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(56)參考文獻：

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申請專利範圍項數：8 項 圖式數：4 共 18 頁

(54)名稱

結晶矽鹼性拋光液的添加劑及其應用

AN ADDITIVE FOR CRYSTALLINE SILICON ALKALINE POLISHING LIQUID AND USE THEREOF

(57)摘要

本發明公開了一種結晶矽鹼性拋光液的添加劑及其應用，該添加劑由 0.5~2% 聚乙二醇、0.5~2% 烷基糖苷、0.5~2% 硬脂酸銨、1~3% 的乙二胺、1~5% 的硫酸銨、2~8% 的尿素和餘量的水組成。在對矽片進行製絨前的拋光預處理時，將本發明的添加劑加入到鹼性溶液中，可達到優異的拋光效果，可在低鹼濃度下實現矽片拋光，提高絨面的均勻性，從而顯著提高電池開路電壓和電池效率。本發明添加劑也適用於矽片擴散後的單面拋光。

The present invention relates to an additive for crystalline silicon alkaline polishing liquid and use thereof, the additive comprising: 0.5~2% PEG, 0.5~2% Alkyl polyglycosides, 0.5~2% Ammonium stearate, 1~3% Ethylenediamine, 1~5% Ammonium sulfate, 2~8% Urea and a remaining amount of water. Using an alkaline solution which is included said additive for pre-polishing surface of silicon chip before texturing process to achieve excellent polishing effect, polishing could be performed in low alkali concentration, and increasing uniformity in texturing, significantly increasing open circuit voltage and efficiency of battery. The present invention also applies to polishing one surface of silicon chip after diffusion.

指定代表圖：

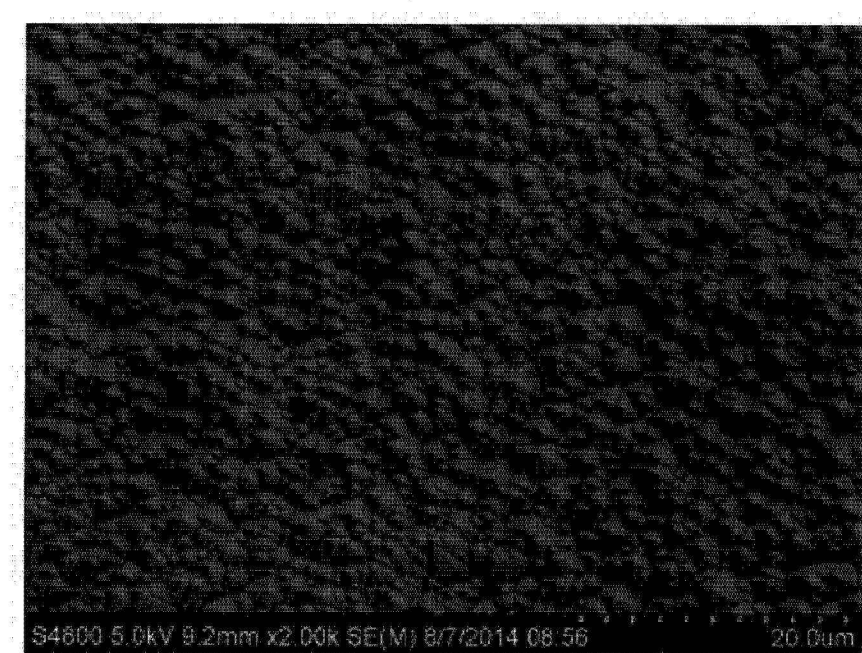


圖 4

公告本

發明摘要

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【發明名稱】(中文/英文)

結晶矽鹼性拋光液的添加劑及其應用/

An additive for crystalline silicon alkaline polishing liquid and use thereof

【中文】

本發明公開了一種結晶矽鹼性拋光液的添加劑及其應用，該添加劑由 0.5~2%聚乙二醇、0.5~2%烷基糖苷、0.5~2%硬酯酸銨、1~3%的乙二胺、1~5%的硫酸銨、2~8%的尿素和餘量的水組成。在對矽片進行製絨前的拋光預處理時，將本發明的添加劑加入到鹼性溶液中，可達到優異的拋光效果，可在低鹼濃度下實現矽片拋光，提高絨面的均勻性，從而顯著提高電池開路電壓和電池效率。本發明添加劑也適用於矽片擴散後的單面拋光。

【英文】

The present invention relates to an additive for crystalline silicon alkaline polishing liquid and use thereof, the additive comprising: 0.5~2% PEG, 0.5~2% Alkyl polyglycosides, 0.5~2% Ammonium stearate, 1~3% Ethylenediamine, 1~5% Ammonium sulfate, 2~8% Urea and a remaining amount of water. Using an alkaline solution which is included said additive for pre-polishing surface of silicon

chip before texturing process to achieve excellent polishing effect, polishing could be performed in low alkali concentration, and increasing uniformity in texturing, significantly increasing open circuit voltage and efficiency of battery. The present invention also applies to polishing one surface of silicon chip after diffusion.

【代表圖】

【本案指定代表圖】：圖 4

【本代表圖之符號簡單說明】：

【本案若有化學式時，請揭示最能顯示發明特徵的化學式】：

無

發明專利說明書

(本說明書格式、順序，請勿任意更動)

【發明名稱】(中文/英文)

結晶矽鹼性拋光液的添加劑及其應用/

An additive for crystalline silicon alkaline polishing liquid and use thereof

【技術領域】

本發明涉及結晶矽鹼性拋光液的添加劑及其應用。

【先前技術】

矽片表面的絨面製作對於太陽電池來說至關重要，不僅可以顯著降低矽的反射率，而且可以通過增加光在矽中的光程來增加矽對光的吸收。目前輔助出絨的方法很多，包括各種製絨添加劑，可以保證絨面出絨率達到 100%，讓製絨工藝變成一個可控的生產環節。隨著製絨工藝的發展，絨面的均勻性是提升電池效率的方法之一。絨面的均勻性越好，則電池片的開壓越高，從而效率也越高。然而，目前習知製絨後的絨面均勻性不佳，如金字塔的尺寸不均一，同時亦有金字塔塔肩上再生長小金字塔的現象。而經過先拋光後製絨工藝的矽片，可以實現均勻的金字塔結構，從而提升電池片的開壓和效率。很多公司採用高濃度的鹼溶液進行拋光後，再在低濃度鹼液中製絨，電池效率獲得了明顯的提升。但這種預處理經常帶來外觀方面的困擾，這是因為在高溫高鹼濃度的溶液中進行拋光時，矽酸鈉極易在表面殘留，並且矽酸鈉在進入製絨槽前就會固化，嚴重干擾矽片後續的製絨過程，導致矽酸

