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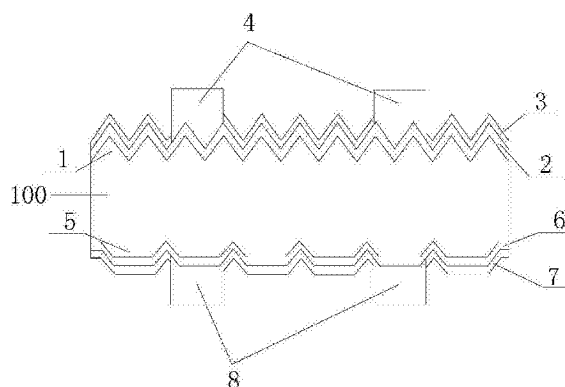
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(54)发明名称

单晶硅双面太阳能电池及其制备方法

(57)摘要

本发明公开了一种单晶硅双面太阳能电池,在单晶硅衬底的正面依次形成正面制绒形貌结构、正面PN发射结、正面钝化减反介质层以及正面电极,在单晶硅衬底的背面依次形成背面制绒形貌结构、背表面场、背面钝化减反介质层以及背面电极,其特征在于:所述背面制绒形貌结构为平台形绒面,各平台结构分散,或者,平铺,或者,部分分散、部分平铺、部分相连、部分交叠地分布在硅衬底上,平台结构具有与硅衬底相连接的下平面及下平面相对的上平面,下平面的尺寸大于上平面;上平面的边长为2至10 μm ,平台结构的高度为1至8 μm 。本发明还公开了一种单晶硅双面太阳能电池的制备方法。本发明可优化双面太阳能电池的少数载流子表面复合和光学吸收特性,提高量子转换效率。



1. 单晶硅双面太阳电池, 在单晶硅衬底(100)的正面依次形成正面制绒形貌结构(1)、正面PN发射结(2)、正面钝化减反介质层(3)以及正面电极(4), 在单晶硅衬底的背面依次形成背面制绒形貌结构(5)、背表面场(6)、背面钝化减反介质层(7)以及背面电极(8), 其特征在于: 所述背面制绒形貌结构(5)为平台形绒面, 各平台结构(5a)分散, 或者, 平铺, 或者, 部分分散、部分平铺、部分相连、部分交叠地分布在硅衬底上; 所述平台结构(5a)具有与硅衬底(100)相连接的下平面及下平面相对的上平面, 下平面的尺寸大于上平面; 所述上平面的边长为2至10 μm , 平台结构(5a)的高度为1至8 μm 。

2. 根据权利要求1所述的单晶硅双面太阳电池, 其特征在于: 所述正面钝化减反介质层(3)和背面钝化减反介质层(7)分别为由氧化硅、氮化硅、氮氧化硅、氧化铝、碳化硅、非晶硅、微晶硅、氧化铟锡或者氧化钛为材料组成的单层膜或多层膜。

3. 根据权利要求1所述的单晶硅双面太阳电池, 其特征在于: 所述正面电极(104)、背面电极(108)为银、铝、铜、镍、钛、锡、铅、镉、金、锌的一种或多种金属或其合金。

4. 一种单晶硅双面太阳电池的制备方法, 用于制备权利要求1-3任一所述单晶硅双面太阳电池, 包括如下步骤:

S1: 在单晶硅衬底表面制绒;

S2: 正面掺杂形成发射结;

S3: 去除背面含杂质玻璃层;

S4: 湿化学法制备背面平台结构, 并去除背面掺杂层;

S5: 背面掺杂形成背表面场;

S6: 制备正面、背面钝化减反介质层;

S7: 制备正面、背面电极。

5. 根据权利要求4所述的单晶硅双面太阳电池的制备方法, 其特征在于: 在步骤S4中, 湿化学法制备背面平台结构所采用的化学药剂有氢氧化钠、氢氧化钾、四甲基氢氧化铵、硝酸、磷酸、氢氟酸、乙醇、异丙醇或乙二醇中的一种或两种以上混合的水溶液; 制备温度是60至80 $^{\circ}\text{C}$, 时间是10-900秒。

6. 根据权利要求4所述的单晶硅双面太阳电池的制备方法, 其特征在于: 在步骤S2和S3之间, 还包括如下步骤:

S2-1: 正面沉积阻挡层: 采用PECVD在正面沉淀氧化硅薄膜的工艺阻挡层, 厚度是50至300nm。

7. 根据权利要求4所述的单晶硅双面太阳电池的制备方法, 其特征在于: 在步骤S5和S6之间, 还包括如下步骤:

S5-1: 使用氢氟酸去除正面的氧化硅、磷硅玻璃和背面的硼硅玻璃。

单晶硅双面太阳电池及其制备方法

技术领域

[0001] 本发明涉及一种太阳电池及其制备方法,尤其涉及一种单晶硅双面太阳电池及其制备方法,属于太阳电池技术领域。

背景技术

[0002] 追求提高电池转换效率,同时降低甚至维持制造成本及是业界不断追求的目标和提高自身竞争力之所在。相对于单面受光的传统晶体硅太阳电池,双面太阳电池利用正、背两个受光面,可以获得更高的光电流密度,很大程度地提高发电功率。根据安装地面和环境,基于双面太阳电池的光伏发电系统可以获得10至30%的功率增益。

[0003] 双面太阳电池结构包括:正、背面的绒面形貌结构、pn结发射极、钝化减反介质层、正、背面电极等。其中,背面的绒面可以有效地提高地面和环境反射光在双面电池背面的吸收,是双面太阳电池的重要结构。目前双面太阳电池的背面都采用与正面类似的绒面形貌结构,即制绒获得的金字塔分布紧密,相互交叠。虽然这种紧密分布的金字塔有利于最大限度地吸收直射光,但不一定是漫反射光的最佳光吸收结构,并且较高的表面积会带来少数载流子复合。因此,双面太阳电池的背面结构有待进一步优化。

发明内容

[0004] 本发明针对现有技术中存在的上述技术问题,提供一种单晶硅双面太阳电池,优化太阳电池少数载流子表面负荷和光学吸收特性,提高量子转换效率。

[0005] 本发明的另一方面,提供一种单晶硅双面太阳电池的制备方法,提高太阳电池的转换效率和生产效率。

[0006] 为此,本发明采用如下技术方案:

[0007] 单晶硅双面太阳电池,在单晶硅衬底(100)的正面依次形成正面制绒形貌结构(1)、正面PN发射结(2)、正面钝化减反介质层(3)以及正面电极(4),在单晶硅衬底的背面依次形成背面制绒形貌结构(5)、背表面场(6)、背面钝化减反介质层(7)以及背面电极(8),其特征在于:所述背面制绒形貌结构(5)为平台形绒面,各平台结构(5a)分散,或者,平铺,或者,部分分散、部分平铺、部分相连、部分交叠地分布在硅衬底上;所述平台结构(5a)具有与硅衬底(100)相连接的下平面及下平面相对的上平面,下平面的尺寸大于上平面;所述上平面的边长为2至10 μm ,平台结构(5a)的高度为1至8 μm 。

