step S1 further includes a process in which the p^+ doped region on the front side of the

N-type silicon is obtained by performing boron diffusion on the front side of the N-type silicon and then removing boron wrap-around diffusion on the back side of the N-type silicon by a wet etching method, and step S2 is performed immediately after the wet etching. Because double-sided silicon oxide is prepared immediately after wet etching, the silicon oxide plays a role of protecting the wafer surface and can reduce process contamination.

[0050] Preferably, the wet etching method after boron diffusion further includes: after double-side texturing the N-type silicon, using boron tribromide as a boron source to perform boron diffusion on the front side of the N-type silicon; for the N-type silicon that has undergone boron diffusion, taking its back side and placing it into a mixed solution of HF, HNO₃, and H₂SO₄ for etching treatment to remove back-side boron wrap-around diffusion and obtain a gentle pyramid surface.

[0051] In one embodiment, step S2 further includes: using a PECVD method to respectively prepare the tunneling oxide layer and the silicon oxide thin film on the back side and the front side of the N-type silicon.

[0052] Further, in order to simplify the preparation process, the method for depositing double-sided silicon oxide is: respectively installing ion sources in the upper and lower parts of the silicon oxide process chamber to achieve simultaneous preparation of the tunneling oxide layer and the silicon oxide thin film; specifically, under conditions of pure oxygen or a silane/oxygen mixed gas, a pressure of 0.01-50 Pa, and a deposition temperature of 200-500°C, the thicknesses of the tunneling oxide layer and the silicon oxide thin film are respectively controlled by respectively controlling the power of the upper and lower ion sources, so that the thicknesses of silicon oxide on the two sides can be respectively controlled without affecting the process tuning window.

[0053] In one embodiment, step S4 further includes: after depositing a passivation film on the front side of the N-type silicon, depositing a passivation antireflection film on the passivation film.

[0054] The present invention further provides an N-TOPCon solar cell, the solar cell being a solar cell manufactured by the above method.

[0055] The present invention further provides an N-TOPCon solar cell module, comprising a front layer material, an encapsulation material, an N-TOPCon solar cell, an encapsulation material, and a back layer material that are connected from top to bottom, wherein the N-TOPCon solar cell is the above-described N-TOPCon solar cell. The structure and working principle of the N-TOPCon solar cell module of this embodiment use technologies well known in the art, and the improvements of the module provided by the present invention only relate to the above-mentioned N-TOPCon solar cell, and no changes are made to other parts. Therefore, this specification only describes the N-TOPCon solar cell and its preparation method in detail, and other components of the N-TOPCon solar cell module and their working principles are not repeated here. Those skilled in the art can implement the N-TOPCon solar cell module of the present invention based on the contents described in this specification.

[0056] The present invention further provides an N-TOPCon solar cell system, comprising one or more N-TOPCon solar cell module connected in series, wherein the N-TOPCon solar cell module is the above-described N-TOPCon solar cell module. The structure and working principle of the N-TOPCon solar cell system of this embodiment use technologies well known in the art, and the improvements of the N-TOPCon solar cell system provided by the present invention only relate to the above-described N-TOPCon solar cell, and no changes are made to other parts. Therefore, this specification only describes the N-TOPCon solar cell and its preparation method in detail, and other components of the N-TOPCon solar cell system and their working principles are not repeated here. Those skilled in the art can implement the N-TOPCon solar cell system of the present invention based on the contents described in this specification.

[0057] FIG. 12 is a schematic diagram of a conventional single-sided silicon oxide preparation process chamber, which can coat only the upper surface of a silicon wafer and can only deposit one oxide layer. In order to prepare double-sided silicon oxide, the present invention also upgrades and modifies the conventional single-sided silicon oxide preparation process chamber, and further provides equipment for preparing double-sided silicon oxide in an N-TOPCon solar cell, as shown in FIG. 11 and FIG. 13, comprising a silicon oxide process chamber 131 filled with a process gas, wherein a first ion source 133 is installed above a carrier plate 132 in the silicon oxide process chamber 131, the first ion source 133 being used to generate oxygen ions on the front side of N-type silicon 134 on the carrier plate 132, and a second ion source 135 is installed below the carrier plate 132, the second ion source 135 being used to synchronously generate oxygen ions on the back side of the N-type silicon 134 that is on the carrier plate 132 while the first ion source 133 is operating.