鈉覆蓋的區域沒有金字塔絨面，在矽片表面呈現發亮的白斑，嚴重影響電池的外觀和成品率。

實現低溫低鹼濃度的矽片拋光，同時避免相應的外觀問題，這將是拋光添加劑的機會和挑戰。

另一方面，目前流行的 PERC 電池（鈍化射極及背接觸式電池，Passivated emitter rear contact solar cells）工藝需要比較平整的背面進行氧化鋁鈍化，優化的方案是背面選用鹼溶液拋光，這樣表面態密度更低，鈍化效果更好。但一般的鹼溶液拋光形成的背面平整度不高，台階面過多，導致後續的鈍化效果降低。如何提升鹼拋光效果以獲得滿意的鈍化結果，對於 PERC 電池來說有著重要的意義。

【發明內容】

本發明的目的在於提供一種結晶矽鹼性拋光液的添加劑及其應用，在對矽片進行製絨前的拋光預處理時，將本發明的添加劑加入到鹼性溶液中，可達到優異的拋光效果，可在低鹼濃度下實現矽片拋光，提高絨面的均勻性，從而顯著提高電池開路電壓和電池效率；且本發明添加劑也適用於矽片擴散後的單面拋光，能夠獲得相對平整、均勻的背拋光表面，特別適用於 PERC 電池工藝，能輔助實現對 PERC 電池鈍化效果的提高。

為實現上述目的，本發明提供一種結晶矽鹼性拋光液的添加劑，由 0.5~2%聚乙二醇、0.5~2%烷基糖苷、0.5~2%硬酯酸銨、1~3%的乙二胺、1~5%的硫酸銨、2~8%的尿素和餘量的水組成。

優選的，所述的結晶矽鹼性拋光液的添加劑，由 1~1.5%聚

乙二醇、1~1.5%烷基糖苷、0.5~1%硬酯酸銨、1~2%的乙二胺、2~4%的硫酸銨、3~6%的尿素和餘量的水組成。

優選的，所述水為去離子水。

本發明還提供一種結晶矽鹼性拋光液，通過如下步驟配製：

1) 將氫氧化鈉、氫氧化鉀或四甲基氫氧化銨溶於去離子水中，得到鹼性溶液；所述氫氧化鈉、氫氧化鉀的品質百分含量為1~5%；所述四甲基氫氧化銨的品質百分含量為2~6%；

2) 將上述的添加劑加入上述步驟1)中的鹼性溶液中，得到結晶矽鹼性拋光液；其中，添加劑與鹼性溶液的品質比為1~6:100。

一種優選的方案，所述氫氧化鈉、氫氧化鉀的品質百分含量為2~3%；所述四甲基氫氧化銨的品質百分含量為3~5%。

另一種優選的方案，所述氫氧化鈉、氫氧化鉀的品質百分含量為1~1.5%；所述四甲基氫氧化銨的品質百分含量為2~2.5%。

優選的，所述添加劑與鹼性溶液的品質比為2~4:100。

本發明還提供一種結晶矽拋光方法，將單晶或多晶矽片浸入到上述的拋光液中進行拋光，溫度控制在攝氏60~80度，時間控制在0.5~5分鐘。

本發明的優點和有益效果在於：提供一種結晶矽鹼性拋光液的添加劑及其應用，在對矽片進行表面拋光時，將本發明的添加劑加入到鹼性溶液中，可達到優異的拋光效果，可在低鹼濃度下實現拋光，且本發明添加劑能適用於先拋光後製絨的工藝，能使矽片的拋光效果提高，同時降低成本，縮短反應時間，降低電池

片碎片率，提高電池片的產能，同時提高電池片的光電轉換效率。

添加劑中的硬酯酸鉍、硫酸鉍能使矽片在較小減重下即可獲得穩定的均勻金字塔結構；選擇將乙二胺、尿素添加在拋光體系中，可以使後道製絨的絨面尺寸和反射率可控，從而滿足不同的需求。

採用本發明添加劑，能使拋光反應速度加快，並可在低鹼濃度下實現拋光，節約鹼用量 15-30%。本發明添加劑應用範圍廣，既能應用於單晶矽片的拋光，亦能應用於多晶矽片的拋光。本發明添加劑更能適用於先拋光後製絨的工藝，經過先拋光後製絨工藝後獲得的絨面相對只經過製絨的絨面更加均勻，金字塔沒有疊加的狀態，從而提升開壓，提升電池效率 0.2% 以上，並且減重可控制在 0.5-0.7 公克（156 單晶矽片），與習知鹼製絨工藝相當。當然，本發明添加劑也能適用於先製絨後背拋光的工藝，矽片經過背拋光後能獲得均勻平整的絨面。

【圖式簡單說明】

圖 1 是習知背拋光矽片表面拋光面的顯微鏡照片；

圖 2 是實施例 1 得到的矽片表面拋光面的顯微鏡照片；

圖 3 是習知製絨絨面的掃描電鏡照片；

圖 4 是實施例 2 得到的先拋光後製絨絨面的掃描電鏡照片。

【實施方式】

下面結合附圖和實施例，對本發明的具體實施方式作進一步描述。以下實施例僅用於更加清楚地說明本發明的技術方案，而不能以此來限制本發明的保護範圍。

本發明具體實施的技術方案是：

實施例 1

先拋光後製絨，其中拋光工藝採取如下步驟：

1) 配製結晶矽鹼性拋光液的添加劑：

以去離子水為溶劑，將 2 公克聚乙二醇(PEG)、2 公克烷基糖苷(Alkyl polyglycosides)、2 公克硬脂酸銨(Ammonium stearate)、3 公克的乙二胺(Ethylenediamine)、5 公克的硫酸銨(Ammonium sulfate)、8 公克的尿素(Urea)溶解於去離子水中，製得 100 公克添加劑；

2) 配製鹼性溶液：

將 50 公克氫氧化鈉溶解於去離子水中，得到 1000 公克鹼性溶液；

3) 在 1000 公克鹼性溶液中加入 60 公克添加劑；

4) 將單晶矽片浸入拋光液中進行拋光，溫度控制在攝氏 80 度，時間控制在 5 分鐘。

習知背拋光矽片表面拋光面的顯微鏡照片如圖 1 所示，可以看到，習知背拋後拋光面方塊尺寸不均一，且拋光面不平整。圖 2 給出了本實施例得到的矽片表面拋光面的顯微鏡照片，從圖 2 中可以看到矽片表面形成了均勻平滑的方塊結構，尺寸約為 20~30 μm (微米)。

實施例 2

先拋光後製絨，其中拋光工藝採取如下步驟：

1) 配製結晶矽鹼性拋光液的添加劑：

以去離子水為溶劑，將 0.5 公克聚乙二醇、0.5 公克烷基糖苷、0.5 公克硬脂酸銨、1 公克的乙二胺、1 公克的硫酸銨、2 公克的尿素溶解於去離子水中，製得 100 公克添加劑；

2) 配製鹼性溶液：

將 20 公克四甲基氫氧化銨溶解於去離子水中，得到 1000 公克鹼性溶液；

3) 在 1000 公克鹼性溶液中加入 10 公克添加劑；

4) 將單晶矽片浸入拋光液中進行拋光，溫度控制在攝氏 60 度，時間控制在 0.5 分鐘。

習知製絨絨面的掃描電鏡照片如圖 3 所示，圖 4 給出了本實施得到的先拋光後製絨絨面的掃描電鏡照片，從圖 4 中可以看到經過拋光-製絨工藝後獲得的絨面相對只經過製絨的絨面更加均勻，金字塔沒有疊加的狀態。

