

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		Improved Hit Solar Cell Structure		
First Named Inventor/Applicant Name:		Peter G. Borden		
Filer:		Mark J. Danielson/Bobbie Jutras		
Attorney Docket Number:		012981/NBNP/CKIM		
Filed as Large Entity				
Provisional Filing Fees				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Provisional application filing	1005	1	210	210
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
Total in USD (\$)				210

Electronic Acknowledgement Receipt	
EFS ID:	2764111
Application Number:	61023342
International Application Number:	
Confirmation Number:	1111
Title of Invention:	Improved Hit Solar Cell Structure
First Named Inventor/Applicant Name:	Peter G. Borden
Customer Number:	71728
Filer:	Mark J. Danielson/Bobbie Jutras
Filer Authorized By:	Mark J. Danielson
Attorney Docket Number:	012981/NBNP/CKIM
Receipt Date:	24-JAN-2008
Filing Date:	
Time Stamp:	18:13:04
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	\$210
RAM confirmation Number	3265
Deposit Account	033975
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1		AMAT_12981.pdf	1532513	yes	15
			1edc710c4181a3285823755c87c82b7bee8951f8		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Provisional Cover Sheet (SB16)		1	2	
	Specification		3	7	
	Claims		8	8	
	Abstract		9	9	
	Drawings-only black and white line drawings		10	11	
	Appendix to the Specification		12	15	
Warnings:					
Information:					
2	Fee Worksheet (PTO-06)	fee-info.pdf	8118	no	2
			2714f0d7bf137ce84aab80a0a5a30701410d4c08b		
Warnings:					
Information:					
Total Files Size (in bytes):			1540631		

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New International Application Filed with the USPTO as a Receiving Office

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET – Page 1 of 2

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. _____

INVENTOR(S)		
Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Peter G.	Borden	San Mateo, California
Additional inventors are being named on the _____ separately numbered sheets attached hereto		
TITLE OF THE INVENTION (500 characters max):		
IMPROVED HIT SOLAR CELL STRUCTURE		
Direct all correspondence to: CORRESPONDENCE ADDRESS		
☒ The address corresponding to Customer Number: 27.498		
OR		
☐ Firm or Individual Name		
Address		
City	State	Zip
Country	Telephone	Email
ENCLOSED APPLICATION PARTS (check all that apply)		
☐ Application Data Sheet. See 37 CFR 1.76		
☐ CD(s), Number of CDs _____		
☒ Drawing(s) Number of Sheets <u>2</u>		
☒ Other (specify) <u>Appendix, 4 sheets</u>		
☒ Specification (e.g. description of the invention) Number of Pages <u>7</u>		
Fees Due: Filing Fee of \$210 (\$105 for small entity). If the specification and drawings exceed 100 sheets of paper, an application size fee is also due, which is \$260 (\$130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).		
METHOD OF PAYMENT OF THE FILING FEE AND APPLICATION SIZE FEE FOR THIS PROVISIONAL APPLICATION FOR PATENT		
☐ Applicant claims small entity status. See 37 CFR 1.27.		
☐ A check or money order is enclosed to cover the filing fee and application size fee (if applicable).		
☐ Payment by credit card. Form PTO-2038 is attached		
☒ The Director is hereby authorized to charge the filing fee and application size fee (if applicable) or credit any overpayment to Deposit		
210.00		
TOTAL FEE AMOUNT (\$)		
Account Number: <u>03-3975</u> A duplicative copy of this form is enclosed for fee processing.		

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This collection of information is required by 37 CFR 1.51. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PROVISIONAL APPLICATION COVER SHEET
Page 2 of 2

PTO/SB/16 (10-07)

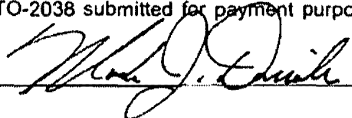
Approved for use through 06/30/2010. OMB 0651-0032
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.	
☒	No.
☐	Yes, the name of the U.S. Government agency and the Government contract number are: _____

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SIGNATURE  Date January 24, 2008

TYPED or PRINTED NAME Mark J. Danielson REGISTRATION NO. 40,580
(if appropriate)

TELEPHONE (650) 233-4777 Docket Number: 012981 /NBNP/SOLAR-OTH /CKIM

IMPROVED HIT SOLAR CELL STRUCTURE

FIELD OF THE INVENTION

[0001] The present invention relates to photovoltaic devices, and more particularly to methods and apparatuses for providing an improved structure of a HIT type or polysilicon emitter type solar cells.