[0058] With the equipment for preparing double-sided silicon oxide of the present invention, the modification method is relatively simple and easy to implement, and it only requires installing ion sources on both sides of the chamber of the silicon oxide preparation process chamber and ensuring that the gas in the chamber is uniform.

[0059] In one embodiment, except for the portion blocked by the support, the area of the carrier plate 132 for

placing the N-type silicon 134 is entirely hollowed out so that the N-type silicon can be coated on both sides at the same time.

[0060] In one embodiment, the first ion source 133 faces downward to aim at the front side of the N-type silicon 134 to prepare a silicon oxide thin film on the front side, and the second ion source 135 faces upward to aim at the back side of the N-type silicon to prepare a tunneling oxide layer on the back side, wherein the power of the first ion source 132 is controlled so that the thickness of the silicon oxide thin film is 0.3-3 nm, the power of the second ion source 135 is controlled so that the thickness of the tunneling oxide layer is 0.5-2 nm, the thickness of the N-type silicon 134 is 150-170 μm , and the resistivity is 0.3-2 $\Omega\cdot\text{cm}$. Of course, the N-type silicon can also be placed with the front and back sides reversed, so that the first ion source 133 faces downward to prepare the tunneling oxide layer, and the second ion source 135 faces upward to prepare the silicon oxide thin film.

[0061] Further, the equipment further includes a first high-frequency radio frequency power supply 136 for driving the first ion source 133 to operate, and a second high-frequency radio frequency power supply 137 for driving the second ion source 135 to operate; by setting two power supplies to respectively drive the two ion sources, separate control of the power of the two ion sources is achieved, thereby respectively adjusting the thicknesses of the upper and lower silicon oxide film layers.

[0062] In one embodiment, gas inlets are further included, the process gas being input into the silicon oxide process chamber through the gas inlets; in practice, input of the process gas into the chamber can be controlled by external equipment.

[0063] Further, the number of gas inlets is two or more, and the gas inlets are evenly distributed at the top and the bottom of the chamber so that the gas in the entire chamber is uniform.

[0064] Referring to FIG. 11, in one embodiment, by sequentially connecting a loading chamber, a heating chamber, a silicon oxide process chamber, an isolation chamber, an amorphous silicon preparation chamber, a cooling chamber, and an unloading chamber, the equipment for preparing double-sided silicon oxide is combined with chain-type polysilicon preparation equipment to form a two-in-one device, thereby further leveraging the equipment's advantages.

[0065] The preparation method of the invention will be described in detail below by specific embodiments.

[0066] Embodiment 1

[0067] An N-type passivated contact structure solar cell of this embodiment, as shown in FIG. 10, comprises, from top to bottom, a front-side p⁺ metal electrode 10, a front-side SiN_x passivation antireflection film 8, a front-side Al₂O₃ passivation film 7, a front-side silicon oxide thin film 3, a p⁺ doped region 2, an n-type silicon substrate 1, a tunneling oxide layer 2, a back-side n⁺ doped region 6, a back-side SiN_x passivation film 9, and a back-side n⁺ metal electrode 11.

[0068] A preparation method of the N-type passivated contact structure solar cell of this embodiment includes the following steps:

[0069] (1) Selecting N-type silicon 1 with a thickness of 150-170 μm , a resistivity of 0.3-2 $\Omega\cdot\text{cm}$, and a size of 156.75 mm $\times$ 156.75 mm as a substrate to perform double-side texturing treatment, and after this step is completed, the cell structure is as shown in FIG. 1.

[0070] (2) For the surface of the N-type silicon after texturing treatment, using boron tribromide to perform boron diffusion on the front side of the N-type silicon, wherein the diffusion temperature is 850-1000°C, the duration is 50-80 min, and the sheet resistance is 80-100 Ω/sqr . After this step is completed, the cell structure is as shown in FIG. 2.