實施例 3

先製絨後背拋光，其中拋光工藝採取如下步驟：

1) 配製結晶矽鹼性拋光液的添加劑：

以去離子水為溶劑，將 1.5 公克聚乙二醇、1.5 公克烷基糖苷、1 公克硬脂酸銨、2 公克的乙二胺、4 公克的硫酸銨、6 公克的尿素溶解於去離子水中，製得 100 公克添加劑；

2) 配製鹼性溶液：

將 30 公克氫氧化鉀溶解於去離子水中，得到 1000 公克鹼性溶液；

3) 在 1000 公克鹼性溶液中加入 40 公克添加劑；

4) 將多晶矽片浸入拋光液中進行拋光，溫度控制在攝氏 70 度，時間控制在 2.5 分鐘。

實施例 4

在實施例 1 的基礎上，改氫氧化鈉為 10 公克，聚乙二醇為 1 公克。

實施例 5

在實施例 1 的基礎上，改氫氧化鈉為 12 公克，烷基糖苷為 1 公克。

實施例 6

在實施例 1 的基礎上，改氫氧化鈉為 15 公克，硬脂酸銨為 0.7 公克。

實施例 7

在實施例 1 的基礎上，改氫氧化鈉為 18 公克，乙二胺為 1.5 公克。

實施例 8

在實施例 1 的基礎上，改氫氧化鈉為 20 公克，硫酸銨為 1.4 公克。

實施例 9

在實施例 1 的基礎上，改氫氧化鈉為 25 公克，尿素為 2.5 公克。

實施例 10

在實施例 1 的基礎上，改氫氧化鈉為 30 公克，在 1000 公克鹼性溶液中加入 15 公克添加劑。

實施例 11

在實施例 1 的基礎上，改氫氧化鈉為 40 公克，聚乙二醇為 1.8 公克。

實施例 12

在實施例 2 的基礎上，改四甲基氫氧化銨為 23 公克，聚乙二醇為 0.7 公克。

實施例 13

在實施例 2 的基礎上，改四甲基氫氧化銨為 25 公克，烷基糖苷為 0.6 公克。

實施例 14

在實施例 2 的基礎上，改四甲基氫氧化銨為 27 公克，硬脂酸銨為 1.5 公克。

實施例 15

在實施例 2 的基礎上，改四甲基氫氧化銨為 30 公克，乙二胺為 2.5 公克。

實施例 16

在實施例 2 的基礎上，改四甲基氫氧化銨為 40 公克，硫酸銨為 2 公克。

實施例 17

在實施例 2 的基礎上，改四甲基氫氧化銨為 50 公克，尿素為 3 公克。

實施例 18

在實施例 2 的基礎上，改四甲基氫氧化銨為 55 公克，在 1000

公克鹼性溶液中加入 20 公克添加劑。

實施例 19

在實施例 2 的基礎上，改四甲基氫氧化銨為 60 公克，烷基糖苷為 1.7 公克。

實施例 20

在實施例 3 的基礎上，改氫氧化鉀為 10 公克，聚乙二醇為 1.3 公克。

實施例 21

在實施例 3 的基礎上，改氫氧化鉀為 13 公克，烷基糖苷為 1.4 公克。

實施例 22

在實施例 3 的基礎上，改氫氧化鉀為 15 公克，硫酸銨為 2.5 公克。

實施例 23

在實施例 3 的基礎上，改氫氧化鉀為 17 公克，尿素為 4 公克。

實施例 24

在實施例 3 的基礎上，改氫氧化鉀為 20 公克，在 1000 公克鹼性溶液中加入 30 公克添加劑。

實施例 25

在實施例 3 的基礎上，改氫氧化鉀為 25 公克，硫酸銨為 4.5 公克。

實施例 26

在實施例 3 的基礎上，改氫氧化鉀為 40 公克，尿素為 7 公克。

實施例 27

在實施例 3 的基礎上，改氫氧化鉀為 50 公克，在 1000 公克鹼性溶液中加入 50 公克添加劑。

以上所述僅是本發明的優選實施方式，應當指出，對於本技術領域的普通技術人員來說，在不脫離本發明技術原理的前提下，還可以做出若干改進和潤飾，這些改進和潤飾也應視為本發明的保護範圍。

【符號說明】

【生物材料寄存】

國內寄存資訊【請依寄存機構、日期、號碼順序註記】

無。

國外寄存資訊【請依寄存國家、機構、日期、號碼順序註記】

無。

【序列表】(請換頁單獨記載)

申請專利範圍

1. 一種結晶矽鹼性拋光液的添加劑，其特徵在於，以質量為基準，由 0.5~2%聚乙二醇、0.5~2%烷基糖苷、0.5~2%硬脂酸銨、1~3%的乙二胺、1~5%的硫酸銨、2~8%的尿素和餘量的水組成。
2. 如申請專利範圍第 1 項所述的結晶矽鹼性拋光液的添加劑，其特徵在於，以質量為基準，由 1~1.5%聚乙二醇、1~1.5%烷基糖苷、0.5~1%硬脂酸銨、1~2%的乙二胺、2~4%的硫酸銨、3~6%的尿素和餘量的水組成。
3. 如申請專利範圍第 1 項或第 2 項所述的結晶矽鹼性拋光液的添加劑，其特徵在於，該水為去離子水。
4. 一種結晶矽鹼性拋光液，其特徵在於，以質量為基準，通過如下步驟配製：
 - 1) 將氫氧化鈉、氫氧化鉀或四甲基氫氧化銨溶於去離子水中，得到鹼性溶液；該氫氧化鈉、該氫氧化鉀的品質百分含量為 1~5%；該四甲基氫氧化銨的品質百分含量為 2~6%；
 - 2) 將申請專利範圍第 1 項至第 3 項其中任一項所述的結晶矽鹼性拋光液的添加劑加入該步驟 1) 中的該鹼性溶液中，得到結晶矽鹼性拋光液；其中，該結晶矽鹼性拋光液的添加劑與該鹼性溶液的品質比為 1~6:100。
5. 如申請專利範圍第 4 項所述的結晶矽鹼性拋光液，其特徵在於，以質量為基準，該氫氧化鈉、該氫氧化鉀的品質百分含量為 2~3%；該四甲基氫氧化銨的品質百分含量為 3~5%。
6. 如申請專利範圍第 4 項所述的結晶矽鹼性拋光液，其特徵在

於，以質量為基準，該氫氧化鈉、該氫氧化鉀的品質百分含量為 1~1.5%；該四甲基氫氧化銨的品質百分含量為 2~2.5%。

7. 如申請專利範圍第 4 項至第 6 項任一項所述的結晶矽鹼性拋光液，其特徵在於，以質量為基準，該結晶矽鹼性拋光液的添加劑與該鹼性溶液的品質比為 2~4:100。
8. 一種結晶矽拋光方法，其特徵在於，將單晶或多晶矽片浸入到申請專利範圍第 4 項至第 7 項其中任一項所述的結晶矽鹼性拋光液中進行拋光，溫度控制在攝氏 60~80 度，時間控制在 0.5~5 分鐘。