[0008] 进一步地,所述正面钝化减反介质层(3)和背面钝化减反介质层(7)分别为由氧化硅、氮化硅、氮氧化硅、氧化铝、碳化硅、非晶硅、微晶硅、氧化铟锡或者氧化钛为材料组成的单层膜或多层膜。

[0009] 进一步地,所述正面电极(104)、背面电极(108)为银、铝、铜、镍、钛、锡、铅、镉、金、锌的一种或多种金属或其合金。

[0010] 本发明中,“分散”是指各平台结构(5a)的底部互不接触;“平铺”是指各相邻平台结构(5a)的底部相互接触,但无交错、重叠;“部分相连”是指部分相邻平台结构(5a)的底部

相互接触,但无交错、重叠;“部分交叠”部分相邻平台结构(5a)重叠在一起;“部分分散、部分平铺、部分相连、部分交叠地分布在硅衬底上”可以是所述四种分布方式任意两种或两种以上的组合。

[0011] 本发明的另一方面,提供一种单晶硅双面太阳电池的制备方法,用于制备所述单晶硅双面太阳电池,包括如下步骤:

[0012] S1:在单晶硅衬底表面制绒;

[0013] S2:正面掺杂形成发射结;

[0014] S3:去除背面含杂质玻璃层;

[0015] S4:湿化学法制备背面平台结构,并去除背面掺杂层;

[0016] S5:背面掺杂形成背表面场;

[0017] S6:制备正面、背面钝化减反介质层;

[0018] S7:制备正面、背面电极。

[0019] 在步骤S4中,湿化学法制备背面平台结构所采用的化学药剂有氢氧化钠、氢氧化钾、四甲基氢氧化铵、硝酸、磷酸、氢氟酸、乙醇、异丙醇或乙二醇中的一种或两种以上混合的水溶液;制备温度是60至80℃,时间是10-900秒。

[0020] 进一步地,在步骤S2和S3之间,还包括如下步骤:S2-1:正面沉积阻挡层。

[0021] 进一步地,在步骤S5和S6之间,还包括如下步骤:S5-1:使用氢氟酸去除正面的氧化硅、磷硅玻璃和背面的硼硅玻璃。

[0022] 本发明的单晶硅双面太阳电池,通过在电池的背面设置平台形绒面,减少太阳电池背面绒面的表面积,明显地降低光生少数载流子在背表面的复合;正面入射的长波长光在背表面的反射增加,透射减小,重新被太阳电池吸收。因此,通过背面平台形貌结构,可以优化双面太阳电池的少数载流子表面复合和光学吸收特性,提高量子转换效率。

[0023] 本发明的单晶硅双面太阳电池的制备方法,仅仅增加一道湿化学方法制备背面平台形貌结构,工艺相对简单,适合于低成本、大批量、稳定的工业制造。

附图说明

[0024] 图1为本发明的单晶硅双面太阳电池的结构示意图;

[0025] 图2为本发明的平台形绒面的显微镜照片;

[0026] 其中,100为单晶硅衬底,1为正面制绒形貌结构,2为正面掺杂发射结,3为正面钝化减反介质层,4为正面电极,5为背面制绒形貌结构,5a为平台结构,6为背表面场,7为背面钝化减反介质层,8为背面电极;图中相应的产品结构仅为示意图,未按比例绘制。

具体实施方式

[0027] 为了使本技术领域的人员更好的理解本发明方案,下面将结合本发明实施例中的附图,对本发明实施例中的技术方案进行清楚、完整的描述。

[0028] 实施例1:

[0029] 本实施例是本发明应用于P型单晶硅的情形。如图1所示,在P型单晶硅衬底100的正面依次形成正面制绒形貌结构1,在本实施例中为正面金字塔形绒面、正面磷掺杂发射结2、正面钝化减反介质层3以及正面电极4,在P型单晶硅衬底的背面依次形成背面制绒形貌

结构5、背面硼掺杂形成的硼掺杂背表面场6、背面钝化减反介质层7以及背面电极8,其中,如图2所示,背面制绒形貌结构5为平台形绒面,各平台结构5a分散,或者,部分相连,或者,部分交叠,或者,部分分散、部分相连、部分交叠地分布在硅衬底上。

[0030] 在本实施例中,各平台结构5a部分分散、部分交叠地分布在硅衬底上。如图1所示,平台结构5a具有与硅衬底100相连接的下平面及下平面相对的上平面,下平面的尺寸大于上平面,上平面的边长为 $2\mu\text{m}$,平台结构5a的高度为 $1\mu\text{m}$ 。正面钝化减反介质层3为由氮化硅制成的单层膜,膜厚70至80nm;背面钝化减反介质层7为由氧化铝和氮化硅制成的双层膜,其中,氧化铝膜厚20至30nm和氮化硅膜厚50至70nm。正面电极104和背面电极108均为银栅电极。

[0031] 实施例2:

[0032] 本实施例与实施例1的不同之处在于:背面制绒形貌结构5中,各平台结构5a部分分散、部分相连地分布在硅衬底上。平台结构5a上平面的边长为 $10\mu\text{m}$,平台结构5a的高度为 $8\mu\text{m}$ 。正面钝化减反介质层3为由氮氧化硅制成的单层膜,膜厚70至80nm;背面钝化减反介质层7为由氧化钛和氧化硅制成的双层膜,其中,氧化钛膜厚20至30nm和氧化硅膜厚50至70nm。正面电极4和背面电极8均为铜电极。

[0033] 实施例3:

[0034] 本实施例是本发明应用于N型单晶硅的情形。如图1所示,在N型单晶硅衬底100的正面依次形成正面金字塔形绒面1、正面掺硼掺杂发射结2、正面钝化减反介质层3以及正面电极4,在N型单晶硅衬底的背面依次形成背面制绒形貌结构5、背面磷掺杂形成的磷掺杂背表面场6、背面钝化减反介质层7以及背面电极8,其中,背面制绒形貌结构5为平台形绒面,各平台结构5a分散地分布在硅衬底上。如图1所示,平台结构5a具有与硅衬底100相连接的下平面及下平面相对的上平面,下平面的尺寸大于上平面,上平面的边长为 $4\mu\text{m}$,平台结构5a的高度为 $3\mu\text{m}$ 。正面钝化减反介质层3为由氧化铝和氮化硅制成的双层膜,其中,氧化铝膜厚20至30nm和氮化硅膜厚50至70nm;背面钝化减反介质层7为由氮化硅制成的单层膜,膜厚70至80nm;正面电极4和背面电极8均为银栅电极。