[0071] (3) For the N-type silicon that has undergone boron diffusion, taking its back side and placing it into a mixed solution of HF and HNO₃, and H₂SO₄ for etching treatment to remove the back-side p⁺ doped region 2 and obtain a gentle pyramid surface after etching, wherein HF:HNO₃:H₂SO₄:H₂O = 1:4:0.6:3, and the mass fraction of HF is 20%. After this step is completed, the cell structure is as shown in FIG. 3.

[0072] (4) Using a PECVD method to respectively prepare an ultrathin tunneling oxide layer 3 and a front-side silicon oxide thin film 4 on the back side and the front side of the N-type silicon after etching in step (3). The schematic diagram of the equipment is as shown in FIG. 11. Specifically, ion sources are respectively installed in the upper and lower parts of the silicon oxide process chamber. During the process, the gas in the entire chamber is the same and the temperature is the same, and the thickness of the silicon oxide can be respectively controlled by respectively controlling the power of the upper and lower ion sources. Under conditions of pure oxygen or a silane/oxygen mixed gas, a pressure of 0.01-50 Pa, and a deposition temperature of 200-500°C, the ion source power is adjustable within a range of 5-500 W, and the reaction time is 3-200 s, obtaining a tunneling oxide layer 3 with a thickness of 0.5-2 nm and a front-side silicon oxide thin film 4 with a thickness of 0.3-3 nm, and after this step is completed, the cell structure is as shown in FIG. 4.

[0073] (5) Preparing a phosphorus-doped amorphous silicon film 5 by the PVD method. When the N-type silicon processed by step (4) enters the PVD process chamber to prepare a phosphorus-doped amorphous silicon layer, the target material is a rotary pure silicon column target material or a phosphorus-doped silicon target material, and argon gas and phosphine are used to generate argon ions through plasma excitation in a magnetic field and sputter the silicon target material, thereby producing a phosphorus-doped amorphous silicon thin film; specifically, the power is 1000-30000 W, the pressure is 0.1-50 Pa, the temperature is 100-700°C, and the reaction time is 3-400 s. After this step is completed, the cell structure is as shown in FIG. 5.

[0074] It should be noted that a plate-type PECVD method can also be used to prepare a phosphorus-doped amorphous silicon layer. Specifically, the power is 50-40000 W, the pressure is 0.1-200 Pa, the temperature is 100-600°C, and the reaction time is 3-400 s.

[0075] (6) Performing rapid annealing treatment for the N-type silicon wafer after step (5), and the phosphorus-doped amorphous silicon 5 will be converted into the phosphorus-doped polysilicon 6. First, the annealing furnace vacuumed to below 10^{-4} Pa, and then nitrogen is filled for use as a protective gas. During annealing, the vacuum degree of the annealing furnace is 500-950 mbar, the annealing time is 20-60 min, and the annealing temperature is 800-900°C. After this step is completed, the cell structure is as shown in FIG. 6.

[0076] (7) Performing surface passivation treatment for the annealed N-type silicon, and depositing an Al_2O_3 passivation film 7 on the front-side silicon oxide film.

[0077] (8) For the N-type silicon wafer after step (7), depositing a SiNx passivation antireflection film 8 on the Al_2O_3 passivation film 7.

[0078] (9) For the N-type silicon wafer after step (8), using the passivation structure of the SiNx passivation film 9 for the n^+ doped region on the back side of the N-type silicon.

[0079] (10) For the N-type silicon wafer after step (9), in the p^+ doped region 2 on the front side of the N-type silicon, using a silver-aluminum paste to print the front-side p^+ metal electrode 10 and performing high-temperature sintering, and in the n^+ doped region 6 on the back side of the N-type silicon, using a silver paste to print the back-side n^+ metal electrode 11 and performing high-temperature sintering.

[0080] Finally, it should be noted that the above embodiments are used only to illustrate the technical solutions of the present invention and are not limitations on the scope of protection of the present invention; although the present invention has been described in detail with reference to preferred embodiments, those of ordinary skill in the art should understand that modifications or equivalent substitutions can be made to the technical solutions of the present invention without departing from the spirit and scope of the technical solutions of the present invention.