BACKGROUND

[0002] HIT type solar cells are high efficiency devices with relatively simple structures. Sanyo Corporation of Japan has reported lab efficiencies of 21.5% and manufacturing efficiency in the mid-19% range. Many other groups have worked on this device, although none has shown as high efficiencies.

[0003] A typical HIT type solar cell structure is shown in FIG. 1. The device is symmetric, with the front and back of the n-type substrate both coated with thin amorphous silicon (a-Si), thicker transparent conducting oxide (TCO) and metal grid line layers. As shown in the blowup portion of FIG. 1, the amorphous silicon layer consists of two layers, an intrinsic layer under a p-type layer on the front, and an intrinsic (i) layer under an n-type layer on the back.

[0004] The purpose of the thin a-Si layers are to both passivate the surface and to provide a heterojunction with a wide bandgap window layer to improve the open circuit voltage, as shown in the graph in the right portion of FIG. 1. However, these layers also introduce considerable complexity into the fabrication of the HIT cell. For example, the layers must be formed on a carefully prepared surface, whose preparation details have not been published. Further, they must not crystallize, as can happen when the amorphous silicon is seeded by the crystal silicon substrate, as this will eliminate the passivation and heterojunction effects.

[0005] Therefore, there is a need for an improved interface that is well controlled and understood and easy to manufacture, and does not seed crystal growth.

SUMMARY

[0006] The present invention relates to improved HIT type or polysilicon emitter solar cells. According to certain aspects, the invention includes forming a masking oxide layer on the front and back of the cell and then patterning holes in the masking oxide. A HIT cell structure or polysilicon emitter solar cell structure is then formed over the patterned oxide, creating the cell junction only in the areas where holes have been cut. Benefits of the invention include that it provides a controlled interface for the HIT cell through insertion of a thin tunnel oxide. Moreover, the tunnel oxide prevents epitaxial growth of amorphous silicon, allowing it to remain amorphous for the optimum band structure. Still further, it provides a layer to protect the surface from plasma damage during deposition of the a-Si layer. Further, it may be used in conjunction with a point contact structure to further increase efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures, wherein:

[0008] Figure 1 shows a HIT cell and its band structure.

[0009] Figure 2 shows the structure of the invention and its band structure.

[0010] Figure 3 shows a process flow to form the structure of this invention.

DETAILED DESCRIPTION

[0011] The present invention will now be described in detail with reference to the drawings, which are provided as illustrative examples of the invention so as to enable those skilled in the art to practice the invention. Notably, the figures and examples below are not meant to limit the scope of the present invention to a single embodiment, but other embodiments are possible by way of interchange of some or all of the described or illustrated elements. Moreover, where certain elements of the present invention can be partially or fully implemented using known components, only those portions of such known components that are necessary for an understanding of the present invention will be described, and detailed descriptions of other portions of such known components will be omitted so as not to obscure the invention. In the present specification, an embodiment showing a singular component should not be considered limiting; rather, the invention is intended to encompass other embodiments including a plurality of the same component, and vice-versa, unless explicitly stated otherwise herein. Moreover, applicants do not intend for any term in the specification or claims to be ascribed an uncommon or special meaning unless explicitly set forth as such. Further, the present invention encompasses present and future known equivalents to the known components referred to herein by way of illustration.

[0012] In general, the present invention forms a masking oxide layer on the front and back of the cell and then patterning holes in the masking oxide. A HIT cell structure or polysilicon emitter solar cell structure is then formed over the patterned oxide, creating the cell junction only in the areas where holes have been cut.

[0013] The present inventors recognize that thin tunnel oxide layers can be used in solar cells. For example, MIS cells are made using aluminum over tunnel oxides. The present

inventors further recognize that tunnel oxides can be used between a heavily doped or insulating layer of polysilicon and a crystal silicon substrate, forming a polysilicon emitter solar cell. Such a solar cell has a similar band structure to a HIT cell, essentially replacing the TCO and a-Si layers with polysilicon. However, such cells do not provide the heterojunction and its benefit of a higher cell voltage due to the higher bandgap of a-Si.