[0035] 实施例4:

[0036] 本实施例与实施例3的不同之处在于:背面制绒形貌结构5中,各平台结构5a部分交叠地分布在硅衬底上,未交叠的部分可以分散、可以平铺;平台结构5a上平面的边长为 $7\mu\text{m}$,平台结构5a的高度为 $6\mu\text{m}$ 。正面钝化减反介质层3为由氧化铟锡和非晶硅制成的双层膜,其中,氧化铟锡膜厚60至80nm和非晶硅膜厚5至20nm;背面钝化减反介质层7为由氧化铟锡和非晶硅制成的双层膜,其中,氧化铟锡膜厚60至80nm和非晶硅膜厚5至20nm;正面电极4和背面电极8均为银电极。

[0037] 实施例5:

[0038] 一种单晶硅双面太阳能电池的制备方法,用于制备实施例1所述的P单晶硅双面太阳能电池,包括如下步骤:

[0039] S1:在单晶硅衬底表面制绒:使用含氢氧化钠和异丙醇的碱性制绒液,温度是 80°C ,对p型单晶硅衬底100表面进行制绒,形成正面绒面形貌1,同时去除硅片切割损伤层;

[0040] S2:正面掺杂形成发射结:进行磷掺杂形成正面掺杂发射结2,磷掺杂可以采用三氯氧磷源的管式炉扩散、离子注入或涂覆含磷杂质层的扩散,扩散方阻是40至 $200\Omega/\square$;

[0041] S2-1: 正面沉积阻挡层: 采用PECVD在正面沉淀氧化硅薄膜的工艺阻挡层, 厚度是50至300nm;

[0042] S3: 去除背面含杂质玻璃层: 使用氢氟酸去除背面的磷硅玻璃层;

[0043] S4: 湿化学法制备背面平台结构, 并去除背面掺杂: 使用含四甲基氢氧化铵和异丙醇的碱性药液, 温度是80℃, 时间是10至900s, 制备形成背面制绒形貌结构5, 同时去除背面磷掺杂层;

[0044] S5: 背面掺杂形成背表面场: 进行硼掺杂形成背表面场6, 硼掺杂可以采用三溴化硼源的管式炉扩散、离子注入或涂覆含硼杂质层的扩散, 扩散方阻是60至200 $\Omega/\square$;

[0045] S5-1: 使用氢氟酸去除正面的氧化硅、磷硅玻璃和背面的硼硅玻璃;

[0046] S6: 制备正面、背面钝化减反介质层: 采用PECVD制备正面氮化硅钝化减反介质层3和背面氧化铝/氮化硅的钝化减反介质层7; 正面氮化硅厚度是70至80nm, 背面氧化铝厚度是20至30nm, 氮化硅厚度是50至70nm;

[0047] S7: 制备正、背面电极: 采用丝网印刷分别在正、背面制备含银栅线电极4和8, 并进行高温烧结, 烧结温度是850至900℃。

[0048] 当然, 在步骤S4中, 也可以采用含硝酸和氢氟酸的酸性药液制备背面平台结构。

[0049] 实施例2的制备方法参照实施例1的制备方法。

[0050] 实施例6:

[0051] 一种单晶硅双面太阳电池的制备方法, 用于制备实施例3所述的N单晶硅双面太阳电池, 包括如下步骤:

[0052] S1: 在单晶硅衬底表面制绒: 使用含氢氧化钠和异丙醇的碱性制绒液, 温度是80℃, 对n型单晶硅衬底100表面进行制绒, 形成正面绒面形貌1, 同时去除硅片切割损伤层;

[0053] S2: 正面掺杂形成发射结: 进行硼掺杂形成正面硼掺杂发射结2, 磷掺杂可以采用三溴化硼源的管式炉扩散、离子注入或涂覆含硼杂质层的扩散, 扩散方阻是60至200 $\Omega/\square$;

[0054] S2-1: 正面沉积阻挡层: 采用PECVD在正面沉淀氧化硅薄膜的工艺阻挡层, 厚度是50至300nm;

[0055] S3: 去除背面含杂质玻璃层: 使用氢氟酸去除背面的硼硅玻璃层;

[0056] S4: 湿化学法制备背面平台结构, 并去除背面掺杂: 使用含四甲基氢氧化铵和异丙醇的碱性药液, 温度是80℃, 时间是10至900s, 制备背面制绒形貌结构5, 同时去除背面硼掺杂层;

[0057] S5: 背面掺杂形成背表面场: 进行磷掺杂形成背表面场6, 磷掺杂可以采用三氯氧磷源的管式炉扩散、离子注入或涂覆含磷杂质层的扩散, 扩散方阻是40至200 $\Omega/\square$;

[0058] S5-1: 使用氢氟酸去除正面的氧化硅、硼硅玻璃和背面的磷硅玻璃;

[0059] S6: 制备正面、背面钝化减反介质层: 采用PECVD制备正面氧化铝/氮化硅钝化减反介质层3和背面氮化硅的钝化减反介质层7; 正面氧化铝厚度是20至30nm, 氮化硅厚度是50至70nm; 背面氮化硅厚度是70至80nm;