圖 式

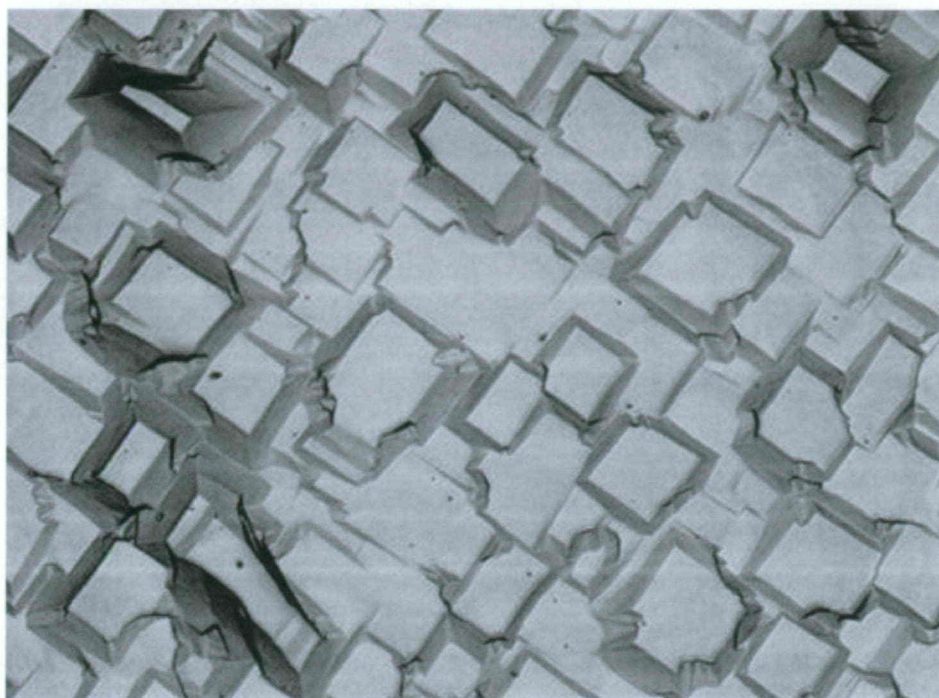


圖 1

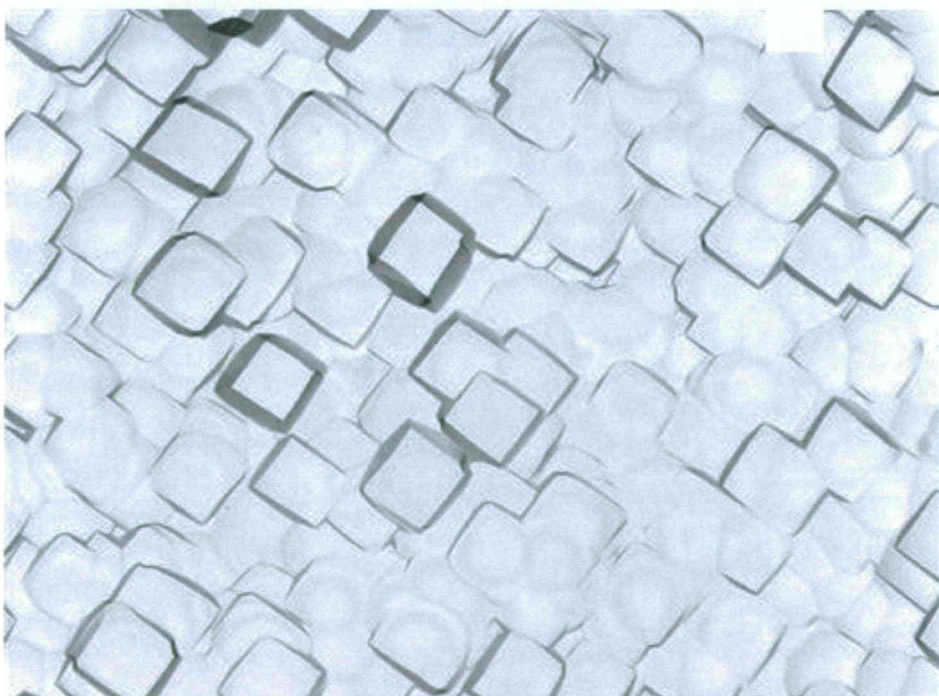


圖 2

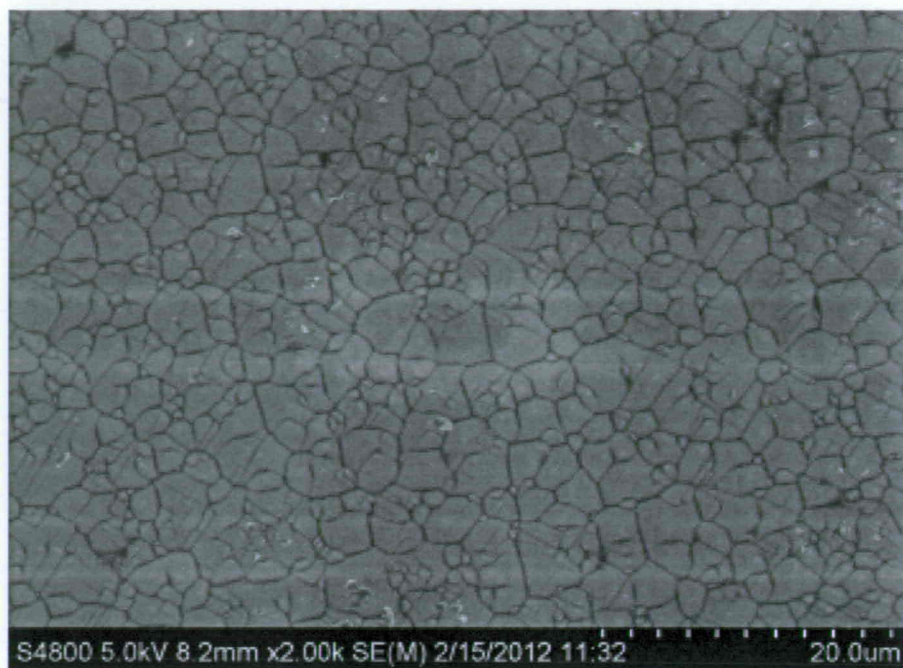


圖 3



圖 4



(19) Intellectual Property Office of the Republic of China
(12) Invention Description Publication

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(51)Int.Cl.: *C09G1/06 (January 2006)*

C09G1/00 (2006.01)

C30B33/00 (2006.01)

B28D5/00 H01L31/18 (January 2006)

B24B29/02 (2006.01)

H01L21/304 (January 2006)

H 0 1L31/18 (2006.01)