[0014] In this invention, a thin dielectric layer is inserted between the a-Si layer and the substrate in a HIT cell. The dielectric layer should be thin, on the order of 8-15Å, in order to support a tunneling current. This structure and the associated band structure is shown in FIG. 2. The thin layer can be formed using conventional methods such as rapid thermal oxidation, furnace oxidation, or the Chemox process (formation in an ozonated H₂O₂ bath). In some cases, the layer may be nitrided or formed using other materials such as silicon nitride or silicon oxynitride.

[0015] The benefits of this layer are several-fold. For example, it may be formed using conventional surface cleaning and preparation methods, as are used to make MOS gates for ICs. Therefore, the surface preparation is well known and understood, and routinely implemented in high volume manufacturing. Moreover, as it is an amorphous layer, it separates the subsequent a-Si layer from the substrate, preventing epitaxial seeding of crystal growth in the a-Si layer. Further, it provides an intervening layer to protect the crystal silicon surface from plasma damage during deposition of the a-Si layer.

[0016] FIG. 3 shows an example of the process flow used to make this structure. First, the front surface of the n-type substrate is textured. This may be accomplished using conventional etching, such as isopropyl alcohol and KOH. Next, the surface is provided with a standard MOS clean to remove native oxides, ionic contamination, and organics. In one

embodiment, a rapid thermal oxide process is used to form a thin tunnel oxide, typically 12 Å thick, on the front surface. In another embodiment, the oxide is formed on both front and back at the same time. Next, the a-Si layers are deposited on the front surface. In one embodiment, the a-Si is formed as a two layer stack, with an intrinsic a-Si, 20-50 Å thick, under a p-type a-Si, 20-50 Å thick. In another embodiment, only a p-type layer is formed, without the i-type layer. The TCO is deposited, which may be a quarter wave thick layer of indium tin oxide. The wafer is then flipped over, and the structure is deposited in the same manner on the back side, now using n-type a-Si instead of p-type. Finally, contacts are formed by screen printing or sputtering.

[0017] Additionally or alternatively, a method to form point contacts for HIT or polysilicon emitter solar cells, as described in co-pending application No. ____ (AMAT-12964), the contents of which are incorporated herein by reference in their entirety, may be used.

[0018] The attached Appendix forms part of the present disclosure and is incorporated herein by reference.

[0019] Although the present invention has been particularly described with reference to the preferred embodiments thereof, it should be readily apparent to those of ordinary skill in the art that changes and modifications in the form and details may be made without departing from the spirit and scope of the invention. It is intended that the appended claims encompass such changes and modifications.

WHAT IS CLAIMED IS:

1. A solar cell including a passivation structure consisting of a tunnel dielectric interposed between a substrate and a layer of an amorphous semiconductor.
2. A solar cell as in claim 1 in which the substrate is silicon and the tunnel dielectric is a layer of silicon dioxide.
3. A solar cell as in claim 1 in which the substrate is silicon and the tunnel dielectric includes nitrogen.
4. A solar cell as in claim 1 in which the amorphous semiconductor is silicon.

ABSTRACT

The present invention relates to improved HIT type or polysilicon emitter solar cells. According to certain aspects, the invention includes forming a masking oxide layer on the front and back of the cell and then patterning holes in the masking oxide. A HIT cell structure or polysilicon emitter solar cell structure is then formed over the patterned oxide, creating the cell junction only in the areas where holes have been cut. Benefits of the invention include that it provides a controlled interface for the HIT cell through insertion of a thin tunnel oxide. Moreover, the tunnel oxide prevents epitaxial growth of amorphous silicon, allowing it to remain amorphous for the optimum band structure. Still further, it provides a layer to protect the surface from plasma damage during deposition of the a-Si layer. Further, it may be used in conjunction with a point contact structure to further increase efficiency.