FIG. 1

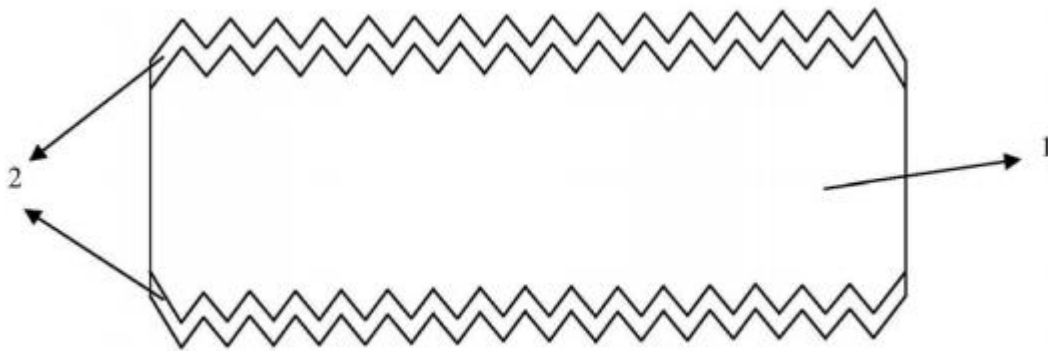


FIG. 2

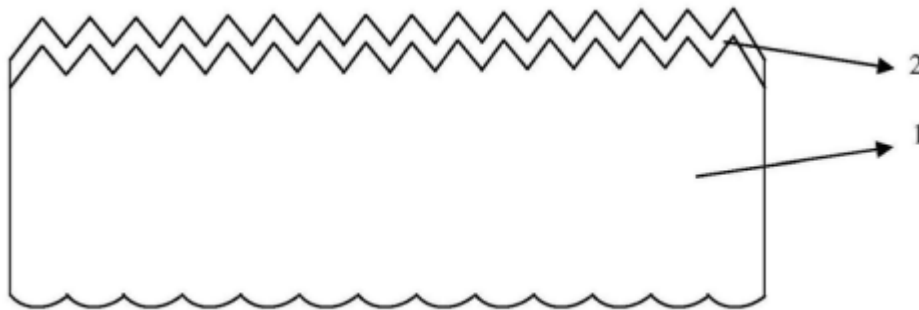


FIG. 3



FIG. 4



FIG. 5

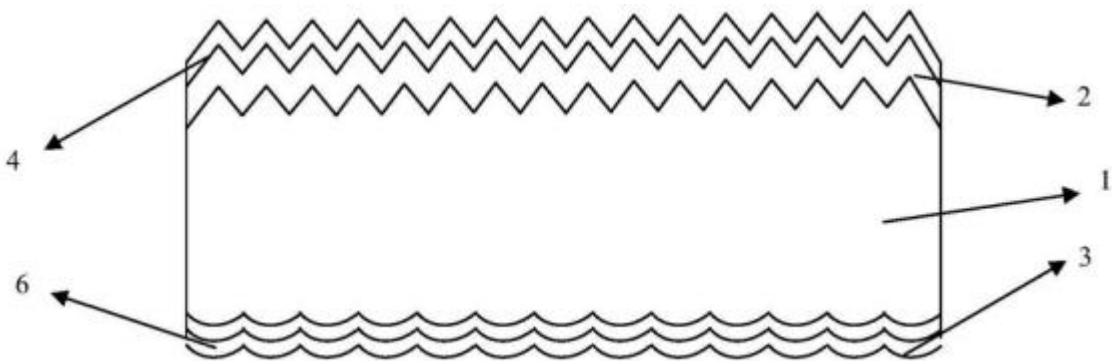


FIG. 6



FIG. 7



FIG. 8

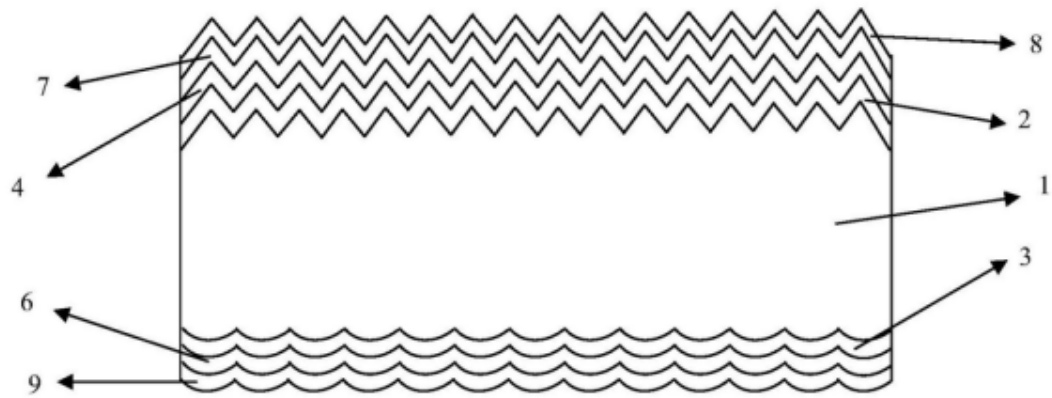


FIG. 9