[0060] S7: 制备正、背面电极: 采用丝网印刷分别在正、背面制备含银栅线电极4和8, 并进行高温烧结, 烧结温度是850至900℃。

[0061] 实施例4的制备方法参照实施例3的制备方法。

[0062] 显然, 所描述的实施例仅仅是本发明的部分实施例, 而不是全部的实施例。基于本

发明中的实施例,本领域普通技术人员在没有做出创造性劳动前提下所获得的所有其他实施例,都应当属于本发明保护的范围。

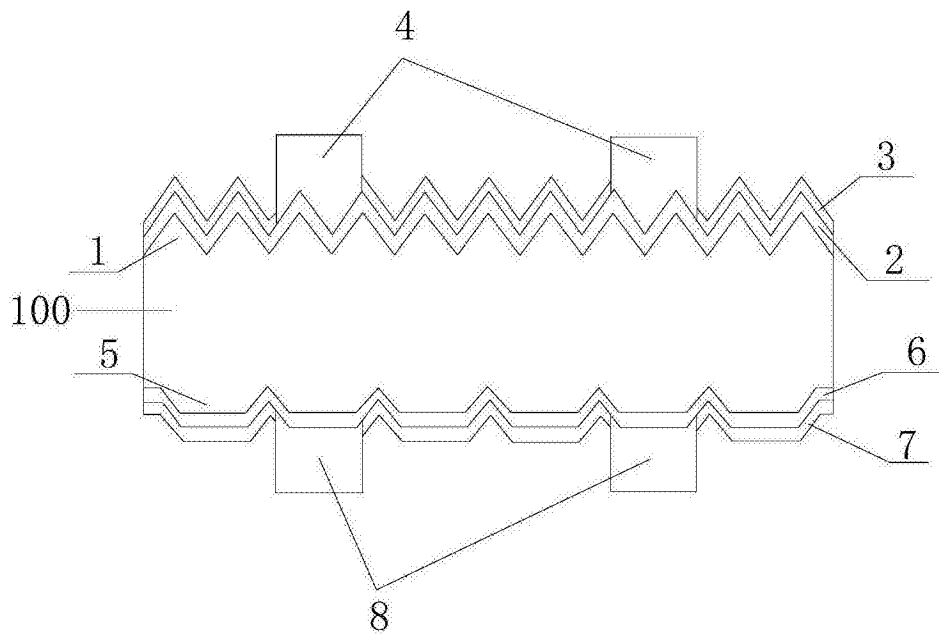


图1

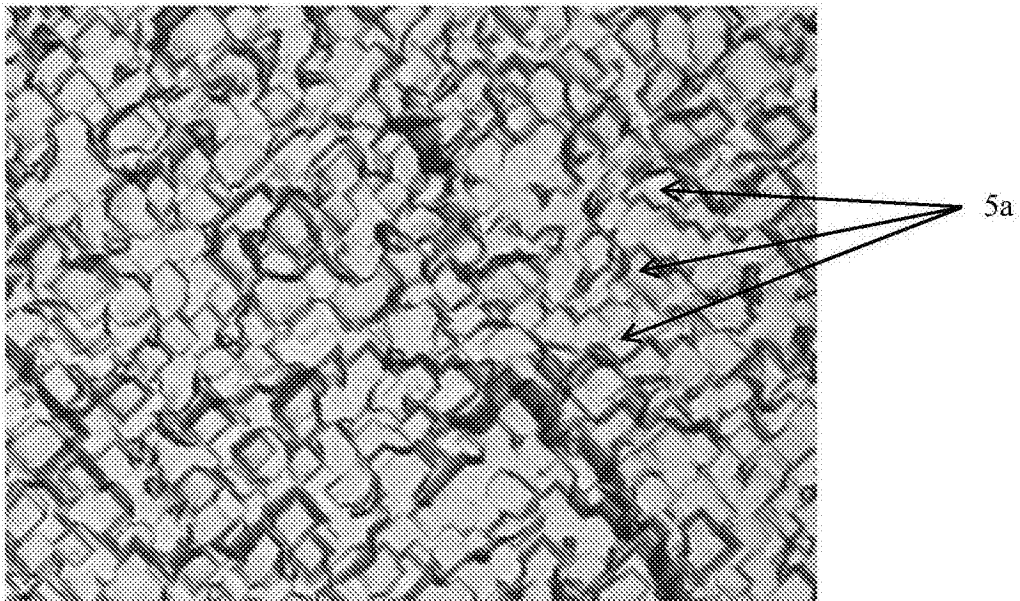


图2



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H01L31/0236 (2006.01)

H01L31/18 (2006.01)

Claims (1 page) Description (5 pages) Drawings (1
page)

(54) Title of Invention

Monocrystalline silicon bifacial solar cells and their preparation
methods

(57) Abstract

This invention discloses a monocrystalline silicon bifacial solar cell. On the front side of a monocrystalline silicon substrate, a front textured structure, a front PN emitter junction, a front passivation antireflection dielectric layer, and a front electrode are sequentially formed. On the back side of the monocrystalline silicon substrate, a back textured structure, a back surface field, a back passivation antireflection dielectric layer, and a back electrode are sequentially formed. The back textured structure is characterized by being a platform-shaped textured surface. The platform structures are dispersed, or laid flat, or partially dispersed, partially laid flat, partially connected, and partially overlapping on the silicon substrate. Each platform structure has a lower plane connected to the silicon substrate and an upper plane opposite to the lower plane. The lower plane is larger than the upper plane. The side length of the upper plane is 2 to 10 μm , and the height of the platform structure is 1 to 8 μm . This invention also discloses a method for fabricating a monocrystalline silicon bifacial solar cell. This invention can optimize the minority carrier surface recombination and optical absorption characteristics of bifacial solar cells, thereby improving quantum conversion efficiency.

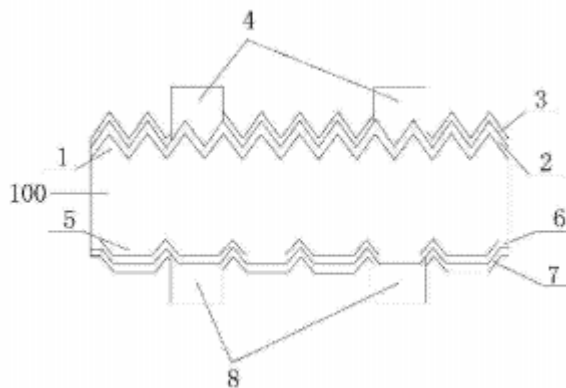


Exhibit B

1. A monocrystalline silicon bifacial solar cell, wherein a front textured morphology structure (1), a front PN emitter junction (2), a front passivation antireflection dielectric layer (3), and a front electrode (4) are sequentially formed on the front side of a monocrystalline silicon substrate (100), and a back textured morphology structure (5), a back surface field (6), a back passivation antireflection dielectric layer (7), and a back electrode (8) are sequentially formed on the back side of the monocrystalline silicon substrate, characterized in that: the back textured morphology structure (5) is a platform-shaped textured surface, and each platform structure (5a) is dispersed, or laid flat, or partially dispersed, partially laid flat, partially connected, and partially overlapping on the silicon substrate; the platform structure (5a) has a lower plane connected to the silicon substrate (100) and an upper plane opposite to the lower plane, the size of the lower plane being larger than that of the upper plane; the side length of the upper plane is 2 to 10 μm , and the height of the platform structure (5a) is 1 to 8 μm .

2. The monocrystalline silicon bifacial solar cell according to claim 1, characterized in that: the front passivation antireflection dielectric layer (3) and the back passivation antireflection dielectric layer (7) are respectively composed of single-layer film or multi-layer film made of silicon oxide, silicon nitride, silicon oxynitride, aluminum oxide, silicon carbide, amorphous silicon, microcrystalline silicon, indium tin oxide or titanium oxide.

3. The monocrystalline silicon bifacial solar cell according to claim 1, characterized in that: the front electrode (104) and the back electrode (108) are one or more metals or alloys of silver, aluminum, copper, nickel, titanium, tin, lead, cadmium, gold, and zinc.