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Mainland China

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SONG, WEI-PING (CN)

(74) Agents: Lin Kuncheng; Lin Ruixiang

(56) References:

TW 201142015A1

CN 103320018A

WO 2012/169721A1

Reviewer : Huang Sheng-Feng

Number of claims: 8; Number of drawings: 4; Total 18 pages

(54) Title

An Additive for Crystalline Silicon Alkaline Polishing Liquid and Use Thereof

(57) Abstract

The present invention relates to an additive for crystalline silicon alkaline polishing liquid and use thereof, the additive comprising: 0.5~2% PEG, 0.5~2% Alkyl polyglycosides, 0.5~2%Ammonium stearate, 1~3% Ethylenediamine, 1~5% Ammonium sulfate, 2~8% Urea and a remaining amount of water. Using an alkaline solution which is included said additive for pre-polishing surface of silicon chip before texturing process to achieve excellent polishing effect, polishing could be performed in low alkali concentration, and increasing uniformity in texturing, significantly increasing open circuit voltage and efficiency of battery. The present invention also applies to polishing one surface of silicon chip after diffusion.

Designated drawings:

TW I589655 B

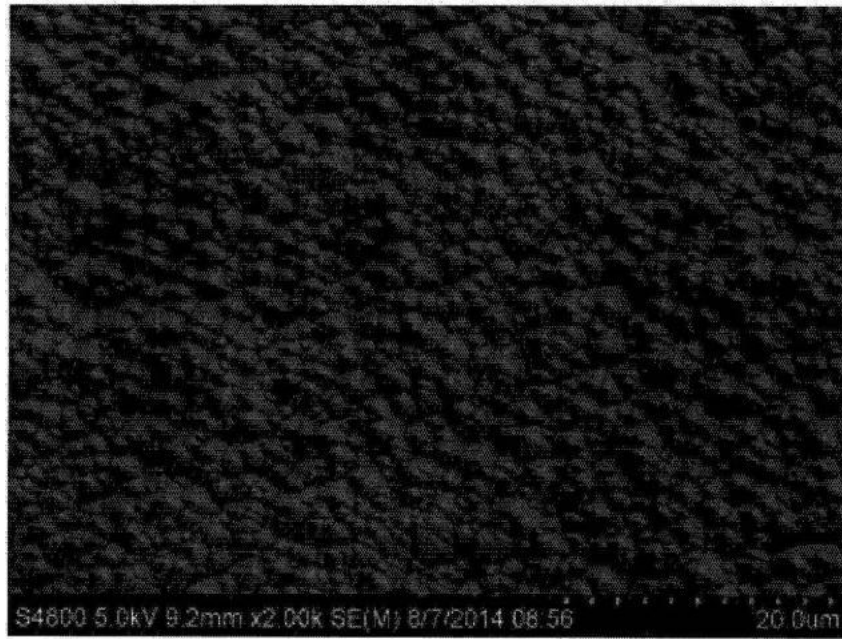


Figure 4

I589655

Announcement

Abstract

※Application Number: 105106755
*Application Date: *IPC Classification:
(05.3.4

(C09G1/06/2006.01)
C09G1/00(2006.01)
C30B33/0012006.01)
(B24B29/02/2006.01)
B28D5/00(2006.01)
H 0 1L21/304(2006.01)
H01L31/18(2006.01)

[Title of Invention] (Chinese/English)

An additive for crystalline silicon alkaline polishing liquid and use thereof

[English]

The present invention relates to an additive for crystalline silicon alkaline polishing liquid and use thereof, the additive comprising: 0.5~2% PEG, 0.5~2% Alkyl polyglycosides, 0.5~2% Ammonium stearate, 1~3% Ethylenediamine, 1~5% Ammonium sulfate, 2~8% Urea and a remaining amount of water. Using an alkaline solution which is included said additive for pre-polishing surface of silicon

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chip before texturing process to achieve excellent polishing effect, polishing could be performed in low alkali concentration, and increasing uniformity in texturing, significantly increasing open circuit voltage and efficiency of battery. The present invention also applies to polishing one surface of silicon chip after diffusion.

[Representative Drawing]

[Designated Representative Drawing]: Figure 4

[Brief Description of Symbols in the Representative Drawing]:

[If the present application involves a chemical formula, please disclose the chemical formula that best illustrates the characteristics of the invention]:

none

Invention Patent Description

(Please do not alter the format or order of this instruction manual.)

[Invention Title] (Chinese/English)

An additive for crystalline silicon alkaline polishing liquid and use thereof

[Technical Field]

This invention relates to an additive for crystalline silicon alkaline polishing liquid and use thereof.

[Prior Art]

The texturing process on silicon wafers is crucial for solar cells. It significantly reduces silicon's reflectivity and increases light absorption by extending the optical path length within the silicon. Currently, many methods assist in texturing, including various texturing additives, ensuring 100% texturing yield and making the texturing process a controllable production step. With advancements in texturing technology, achieving uniform texture is one way to improve cell efficiency. Better texture uniformity leads to higher cell open voltage and thus higher efficiency. However, current texturing methods often result in poor uniformity, such as uneven pyramid sizes and the regrowth of smaller pyramids on the pyramid shoulders. Silicon wafers that undergo a pre-polishing and subsequent texturing process can achieve a uniform pyramid structure, thereby improving cell open voltage and efficiency. Many companies have explored polishing with a high-concentration alkaline solution followed by texturing in a low-concentration alkaline solution, resulting in a significant improvement in cell efficiency. However, this pretreatment often causes problems with appearance. This is because when polishing in a high-temperature, high-alkali solution, sodium silicate is very easy to remain on the surface. Furthermore, sodium silicate will solidify before entering the texturing tank, which seriously interferes with the subsequent texturing process of the silicon wafer.

As a result, the area covered by sodium silicate does not have a pyramidal texture and appears as shiny white spots on the surface of the silicon wafer, which seriously affects the appearance of the battery and the yield.

Achieving low-temperature, low-alkali-concentration silicon wafer polishing while avoiding corresponding appearance problems presents both an opportunity and a challenge for polishing additives.

On the other hand, the currently popular PERC cell (Passivated emitter rear contact solar cell) process requires a relatively flat back surface for aluminum oxide passivation. An optimized approach is to use alkaline solution polishing for the back surface, which results in a lower surface state density and better passivation. However, typical alkaline solution polishing often results in a less smooth back surface with too many steps, leading to a reduced passivation effect. Therefore, improving the alkaline polishing effect to achieve satisfactory passivation results is of great significance for PERC cells.

[Summary of the Invention]

The purpose of this invention is to provide an additive for alkaline polishing fluid of crystalline silicon and its application. When adding this additive to an alkaline solution during the polishing pretreatment before texturing silicon wafers, excellent polishing results can be achieved. Silicon wafer polishing can be performed at low alkaline concentrations, improving the uniformity of the textured surface, thereby significantly improving the open-circuit voltage and battery efficiency. Furthermore, this additive is also suitable for single-sided polishing of silicon wafers after diffusion, enabling the acquisition of a relatively flat and uniform back-polished surface, particularly suitable for PERC. Battery technology can help improve the passivation effect of PERC batteries.