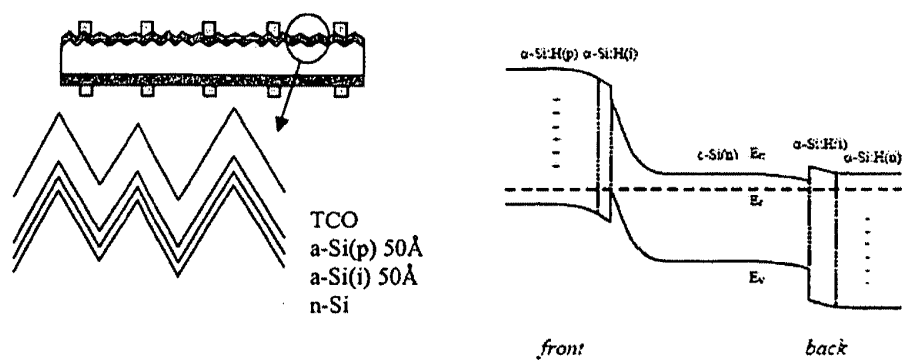


FIG. 1

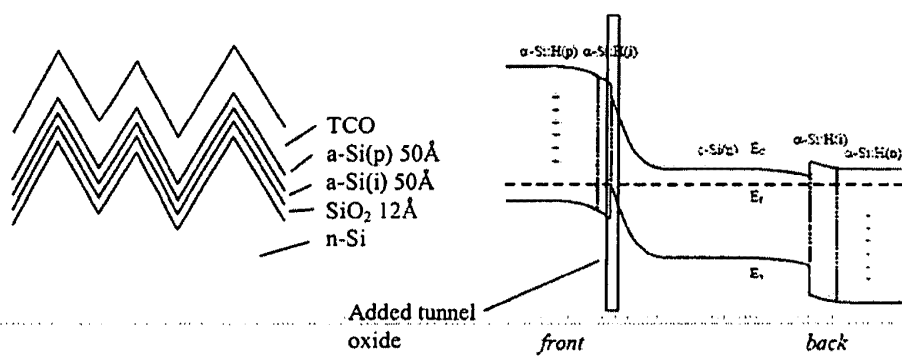


FIG. 2

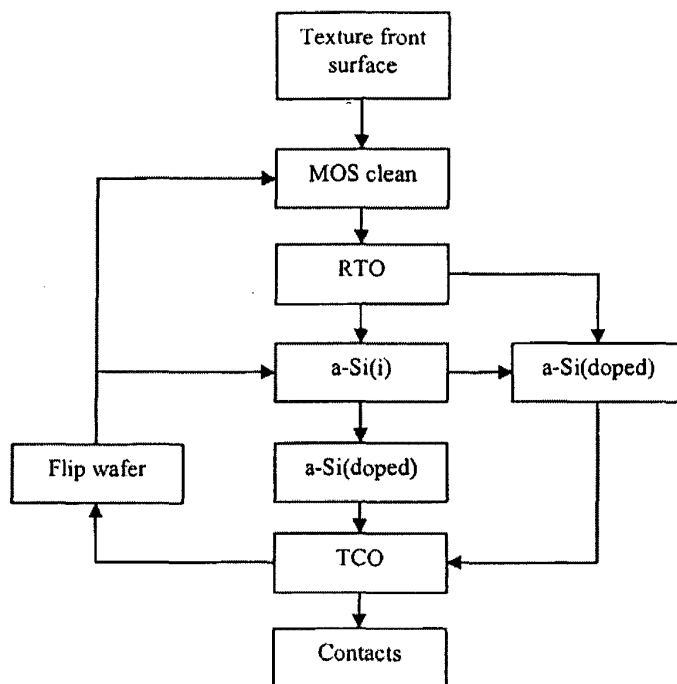
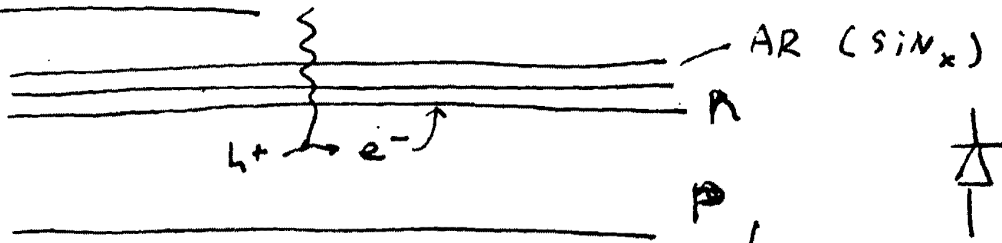