4. A method for preparing a monocrystalline silicon bifacial solar cell, used to prepare the monocrystalline silicon bifacial solar cell according to any one of claims 1-3, comprising the following steps:

S1: Texturing the surface of a single-crystal silicon substrate;

S2: Front-side doping forms an emitter junction;

S3: Remove the impurity-containing glass layer on the back;

S4: The back platform structure was prepared by wet chemical method, and the back-side doped layer was removed;

S5: Back-side doping forms a back surface field;

S6: Prepare front and back passivation and antireflection dielectric layers;

S7: Prepare the front and back electrodes.

5. The method for preparing a monocrystalline silicon bifacial solar cell according to claim 4, characterized in that: in step S4, the chemical reagents used in the wet chemical method for preparing the back platform structure are one or more aqueous solutions of sodium hydroxide, potassium hydroxide, tetramethylammonium hydroxide, nitric acid, phosphoric acid, hydrofluoric acid, ethanol, isopropanol or ethylene glycol; the preparation temperature is 60 to 80°C, and the time is 10 to 900 seconds.

6. The method for preparing a monocrystalline silicon bifacial solar cell according to claim 4, characterized in that: between steps S2 and S3, the following step is further included:

S2-1: front-side deposition of a barrier layer: a process barrier layer of silicon oxide thin film is deposited on the front side by PECVD, with a thickness of 50 to 300 nm.

7. The method for preparing a monocrystalline silicon bifacial solar cell according to claim 4, characterized in that: between steps S5 and S6, the following step is further included:

S5-1: using hydrofluoric acid to remove the silicon oxide, phosphosilicate glass on the front side and the borosilicate glass on the back side.

Monocrystalline silicon bifacial solar cells and their preparation methods

Technical Field

[0001] This invention relates to a solar cell and its preparation method, and more particularly to a monocrystalline silicon bifacial solar cell and its preparation method, belonging to the field of solar cell technology.

Background Art

[0002] Improving battery conversion efficiency while reducing or even maintaining manufacturing costs is a constant goal and a key to enhancing competitiveness in the industry. Compared to traditional crystalline silicon solar cells that receive light from only one side, bifacial solar cells utilize two light-receiving surfaces (front and back) to achieve higher photocurrent density, significantly increasing power generation. Depending on the installation site and environment, photovoltaic power generation systems based on bifacial solar cells can achieve a power gain of 10% to 30%.

[0003] The structure of a bifacial solar cell includes: textured surface structures on the front and back sides, a pn junction emitter, a passivation and antireflection dielectric layer, and front and back electrodes. Among these, the textured surface on the back side effectively improves the absorption of ground- and ambient reflected light on the back side of the bifacial cell, making it a crucial structural element. Currently, the back side of bifacial solar cells employs a similar textured surface structure to the front side, with closely spaced, overlapping pyramids obtained through texturing. While this close-packed pyramid structure maximizes the absorption of direct sunlight, it is not necessarily the optimal light absorption structure for diffuse reflection, and the higher surface area can lead to minority carrier recombination. Therefore, the back side structure of bifacial solar cells requires further optimization.

Summary of the Invention

[0004] In view of the above-mentioned technical problems existing in the prior art, the present invention provides a monocrystalline silicon bifacial solar cell, which optimizes the minority carrier surface load and optical absorption characteristics of the solar cell and improves the quantum conversion efficiency.

[0005] In another aspect, the present invention provides a method for preparing a monocrystalline silicon bifacial solar cell, thereby improving the conversion efficiency and production efficiency of the solar cell.

[0006] Therefore, the present invention adopts the following technical solution:

[0007] A monocrystalline silicon bifacial solar cell is formed by sequentially forming a front-side texturing morphology structure on the front side of a monocrystalline silicon substrate (100).

(1) A front PN emitter junction (2), a front passivation antireflection dielectric layer (3), and a front electrode (4) are sequentially formed on the back side of a single-crystal silicon substrate. A back textured morphology structure (5), a back surface field (6), a back passivation antireflection dielectric layer (7), and a back electrode (8) are formed in sequence. The back textured morphology structure (5) is a platform-shaped textured surface. Each platform structure (5a) is dispersed, or laid flat, or partially dispersed, partially laid flat, partially connected, and partially overlapping on the silicon substrate. The platform structure (5a) has a lower plane connected to the silicon substrate (100) and an upper plane opposite to the lower plane. The size of the lower plane is larger than that of the upper plane. The side length of the upper plane is 2 to 10 μm , and the height of the platform structure (5a) is 1 to 8 μm .

[0008] Further, the front passivation antireflection dielectric layer (3) and the back passivation antireflection dielectric layer (7) are respectively single-layer films or multi-layer films composed of silicon oxide, silicon nitride, silicon oxynitride, aluminum oxide, silicon carbide, amorphous silicon, microcrystalline silicon, indium tin oxide or titanium oxide.

[0009] Further, the front electrode (104) and the back electrode (108) are one or more metals or alloys of silver, aluminum, copper, nickel, titanium, tin, lead, cadmium, gold, and zinc.

[0010] In this invention, “dispersed” means that the bottoms of each platform structure (5a) do not contact each other; “flat” means that the bottoms of each adjacent platform structure (5a) contact each other but do not overlap or intersect; “partially connected” means that the bottoms of some adjacent platform structures (5a) contact each other but do not overlap or

intersect; “partially overlapping” means that some adjacent platform structures (5a) overlap each other; “partially dispersed, partially flat, partially connected, and partially overlapping on the silicon substrate” can be any combination of two or more of the four distribution methods.

[0011] In another aspect, the present invention provides a method for preparing a monocrystalline silicon bifacial solar cell, comprising the following steps:

[0012] S1: Texturing the surface of a single-crystal silicon substrate;

[0013] S2: Front-side doping forms an emitter junction;

[0014] S3: Remove the glass layer containing impurities on the back side;

[0015] S4: Prepare the back platform structure using a wet chemical method and remove the back-side doped layer;

[0016] S5: Back-side doping forms a back surface field;

[0017] S6: Prepare front and back passivation antireflection dielectric layers;

[0018] S7: Prepare the front and back electrodes.

[0019] In step S4, the chemical reagents used in the wet chemical method to prepare the back platform structure are one or more aqueous solutions of sodium hydroxide, potassium hydroxide, tetramethylammonium hydroxide, nitric acid, phosphoric acid, hydrofluoric acid, ethanol, isopropanol or ethylene glycol; the preparation temperature is 60 to 80°C and the time is 10 to 900 seconds.

[0020] Further, between steps S2 and S3, the following step is also included: S2-1: Front-side deposition of a barrier layer.

[0021] Further, between steps S5 and S6, the following steps are also included: S5-1: Use hydrofluoric acid to remove the silicon oxide, phosphosilicate glass on the front side and the borosilicate glass on the back side.