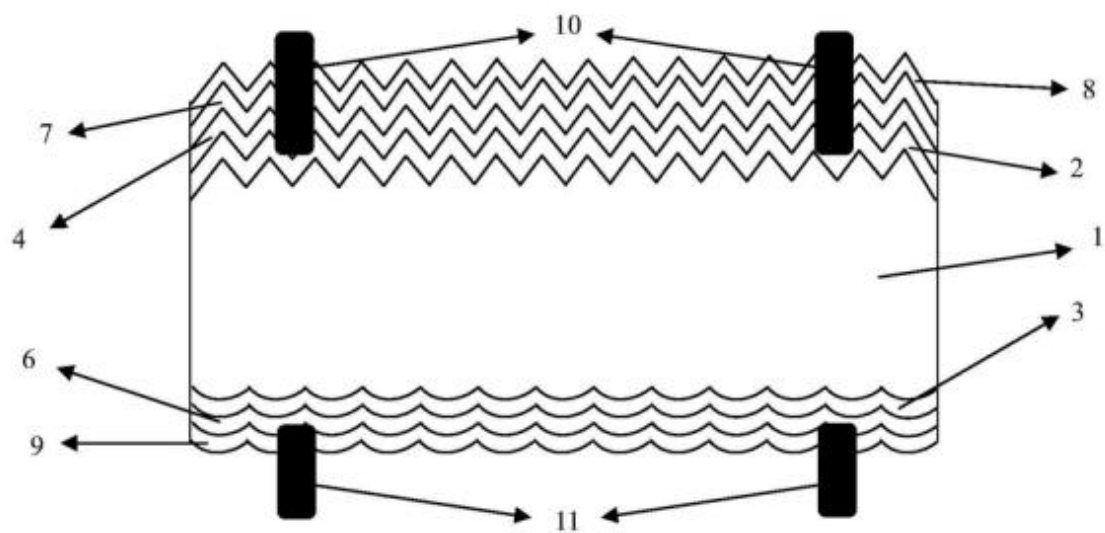


FIG. 10

Loading chamber	Heating chamber	Ion source Silicon oxide process chamber	Isolation chamber	Amorphous silicon preparation chamber	Cooling chamber	Unloading chamber
Carrier plate travel position						
		Ion				