FIG. 3

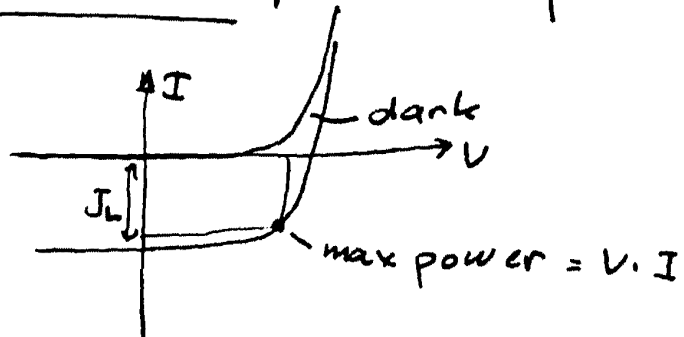
APPENDIX

Atty. Dkt. 012981 / NBNP/SOLAR-OTH
/CKIM

Buried oxide photon



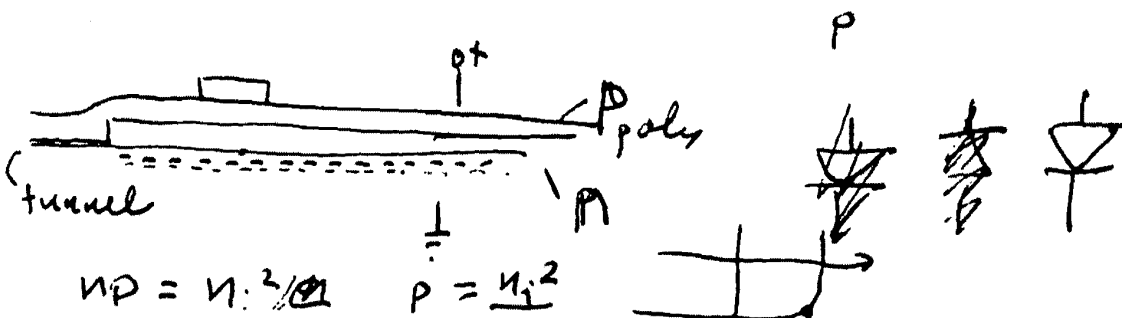
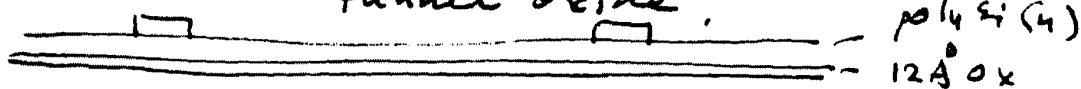
$$J = J_0 \left(e^{\frac{qV}{kT}} - 1 \right) - J_L$$