[0022] The monocrystalline silicon bifacial solar cell of the present invention reduces the surface area of the textured surface on the back of the cell by providing a platform-shaped textured surface, which significantly reduces the recombination of photogenerated minority carriers on the back surface; the reflection of long-wavelength light incident from the front surface increases and the transmission decreases, and the light is reabsorbed by the solar cell. Therefore, the platform-shaped morphology on the back can optimize the surface recombination and optical absorption characteristics of minority carriers in the bifacial solar cell, thereby improving the quantum conversion efficiency.

[0023] The method for preparing a monocrystalline silicon bifacial solar cell of the present invention only adds a wet chemical method to prepare the back platform morphology structure. The process is relatively simple and suitable for low-cost, large-scale, and stable industrial manufacturing.

Brief Description of the Drawings

[0024] Figure 1 is a schematic diagram of the structure of the monocrystalline silicon bifacial solar cell of the present invention;

[0025] Figure 2 is a microscope photograph of the platform-shaped textured surface of the present invention;

[0026] Wherein, 100 is a single crystal silicon substrate, 1 is a front textured morphology structure, 2 is a front doped emitter junction, 3 is a front passivation antireflection dielectric layer, 4 is a front electrode, 5 is a back textured morphology structure, 5a is a platform structure, 6 is a back surface field, 7 is a back passivation antireflection dielectric layer, and 8 is a back electrode; the corresponding product structures in the figure are only schematic diagrams and are not drawn to scale.

Detailed Description of the Embodiments

[0027] In order to enable those skilled in the art to better understand the present invention, the technical solutions of the present invention will be clearly and completely described below with reference to the accompanying drawings in the embodiments of the present invention.

[0028] Embodiment 1:

[0029] This embodiment describes the application of the present invention to P-type single-crystal silicon. As shown in FIG1, a front-side texturing structure 1 is sequentially formed on the front side of the P-type single-crystal silicon substrate 100. In this embodiment, it consists of a front-side pyramidal texturing surface, a front phosphorus-doped emitter junction 2, a front passivation antireflection dielectric layer 3, and a front electrode 4. On the back of the P-type single-crystal silicon

substrate, a back texturing structure 5, a back-side boron-doped back surface field 6, a back passivation antireflection dielectric layer 7, and a back electrode 8 are sequentially formed. As shown in FIG2, the back texturing structure 5 is a platform-shaped texturing surface. Each platform structure 5a is dispersed, or partially connected, or partially overlapping, or partially dispersed, partially connected, and partially overlapping distributed on the silicon substrate.

[0030] In this embodiment, the platform structures 5a are partially dispersed and partially overlapped on the silicon substrate. As shown in FIG1, the platform structure 5a has a lower plane connected to the silicon substrate 100 and an upper plane opposite to the lower plane. The size of the lower plane is larger than that of the upper plane, the side length of the upper plane is 2 μm , and the height of the platform structure 5a is 1 μm . The front passivation antireflection dielectric layer 3 is a single-layer film made of silicon nitride with a thickness of 70 to 80 nm; the back passivation antireflection dielectric layer 7 is a double-layer film made of aluminum oxide and silicon nitride, wherein the aluminum oxide film is 20 to 30 nm thick and the silicon nitride film is 50 to 70 nm thick. The front electrode 104 and the back electrode 108 are both silver gate electrodes.

[0031] Embodiment 2:

[0032] The difference between this embodiment and Embodiment 1 is that in the back texturing structure 5, each platform structure 5a is partially dispersed and partially connected on the silicon substrate. The side length of the upper plane of the platform structure 5a is 10 μm , and the height of the platform structure 5a is 8 μm . The front passivation antireflection dielectric layer 3 is a single-layer film made of silicon oxynitride with a thickness of 70 to 80 nm; the back passivation antireflection dielectric layer 7 is a double-layer film made of titanium oxide and silicon oxide, wherein the titanium oxide film thickness is 20 to 30 nm and the silicon oxide film thickness is 50 to 70 nm. Both the front electrode 4 and the back electrode 8 are copper electrodes.

[0033] Embodiment 3:

[0034] This embodiment describes the application of the present invention to N-type single-crystal silicon. As shown in FIG1, a front pyramid-shaped textured surface 1, a front boron-doped emitter junction 2, a front passivation antireflection dielectric layer 3, and a front electrode 4 are sequentially formed on the front side of the N-type single-crystal silicon substrate 100. On the back side of the N-type single-crystal silicon substrate, a back textured morphology structure 5, a phosphorus-doped back surface field 6 formed by back phosphorus doping, a back passivation antireflection dielectric layer 7, and a back electrode 8 are sequentially formed. The back textured morphology structure 5 is a platform-shaped textured surface, and each platform structure 5a is dispersedly distributed on the silicon substrate. As shown in FIG1, the platform structure 5a has a lower plane connected to the silicon substrate 100 and an upper plane opposite to the lower plane. The size of the lower plane is larger than that of the upper plane. The side length of the upper plane is 4 μm , and the height of the platform structure 5a is 3 μm . The front passivation antireflection dielectric layer 3 is a bilayer film made of aluminum oxide and silicon nitride, wherein the aluminum oxide film is 20 to 30 nm thick and the silicon nitride film is 50 to 70 nm thick; the back passivation antireflection dielectric layer 7 is a single layer film made of silicon nitride, with a film thickness of 70 to 80 nm; the front electrode 4 and the back electrode 8 are both silver gate electrodes.

[0035] Embodiment 4:

[0036] The difference between this embodiment and embodiment 3 is that: in the back-side texturing morphology structure 5, each platform structure 5a is partially overlapped on the silicon substrate, and the non-overlapping parts can be dispersed or laid flat; the side length of the upper plane of the platform structure 5a is 7 μm , and the height of the platform structure 5a is 6 μm . The front passivation antireflection dielectric layer 3 is a bilayer film made of indium tin oxide and amorphous silicon, wherein the indium tin oxide film thickness is 60 to 80 nm and the amorphous silicon film thickness is 5 to 20 nm; the back passivation antireflection dielectric layer 7 is a bilayer film made of indium tin oxide and amorphous silicon, wherein the indium tin oxide film thickness is 60 to 80 nm and the amorphous silicon film thickness is 5 to 20 nm; the front electrode 4 and the back electrode 8 are both silver electrodes.

[0037] Embodiment 5:

[0038] A method for preparing a monocrystalline silicon bifacial solar cell, used to prepare the P-monocrystalline silicon bifacial solar cell described in Embodiment 1, includes the following steps:

[0039] S1: Texturing the surface of a single-crystal silicon substrate: Using an alkaline texturing solution containing sodium hydroxide and isopropanol at a temperature of 80°C, texturing is performed on the surface of a p-type single-crystal silicon substrate 100 to form a front textured surface morphology 1, while removing the silicon wafer cutting damage layer.