To achieve the above objectives, the present invention provides an additive for a crystalline silicon alkaline polishing solution, comprising 0.5-2% polyethylene glycol, 0.5-2% alkyl glycoside, 0.5-2% ammonium stearate, 1-3% ethylenediamine, 1-5% ammonium sulfate, 2-8% urea, and the balance being water.

Preferably, the additives in the crystalline silicon alkaline polishing solution consist of 1-1.5% polyethylene glycol, 1-1.5% alkyl glycoside, 0.5-1% ammonium stearate, 1-2% ethylenediamine, 2-4% ammonium sulfate, 3-6% urea, and the balance being water.

Preferably, the water is deionized water.

The present invention also provides an alkaline polishing solution for crystalline silicon, which is prepared by the following steps:

1) Dissolve potassium hydroxide, potassium hydroxide, or tetramethylammonium hydroxide in deionized water to obtain an alkaline solution; the mass percentage of the hydroxide and potassium hydroxide is 1-5%; the mass percentage of the tetramethylammonium hydroxide is 2-6%.

2) Add the above-mentioned additive to the alkaline solution in step 1) above to obtain crystalline silicon alkaline polishing solution; wherein the mass ratio of additive to alkaline solution is 1~6:100.

In a preferred embodiment, the sodium hydroxide and potassium hydroxide have a mass percentage content of 2-3%; and the tetramethylammonium hydroxide has a mass percentage content of 3-5%.

In another preferred embodiment, the sodium hydroxide and potassium hydroxide have a mass percentage content of 1-1.5%; and the tetramethylammonium hydroxide has a mass percentage content of 2-2.5%.

Preferably, the mass ratio of the additive to the alkaline solution is 2-4:100.

The present invention also provides a method for polishing crystalline silicon, wherein a single-crystal or polycrystalline silicon wafer is immersed in the above-mentioned polishing liquid for polishing, the temperature is controlled at 60 to 80 degrees Celsius, and the time is controlled at 0.5 to 5 minutes.

The advantages and beneficial effects of this invention are as follows: It provides an additive for alkaline polishing fluid of crystalline silicon and its application. When polishing the surface of silicon wafers, adding the additive of this invention to the alkaline solution can achieve excellent polishing effect. Polishing can be achieved at low alkali concentrations. Furthermore, the additive of this invention is applicable to the process of polishing before texturing, which can improve the polishing effect of silicon wafers, reduce costs, shorten reaction time, reduce cell breakage rate, increase cell production capacity, and improve the photoelectric conversion efficiency of cells.

Ammonium stearate and ammonium sulfate in the additives enable silicon wafers to obtain a stable and uniform pyramid structure with relatively small weight reduction; adding ethylenediamine and urea to the polishing system allows for controllable fabric size and reflectivity in subsequent texturing processes, thereby meeting different requirements.

The additive of this invention accelerates the polishing reaction and enables polishing at low concentrations, saving 15-30% of alkali usage. This additive has a wide range of applications, suitable for polishing both monocrystalline and polycrystalline silicon wafers. It is particularly suitable for processes where polishing precedes texturing. The resulting textured surface is more uniform than that obtained with texturing alone, without any pyramidal distortion, thus improving the open voltage and increasing battery efficiency by over 0.2%. Weight reduction can be controlled within 0.5-0.7 grams (for 156 monocrystalline silicon wafers), comparable to conventional alkali texturing processes. Furthermore, this additive is also suitable for processes where texturing precedes back polishing, resulting in a uniform and smooth textured surface after back polishing.

[Brief Description of the Drawings]

Figure 1 is a microscope photograph of the polished surface of a conventionally back-polished silicon wafer;

Figure 2 This is a microscope image of the polished surface of the silicon wafer obtained in Embodiment 1;

Figure 3 It is a scanning electron microscope image of a conventionally fabricated velvety surface;

Figure 4 This is a scanning electron microscope image of the polished and then textured surface obtained in Embodiment 2.

[Embodiments]

The specific embodiments of the present invention will be further described below with reference to the accompanying drawings and Embodiments. The following Embodiments are only used to more clearly illustrate the technical solutions of the present invention and should not be construed as limiting the scope of protection of the present invention.

The specific technical solution of this invention is as follows:

Embodiment 1

Polishing is performed before texturing, with the polishing process involving the following steps:

1) Additives for preparing alkaline polishing solutions for crystalline silicon:

Using deionized water as a solvent, 2 grams of polyethylene glycol (PEG), 2 grams of alkyl polyglycosides, 2 grams of ammonium stearate, 3 grams of ethylenediamine, 5 grams of ammonium sulfate, and 8 grams of urea were dissolved in deionized water to prepare 100 grams of additive.

2) Preparation of alkaline solution:

Dissolve 50 grams of hydroxide in deionized water to obtain 1000 grams of alkaline solution;

3) Add 60 grams of additive to 1000 grams of alkaline solution;

4) Immerse the monocrystalline silicon wafer in the polishing solution for polishing, with the temperature controlled at 80 degrees Celsius and the time controlled at 5 minutes.

Figure 1 shows a microscopic photograph of the polished surface of a conventionally back-polished silicon wafer. It can be seen that the size of the square blocks on the conventionally back-polished surface is not uniform, and the polished surface is not smooth. Figure 2 shows a microscopic photograph of the polished surface of the silicon wafer obtained in this embodiment. It can be seen from Figure 2 that a uniform and smooth square structure has been formed on the silicon wafer surface, with a size of approximately 20~30 μm (micrometers).

Embodiment 2

Polishing is performed before texturing, with the polishing process involving the following steps:

1) Additives for preparing alkaline polishing solutions for crystalline silicon:

0.5 g of polyethylene glycol, 0.5 g of alkyl glycoside, 0.5 g of ammonium stearate, 1 g of ethylenediamine, 1 g of ammonium sulfate, and 2 g of urea were dissolved in deionized water to prepare 100 g of additive.

2) Preparation of alkaline solution:

Dissolve 20 grams of tetramethylammonium hydroxide in deionized water to obtain 1000 grams of alkaline solution;

3) Add 10 grams of additive to 1000 grams of alkaline solution;

4) Immerse the monocrystalline silicon wafer in the polishing solution for polishing, with the temperature controlled at 60 degrees Celsius and the time controlled at 0.5 minutes.

Figure 3 shows a conventional scanning electron microscope (SEM) image of a textured surface. Figure 4 shows an SEM image of a textured surface obtained in this embodiment after polishing followed by texturing. As can be seen from Figure 4, the textured surface obtained after the polishing-texturing process is more uniform than the textured surface that has only been texturing, and the pyramids are not stacked.

Embodiment 3

First, the fabric is velvet-textured, then the back is polished. The polishing process involves the following steps:

1) Additives for preparing alkaline polishing solutions for crystalline silicon:

Using deionized water as a solvent, 1.5 grams of polyethylene glycol and 1.5 grams of alkyl glycoside were added.