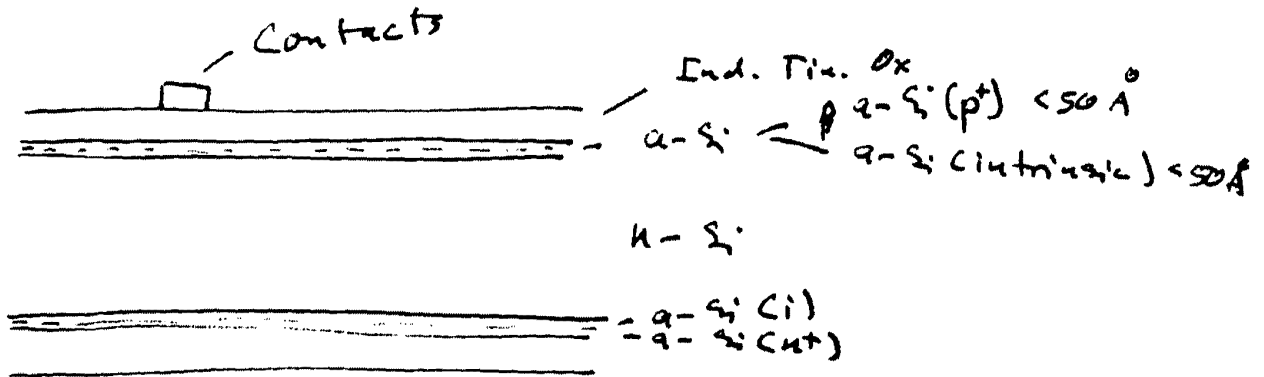
Key: collect before carriers recombine

- long bulk lifetime ✓
- passivate the surfaces ✓
- minimize contact area ✓
esp. metal contacts.
- Thin surface doped layer. ✓

Note: w/ p-type poly. → B dopant, diffuses thru oxide ∴ may want to nitride the tunnel oxide.



HIT



+ low temp planar process

no diffusions

good efficiency

Sanyo has ~ 20% cells in mfg.

- interface very tricky

✓ $a-Si$ can epitaxially regrow

✓ plasma damage in deposition

✓ requires special prep (unknown)

- low temp - limits usable processes.

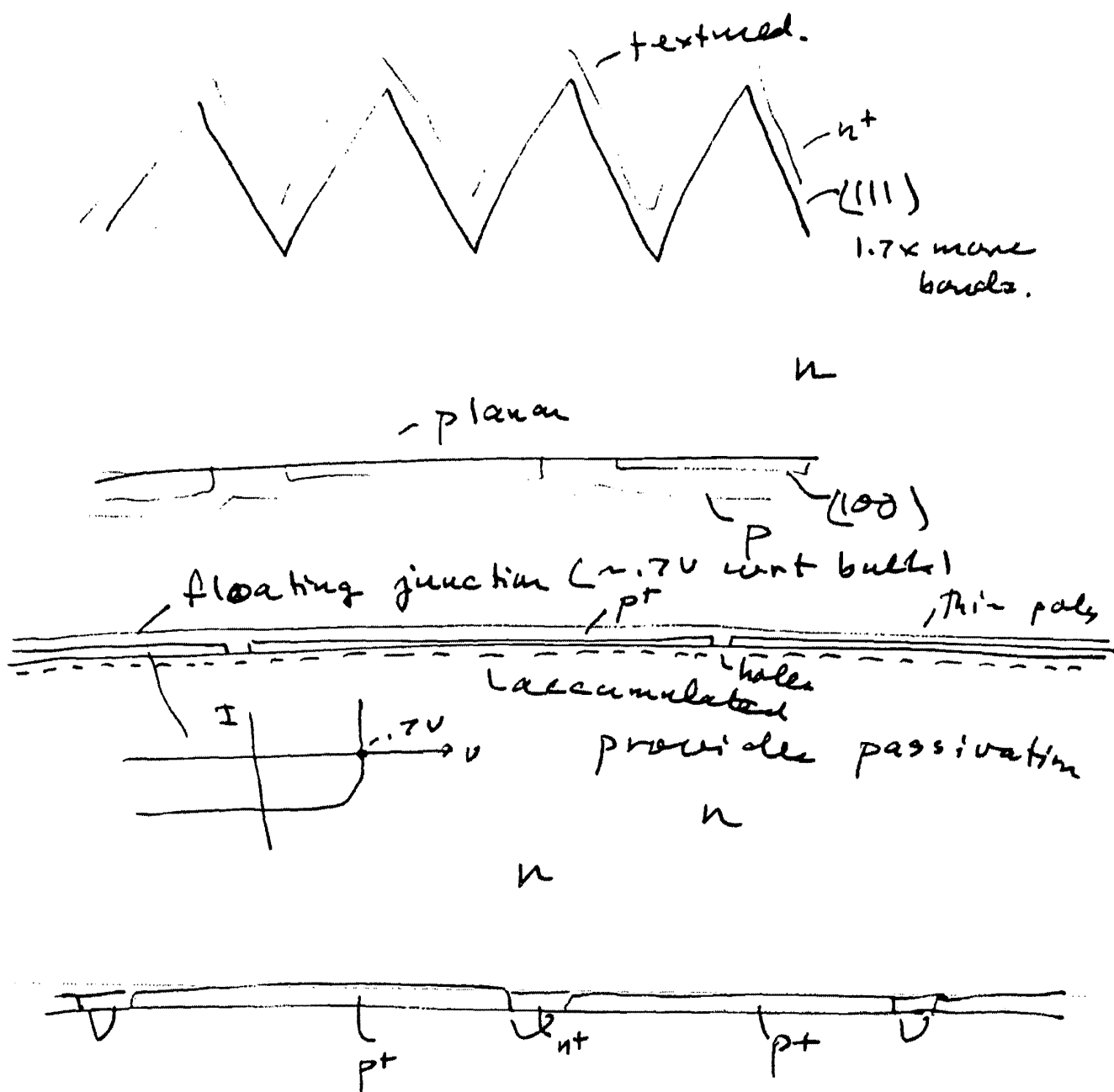
this oxide overcomes limitations.