[0040] S2: Front-side doping to form an emitter junction: Phosphorus doping is performed to form a front doped emitter junction 2. Phosphorus doping can be performed by tube furnace diffusion with phosphorus oxychloride source, ion implantation, or diffusion by coating with a phosphorus-containing impurity layer. The diffusion sheet resistance is 40 to 200 $\Omega/\square$.

- [0041] S2-1: Front-side deposition barrier layer: A process barrier layer with a thickness of 50 to 300 nm is deposited on the front side using PECVD to deposit a silicon oxide thin film;
- [0042] S3: Remove the impurity-containing glass layer on the back side: Use hydrofluoric acid to remove the phosphosilicate glass layer on the back side;
- [0043] S4: Prepare the back plateau structure by wet chemical method and remove the back doping: Use an alkaline solution containing tetramethylammonium hydroxide and isopropanol at a temperature of 80°C for 10 to 900s to prepare the back-side texturing morphology structure 5, while removing the back phosphorus doping layer.
- [0044] S5: Back surface doping to form a back surface field: Boron doping is performed to form a back surface field 6. Boron doping can be performed by tube furnace diffusion with boron tribromide source, ion implantation, or diffusion by coating with a boron-containing impurity layer. The diffusion sheet resistance is 60 to 200 $\Omega/\square$.
- [0045] S5-1: Use hydrofluoric acid to remove the silicon oxide, phosphosilicate glass on the front side and the borosilicate glass on the back side;
- [0046] S6: Preparation of front and back passivation antireflection dielectric layers: The front silicon nitride passivation antireflection dielectric layer 3 and the back aluminum oxide/silicon nitride passivation antireflection dielectric layer 7 are prepared by PECVD; the thickness of the front silicon nitride is 70 to 80 nm, the thickness of the back aluminum oxide is 20 to 30 nm, and the thickness of the silicon nitride is 50 to 70 nm;
- [0047] S7: Preparation of front and back electrodes: Silver-containing grid line electrodes 4 and 8 are prepared on the front and back sides respectively by screen printing, and then sintered at high temperature. The sintering temperature is 850 to 900°C.
- [0048] Of course, in step S4, an acidic solution containing nitric acid and hydrofluoric acid can also be used to prepare the back platform structure.
- [0049] The preparation method of Embodiment 2 is the same as that of Embodiment 1.
- [0050] Embodiment 6:
- [0051] A method for preparing a monocrystalline silicon bifacial solar cell, used to prepare the N monocrystalline silicon bifacial solar cell described in Embodiment 3, includes the following steps:
- [0052] S1: Texturing the surface of a single-crystal silicon substrate: Using an alkaline texturing solution containing sodium hydroxide and isopropanol at a temperature of 80°C, texturing is performed on the surface of an n-type single-crystal silicon substrate 100 to form a front textured surface morphology 1, while removing the silicon wafer cutting damage layer.
- [0053] S2: Front-side doping to form an emitter junction: Boron doping is performed to form a front boron-doped emitter junction 2. Phosphorus doping can be achieved by tube furnace diffusion with a boron tribromide source, ion implantation, or diffusion with a boron-containing impurity layer. The diffusion sheet resistance is 60 to 200 $\Omega/\square$.
- [0054] S2-1: Front-side deposition barrier layer: A process barrier layer with a thickness of 50 to 300 nm is deposited on the front side using PECVD to deposit a silicon oxide thin film;
- [0055] S3: Remove the impurity-containing glass layer on the back: Use hydrofluoric acid to remove the borosilicate glass layer on the back;
- [0056] S4: Prepare the back plateau structure by wet chemical method and remove the back doping: Use an alkaline solution containing tetramethylammonium hydroxide and isopropanol at a temperature of 80°C for 10 to 900 s to prepare the back-side texturing morphology structure 5, while removing the back boron doping layer.
- [0057] S5: Back-side doping to form a back surface field: Phosphorus doping is performed to form a back surface field 6. Phosphorus doping can be performed by tube furnace diffusion with phosphorus oxychloride source, ion implantation, or diffusion by coating with a phosphorus-containing impurity layer. The diffusion sheet resistance is 40 to 200 $\Omega/\square$.
- [0058] S5-1: Use hydrofluoric acid to remove the silicon oxide, borosilicate glass on the front side and the phosphosilicate glass on the back side;
- [0059] S6: Preparation of front and back passivation antireflection dielectric layers: The front alumina/silicon nitride passivation antireflection dielectric layer 3 and the back silicon nitride passivation antireflection dielectric layer 7 are prepared by PECVD; the front alumina thickness is 20 to 30 nm, the silicon nitride thickness is 50 to 70 nm, and the back silicon nitride thickness is 70 to 80 nm;
- [0060] S7: Preparation of front and back electrodes: Silver-containing grid line electrodes 4 and 8 are prepared on the front and back sides respectively by screen printing, and then sintered at high temperature. The sintering temperature is 850 to 900°C.
- [0061] The preparation method of Embodiment 4 is the same as that of Embodiment 3.
- [0062] Obviously, the described embodiments are only some embodiments of the present invention, and not all embodiments.

Based on the embodiments of this invention, all other embodiments obtained by those skilled in the art without creative effort should fall within the scope of protection of this invention.