1 gram of ammonium stearate, 2 grams of ethylenediamine, 4 grams of ammonium sulfate, and 6 grams of urea were dissolved in deionized water to prepare 100 grams of additive;

2) Preparation of alkaline solution:

Dissolve 30 grams of potassium hydroxide in deionized water to obtain 1000 grams of alkaline solution;

3) Add 40 grams of additive to 1000 grams of alkaline solution;

4) Immerse the polycrystalline silicon wafer in the polishing solution for polishing. The temperature is controlled at 70 degrees Celsius and the time is controlled at 2.5 minutes.

Embodiment 4

Based on Embodiment 1, the amount of sodium hydroxide was changed to 10 grams and the amount of polyethylene glycol to 1 gram.

Embodiment 5

Based on Embodiment 1, the amount of sodium hydroxide was changed to 12 grams and the amount of alkyl glycoside was changed to 1 gram.

Embodiment 6

Based on Embodiment 1, the amount of hydroxide pot was changed to 15 grams, and the amount of ammonium stearate was changed to 0.7 grams.

Embodiment 7

Based on Embodiment 1, the amount of hydroxide flask was changed to 18 grams and the amount of ethylenediamine was changed to 1.5 grams.

Embodiment 8

Based on Embodiment 1, the amount of hydroxide pot was changed to 20 grams and the amount of ammonium sulfate was changed to 1.4 grams.

Embodiment 9

Based on Embodiment 1, the amount of sodium hydroxide was changed to 25 grams and the amount of urea to 2.5 grams.

Embodiment 10

Based on Embodiment 1, the amount of cobalt hydroxide was changed to 30 g, and 15 g of an additive was added to 1,000 g of an alkaline solution.

Embodiment 11

Based on Embodiment 1, the amount of sodium hydroxide was changed to 40 grams and the amount of polyethylene glycol to 1.8 grams.

Embodiment 12

Based on Embodiment 2, the amount of tetramethylammonium hydroxide was changed to 23 grams and the amount of polyethylene glycol to 0.7 grams.

Embodiment 13

Based on Embodiment 2, the tetramethylammonium hydroxide was changed to 25 grams and the alkyl glycoside to 0.6 grams.

Embodiment 14

Based on Embodiment 2, the amount of tetramethylammonium hydroxide was changed to 27 grams and the amount of ammonium stearate was changed to 1.5 grams.

Embodiment 15

Based on Embodiment 2, the amount of tetramethylammonium hydroxide was changed to 30 grams and the amount of ethylenediamine to 2.5 grams.

Embodiment 16

Based on Embodiment 2, the amount of tetramethylammonium hydroxide was changed to 40 grams and the amount of ammonium sulfate to 2 grams.

Embodiment 17

Based on Embodiment 2, the tetramethylammonium hydroxide was changed to 50 grams, and the urea was 3 grams.

Embodiment 18

Based on Embodiment 2, the amount of tetramethylammonium hydroxide was changed to 55 grams, and 20 grams of additive were added to 1000 grams of alkaline solution.

Embodiment 19

Based on Embodiment 2, the amount of tetramethylammonium hydroxide was changed to 60 grams and the amount of alkyl glycoside was changed to 1.7 grams.

Embodiment 20

Based on Embodiment 3, the amount of potassium hydroxide was changed to 10 grams and the amount of polyethylene glycol to 1.3 grams.

Embodiment 21

Based on Embodiment 3, the amount of potassium hydroxide was changed to 13 grams and the amount of alkyl glycoside was changed to 1.4 grams.

Embodiment 22

Based on Embodiment 3, the amount of potassium hydroxide was changed to 15 grams and the amount of ammonium sulfate to 2.5 grams.

Embodiment 23

Based on Embodiment 3, the amount of potassium hydroxide was changed to 17 grams and the amount of urea to 4 grams.

Embodiment 24

Based on Embodiment 3, the potassium hydroxide was changed to 20 grams, and 30 grams of additive were added to 1000 grams of alkaline solution.

Embodiment 25

Based on Embodiment 3, the amount of potassium hydroxide was changed to 25 grams and the amount of ammonium sulfate to 4.5 grams.

Embodiment 26

Based on Embodiment 3, the amount of potassium hydroxide was changed to 40 grams and the amount of urea to 7 grams.

Embodiment 27

Based on Embodiment 3, the potassium hydroxide was changed to 50 grams, and 50 grams of additive were added to 1000 grams of alkaline solution.

The above description is only a preferred embodiment of the present invention. It should be noted that for those skilled in the art, several improvements and modifications can be made without departing from the technical principles of the present invention, and these improvements and modifications should also be considered within the scope of protection of the present invention.

I589655

[Symbol Explanation]

[Biomaterial Storage]

Domestic storage information [Please note in the order of storage institution, date, and number]: None.

Overseas storage information [Please note in the order of storage country, institution, date, and number]: None.

[Sequence List] (Please list on a separate page)

Scope of patent application

1. An additive for a crystalline silicon alkaline polishing fluid, characterized in that, based on mass, it comprises 0.5–2% polyethylene glycol, 0.5–2% alkyl glycoside, 0.5–2% ammonium stearate, 1–3% ethylenediamine, 1–5% ammonium sulfate, 2–8% urea, and the balance being water.
2. The additive for the crystalline silicon alkaline polishing fluid as described in claim 1, characterized in that, based on mass, it comprises 1-1.5% polyethylene glycol, 1-1.5% alkyl glycoside, 0.5-1% ammonium stearate, 1-2% ethylenediamine, 2-4% ammonium sulfate, 3-6% urea, and the balance being water.
3. The additive for the crystalline silicon alkaline polishing liquid as described in claim 1 or 2, characterized in that the water is deionized water.
4. A crystalline silicon alkaline polishing solution, characterized in that it is prepared by means of the following steps, based on mass:
 - 1) Dissolve sodium hydroxide, potassium hydroxide, or tetramethylammonium hydroxide in deionized water to obtain an alkaline solution; the mass percentage of sodium hydroxide and potassium hydroxide is 1-5%; the mass percentage of tetramethylammonium hydroxide is 2-6%.
 - 2) Add the additive of any one of the claims 1 to 3 of the crystalline silicon alkaline polishing liquid to the alkaline solution in step 1) to obtain the crystalline silicon alkaline polishing liquid; wherein the mass ratio of the additive of the crystalline silicon alkaline polishing liquid to the alkaline solution is 1 to 6:100.
5. The crystalline silicon alkaline polishing liquid as described in claim 4, characterized in that, based on mass, the sodium hydroxide and potassium hydroxide have a mass percentage content of 2-3%; and the tetramethylammonium hydroxide has a mass percentage content of 3-5%.
6. The crystalline silicon alkaline polishing liquid as described in claim 4, characterized in that, based on mass, the sodium hydroxide and potassium hydroxide have a mass percentage content of 1-1.5%; and the tetramethylammonium hydroxide has a mass percentage content of 2-2.5%.