+ know how to prepare surface.

istd. IC process

protects from damage

isolates to prevent epi seeding





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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
61/023,342	01/24/2008		210	012981 /NBNP/SOLAR-OTH /C		

CONFIRMATION NO. 1111

27498

PILLSBURY WINTHROP SHAW PITTMAN LLP
P.O. BOX 10500
MCLEAN, VA 22102

FILING RECEIPT



0000000028488101

Date Mailed: 02/27/2008

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Peter G. Borden, San Mateo, CA;

Power of Attorney:

Mark Danielson--40580

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

Title

Hit Solar Cell Structure

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION of:
Peter G. BORDEN

Application No.: 61/023,342

Confirmation No: 1111

Filing Date: January 24, 2008

Attorney Docket No.:
012984 /NBNP/SOLAR-OTH

Title: Improved Hit Solar Cell Structure

Filed electronically via EFS on April 8, 2008.

REQUEST FOR CORRECTED FILING RECEIPT

Office of Initial Patent Examination's Filing Receipt Corrections
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicant's attorney respectfully requests correction of the Filing Receipt for the above application. There is an error with respect to the title:

Error In Title

Hit Solar Cell Structure

Correct Data

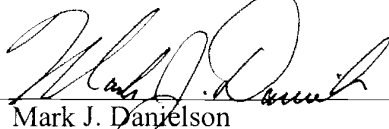
Improved Hit Solar Cell Structure

Enclosed is a marked up copy of the Filing Receipt indicating the change.

The Commissioner is authorized to charge any required fee(s) or to credit any overpayment(s) to Pillsbury Winthrop Shaw Pittman LLP's deposit account no. 03-3975 (order no. 017499-0367692).

Respectfully submitted,
PILLSBURY WINTHROP SHAW PITTMAN LLP

Date: April 8, 2008


Mark J. Danielson

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO.	TOT CLAIMS	IND CLAIMS
61/023,342	01/24/2008		RECEIVED	1012984 / BNP/SOLAR-OTH / C		

27498

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PILLSBURY WINTHROP SHAW PITTMAN

CONFIRMATION NO. 1111

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FEB 28 2008



0000000028488101

Date Mailed: 02/27/2008

CL 017499 MT# 0367692
ATTY(S) mjd
DUE: 5/1
DKT BY(1) LT (2)

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections

Applicant(s)

Peter G. Borden, San Mateo, CA;

Power of Attorney:

Mark Danielson-40580

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

Title

Improved Hit Solar Cell Structure

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

page 1 of 3

Electronic Acknowledgement Receipt	
EFS ID:	3122374
Application Number:	61023342
International Application Number:	
Confirmation Number:	1111
Title of Invention:	Hit Solar Cell Structure
First Named Inventor/Applicant Name:	Peter G. Borden
Customer Number:	27498
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Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Corrected Filing Receipt	AMAT-12981-P.PDF	41450 11c2f74f6c11905c5b17ebc011a7124f3cd82be2	no	2

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61/023,342

01/24/2008

Peter G. Borden

012981 /NBNP/SOLAR-
OTH /C

CONFIRMATION NO. 1111

IMPROPER CFR REQUEST



27498

PILLSBURY WINTHROP SHAW PITTMAN LLP

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Date Mailed: 04/14/2008

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/hsarwari/

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