FIG. 11

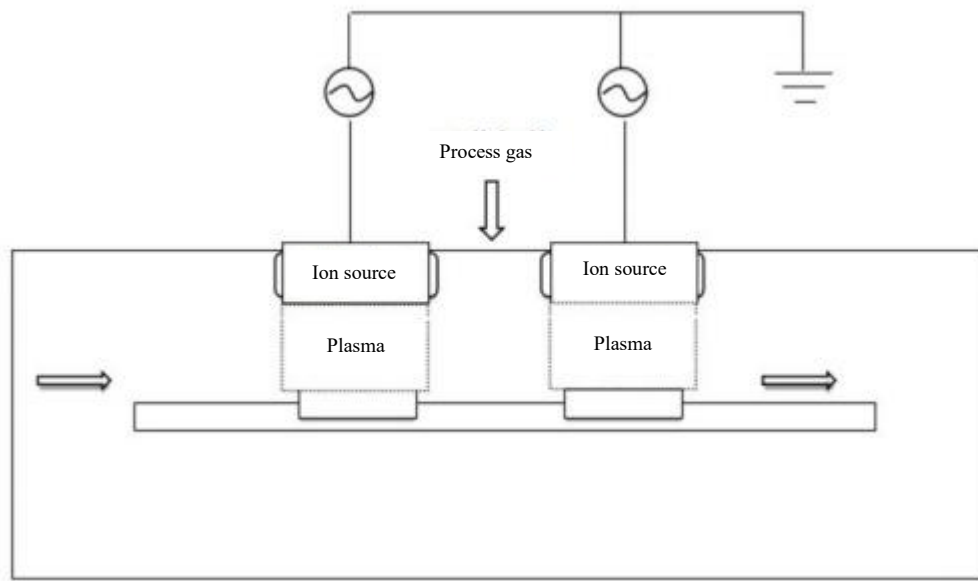


FIG. 12

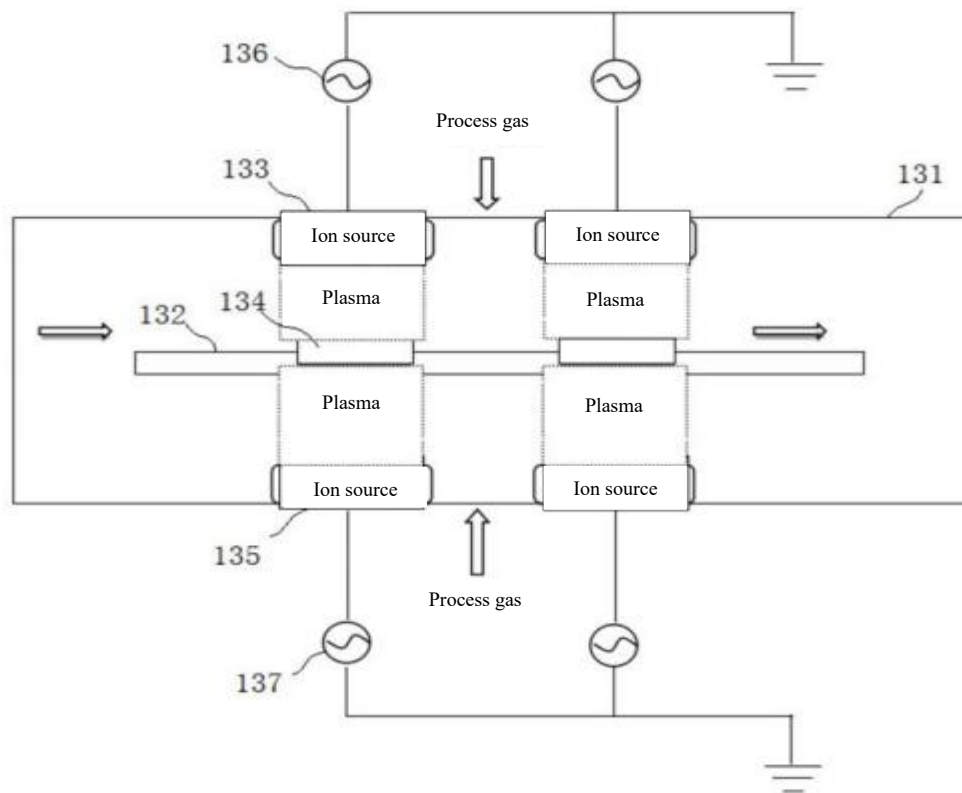


FIG. 13

13

CERTIFICATE OF ACCURACY

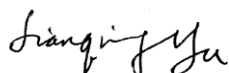
Attached as Ex A is the original document identified as patent application number CN113193074A and attached as Ex B is the translation of the original document from Chinese to English.