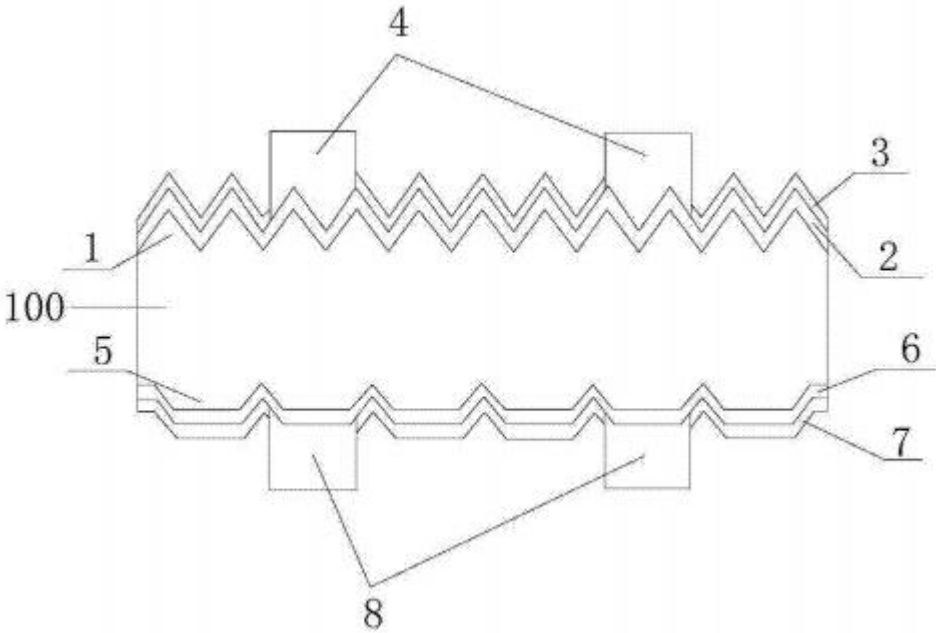


Figure 1

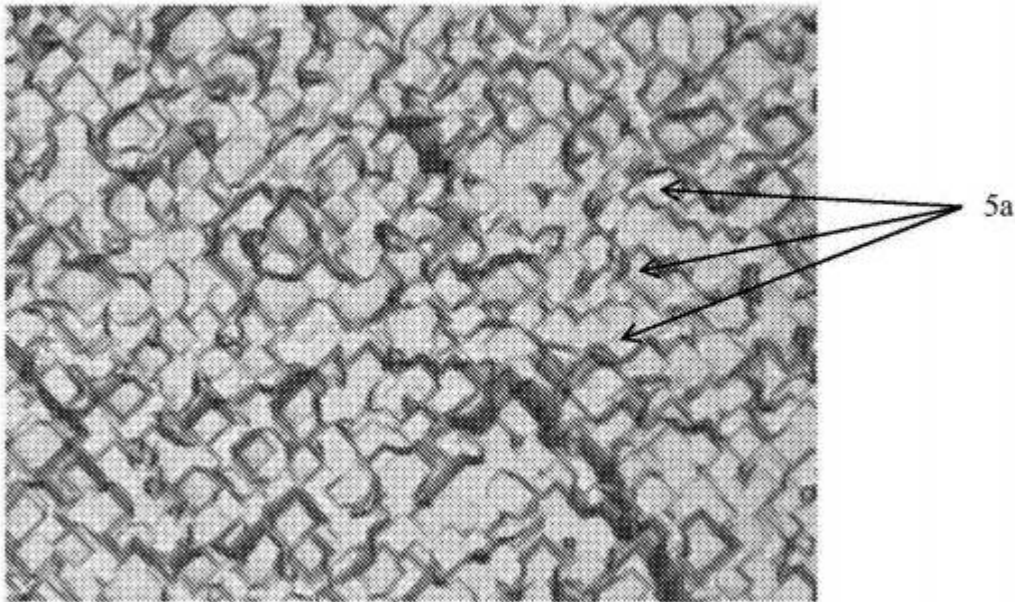


Figure 2

CERTIFICATE OF ACCURACY

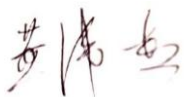
Attached as Ex A is the original document identified as patent application number CN105826411B and attached as Ex B is the translation of the original document from Chinese to English.

This is to certify under penalty of perjury that I, Weijie Huang, 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 15 years of experience in translating Chinese to English and hold a Bachelor's degree in Linguistics from Beijing Language and Culture 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: 01/19/2026



Weijie Huang
Chinese > English Linguist

Your
legal
translation
partner 

Weijie Huang

Highlights

15 years in translation between Chinese and English in multiple domains with a focus on litigation.

Experience

Translator | Mar 2008 – Present

- Extensive experience translating litigation and dispute-related documents, including court pleadings, judgments, affidavits, witness statements, evidentiary materials, and legal correspondence for use in cross-border litigation and arbitration.
- Proven expertise in financial and corporate translation, covering annual reports, audited financial statements, investment agreements, shareholder agreements, trust deeds, compliance materials, and internal governance documents.
- Specialized experience in patent and IP translation, including patent specifications, claims, abstracts, office actions, prosecution history, prior art references, and related technical-legal documentation, with strict adherence to jurisdiction-specific terminology and formatting requirements.

Partial list of subject matter experience:

Telecommunications

- 4G/LTE, 5G NR, and 6G Standards
- Network Architecture and Protocols (TCP/IP, RAN, NFV)
- Wireless and Mobile Communication
- Signal Processing and Data Encoding
- Internet of Things (IoT) and M2M
- Satellite and Microwave Communication
- Cybersecurity and Encryption Protocols

Mechanical Engineering

- Automotive Engineering (EV Drivetrains, Autonomous Systems)
- Robotics and Industrial Automation
- Thermodynamics and Heat Exchange Systems
- Fluid Dynamics and Hydraulic/Pneumatic Systems
- Aerospace and Aeronautical Engineering
- Manufacturing and Tooling (CNC, Additive Manufacturing)

Pharmaceuticals

- Drug Delivery
- Biologics and Monoclonal Antibodies (mAbs)
- Gene and Cell Therapy (CRISPR, mRNA)
- Small Molecule Synthesis and API Manufacturing
- Pharmacokinetics and Pharmacodynamics (ADME)
- Clinical Trial Protocols and Regulatory Documentation
- Immunology and Vaccine Development
- Medicinal Chemistry

Chemistry

- Polymer and Materials Science
- Organic and Inorganic Synthesis
- Electrochemistry (Batteries, Fuel Cells)
- Heterogeneous and Homogeneous Catalysis
- Nanotechnology and Nanomaterials
- Petrochemicals and Refining Processes
- Analytical Chemistry and Spectroscopic Methods
- Biochemistry and Enzymology

- Regularly handles high-stakes legal translations submitted to courts, regulators, arbitration panels, and government authorities, ensuring precision, consistency, and defensibility of terminology.
- Deep familiarity with common law and civil law systems, enabling accurate rendering of legal concepts across jurisdictions without distortion of legal effect or procedural meaning.
- Experienced in translating complex, multi-entity and multi-jurisdictional matters, including materials involving offshore structures, trusts, cross-border investments, and regulatory filings.
- Skilled in maintaining terminology consistency across large-volume projects through glossaries, style guides, and parallel reference materials, particularly in long-running litigation or patent portfolios.
- Experienced in producing certified and court-ready translations, including Certificates of Accuracy where required, and working under tight litigation and regulatory deadlines.
- Comfortable collaborating with law firms, in-house legal teams, IP professionals, financial advisors, and compliance teams, responding to revision requests and clarification queries with precision and professionalism.
- Strong attention to detail, formatting fidelity, and document structure, ensuring translated documents mirror the original legal and technical layout for seamless reference and submission.

Education and Training

Bachelor of English Language and Literature, Beijing Language & Culture University (BLCU) (2004-2008)
Master of Professional Studies, Informatics with Concentration in Data Analytics, Northeastern University, (2022-2024)

Skills & Language Abilities

Bilingual (English-Mandarin) with fluency in Cantonese and basic French