7. The crystalline silicon alkaline polishing solution as described in any one of claims 4 to 6, characterized in that, based on mass, the mass ratio of the additives in the crystalline silicon alkaline polishing solution to the alkaline solution is 2 to 4:100.
8. A method for polishing crystalline silicon, characterized in that a single-crystal or polycrystalline silicon wafer is immersed in an alkaline polishing solution of crystalline silicon as described in any one of claims 4 to 7 for polishing, with the temperature controlled at 60 to 80 degrees Celsius and the time controlled at 0.5 to 5 minutes.

Schematic

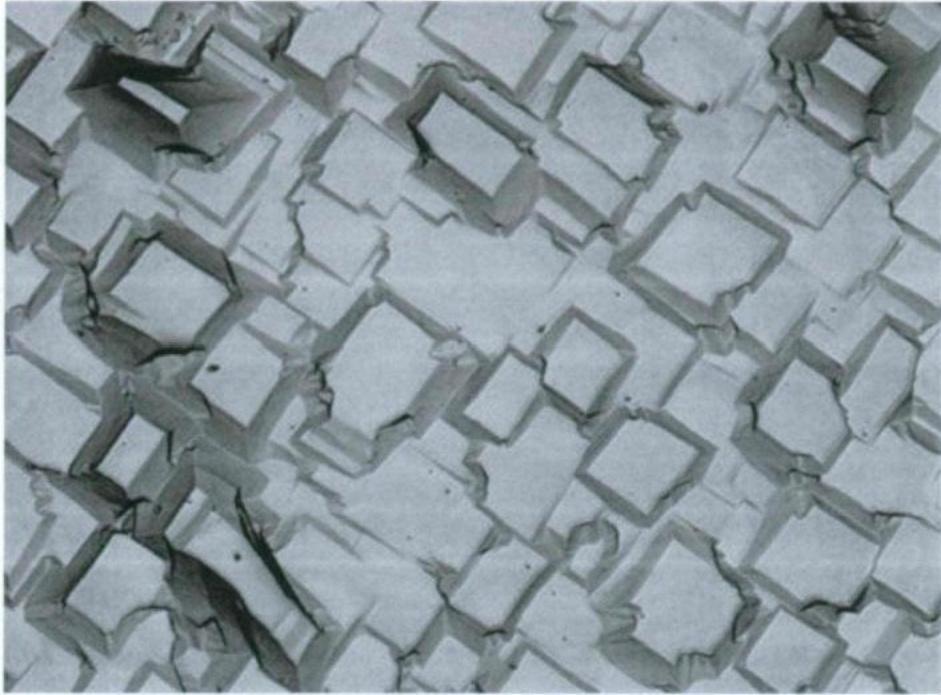


Figure 1

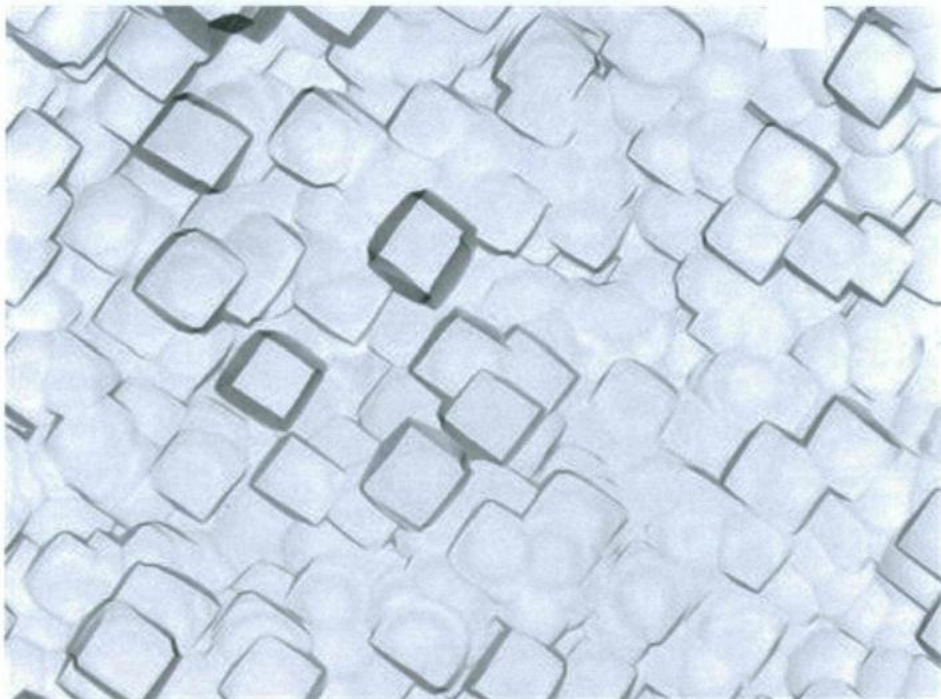


Figure 2

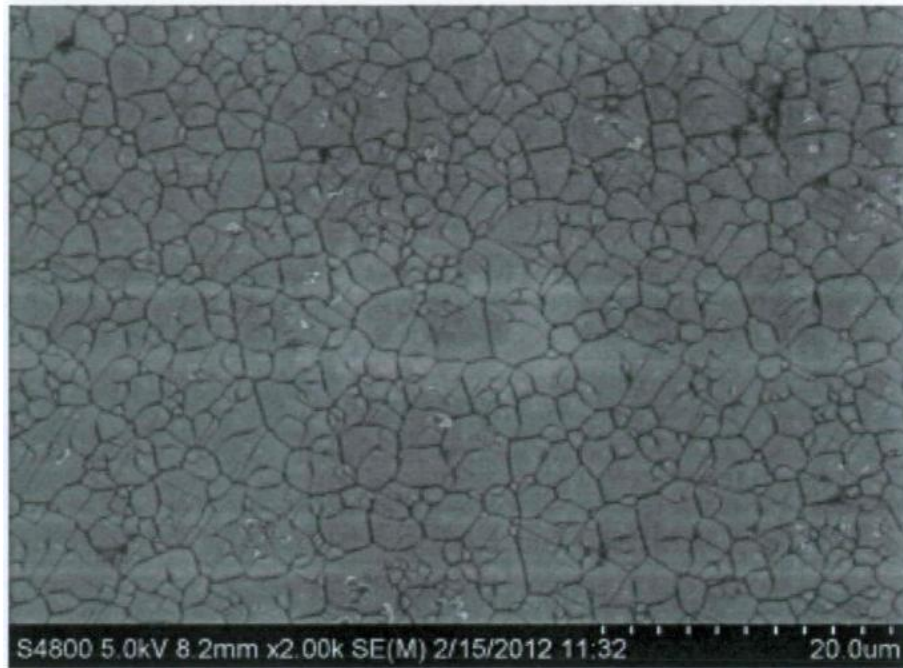


Figure 3



Figure 4

CERTIFICATE OF ACCURACY

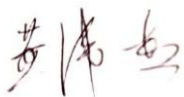
Attached as Ex A is the original document identified as patent application number TWI589655B and attached as Ex B is the translation of the original document from Chinese to English.

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