This is to certify under penalty of perjury that I, Jianqing Yu, translated the document attached as Exhibit B and it is a true, accurate, and complete translation of Exhibit A.

I am thoroughly familiar with and competent in both Chinese and English languages. I have over 20 years of experience in translating Chinese to English and hold a Bachelor's degree in Mechanical Engineering from Fuzhou University. Attached as Exhibit C is a copy of my current CV.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: 02/05/2026



Jianqing Yu
Translator

Your
legal
translation
partner 

Jane Yu

16768 22A Ave. Surrey, B.C. V3Z 0M7, Canada || Tel:+1 (778)-294-2026 | Cell: +1(604)-908-2300 | janeyu_sh@vip.163.com

CHINESE/JAPANESE/KOREAN/ENGLISH TRANSLATOR

Freelance translator with extensive experience in most technical fields including patents, pharmaceutical, medical, chemical, mechanical, electrical, IT, electronics, instruments, automotive, energy, engineering & construction, legal, textiles, and more.

Translation skills include:

- Near-native English with 15 years' practice in Canada
- Over two decades translation experience
- [STIBC \(Canada\) certified](#) from English into Chinese
- Broad range of software & CAT use
- Experienced in a wide range of technical fields
- [ATA certified from English into Chinese](#)
- Diverse technical vocabulary in all four languages

EXPERIENCE

Full-time Freelance Translator, Vancouver, BC/Shanghai, P.R. China

2003 – Present

Multilingual Translator

With 21 years of full-time practice translating over 20 million words, I am experienced in a wide range of fields. The following is a conservative estimate of the translation work I have completed during this period:

- Six million words from English into Simplified (and Traditional) Chinese, working with documents in the fields of pharmaceutical (patents, clinical trials, informed consents, adverse events, drug regulatory-related documents, academic paper, essays, articles, etc.), medical (patents, medical records, patient discharge summaries, patient/physicians handwritten notes, examination and laboratory test reports, patient questionnaires, medical device/instrument user manuals/product flyers/catalogues/brochures/specifications, medical insurance-related documents such as receipts and medical reports), chemical/mechanical/electrical/electronic/IT (patents, technical specifications, user manuals, product standards/specifications, SOP, national standards, etc.), engineering & construction (design and technical specifications, work procedures, installation manuals, drawings, etc.), automotive (patents, product manuals/specifications, etc.), energy (patents, engineering and general), legal (contracts, agreements, complaints, summons, etc.), textiles/garments (patents, technical specifications, machinery, SOP, etc.), and general misc. documents in virtually every field
- Eight million words from Chinese (Simplified & Traditional) into English, with the types of documents as listed above
- Five million words from Japanese into English, with the types of documents as listed above
- Three million words from Korean into English, with the types of documents as listed above

Lately, my capacities in Japanese and Korean are growing significantly.

[Huawei Technologies](#), Shenzhen, P.R. China

2001 – 2002

In-House Translator

Translating technical specifications and standards for Huawei Technologies, Ltd., a leading telecom equipment manufacturer in China.

Materials translated:

- Highly technical GSM, CDMA and 3G product brochures, specifications, catalogues, etc.
- User manuals for routers, data/video communications, wireless, optical and fixed networks, etc.

[Bechtel China Inc., Meizhou Wan Power Plant Project](#), Fujian, China

1998 – 2001

Mechanical field engineer & translator/interpreter

Working in the power block for installation of two 362MW net steam turbine-generator units in Meizhou Wan Power Plant project.

EDUCATION & TRAINING

Tongji University Institute of Mechanical Engineering, Shanghai, P.R. China

1996

Master of Engineering, Mechanical Engineering

Fuzhou University, Fuzhou, P.R. China

1990

Bachelor of Engineering (Mechanical Engineering)

Software & Computer Assisted Translation Tools:
SDL TRADOS, Wordfast, MemoQ, and AutoCAD

Exhibit C

[Patent Translations Reference](#)

[Medical Translations Reference](#)