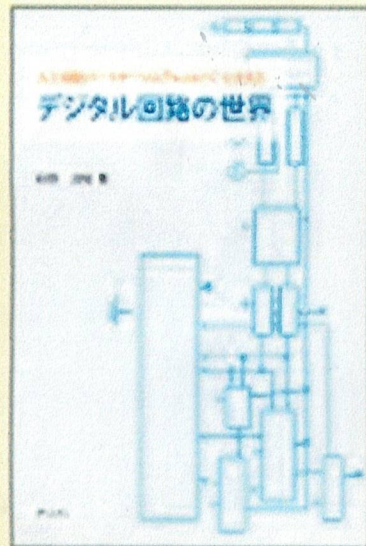


人工知能パートナーシステム (AIPS) を支えるデジタル回路の世界 | 青山社

私をはじめてBipolar Transistorの構造と動作原理を学んだのは母校Caltechで大学2年生の時、Feynman の物理の授業でした。



人工知能パートナーシステム(AIPS)を支える デジタル回路の世界

IEEE Life Fellow, Ph.D.

萩原 良昭 著

ISBN978-4-88359-339-2 B5判 上製 475頁

定価(本体9,000円+税)

未来の人間社会には人工知能パートナーシステム(AIPS)とも言える人間にやさしい支援システムが出現すると期待している。AIPS搭載の自動走行車や老人介護システム、人間型歩行ロボットやロボット・ハウスなどである。そこで本書では、そのAIPSを支える「デジタル回路の世界」と題し、ハードとソフトの両面で、人とコンピュータをつなぐデジタル技術について紹介している。図や絵をたくさん用意して、基礎からやさしく解説している。

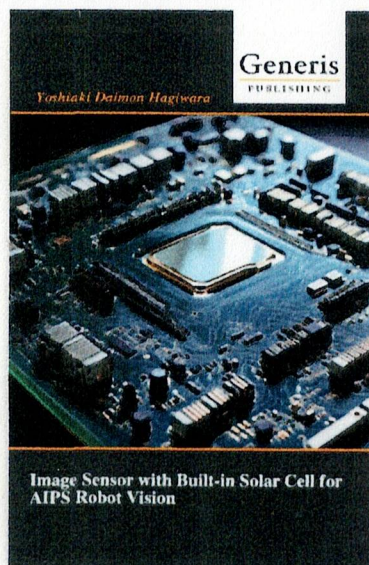


Image Sensor with Built-in Solar Cell for AIPS Robot Vision

Yoshiaki Daimon Hagiwara

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Image Sensor with Built-in Solar Cell for AIPS Robot Vision

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Description

Details

Pages: 168

Published: 2026

ISBN: 979-8-89966-794-7

Language: English

Category: Technology

This book explains key steps of development of silicon-based image sensors chronologically to provide the overall picture of the image sensor development. A new AI robot vision chip with the double and multi-junction type photodiodes are now fabricated by the modern 3DIC CMOS image sensor technology. A real-time AI smart robot vision system in a 3-D multi-chip architecture is composed of many kinds of semiconductor elements such as an array of pinned-surface buried-channel PP-NP-P+ double junction photodiodes, in-pixel ADCs, Cache SRAMs and high-frequency data-stream shift-registers with mask-and-match multi-bit real-time comparators. With a unique analog-signal switching MOS transistor circuit, the pinned-surface buried-channel PP-N-P-P+ double junction photo diodes in image sensor array also function as a solar cell power-supply unit in external power-off mode.

Technique Report | Received 21 October 2024; Accepted 11 January 2025; Published 12 May 2025
https://doi.org/10.55092/20250003

Pinned-surface and double-junction photodiode type super high-performance image sensor with built-in solar cell structure

Yoshiaki Daimon Hagiwara

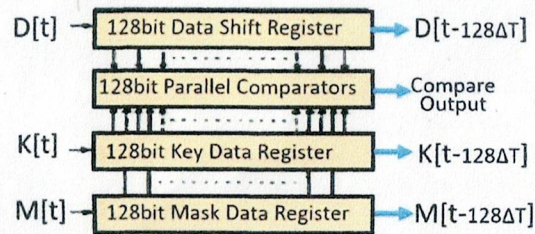
President Office, Sojo University, Kumamoto, Japan; E-mail: hagiwara@ofc.sojo-u.ac.jp.



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Hagiwara YD, Electron. Signal Process. 2025(1):0003

128-bit Comparator Block



$c_0 = 1$ only if $M[i]=0$ and $D[i]=K[i]$ for all i 's;
When ϕ_3 is ON the block is in latch-state.

$\bar{m}$	d	k	c	$c = \text{OR (EXNOR}(d,k),m)$
1	1	1	1	
1	0	0	1	
1	1	0	0	
1	0	1	0	
0	-	-	1	

If $m=0$ and $d=k$, no passage to the ground, inactive with c pulled up to Vdd.
If $m=0$ and if d is not k , c is pulled down, active with a passage to the ground.
If $m=1$, no passage to the ground, always inactive with c pulled up to Vdd

one-bit Comparator Element Block

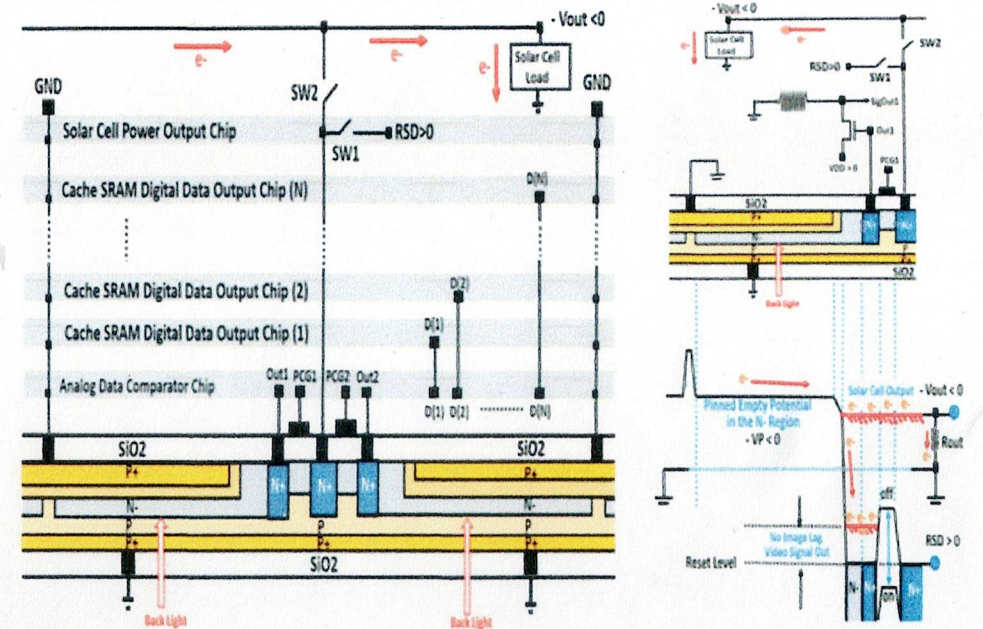
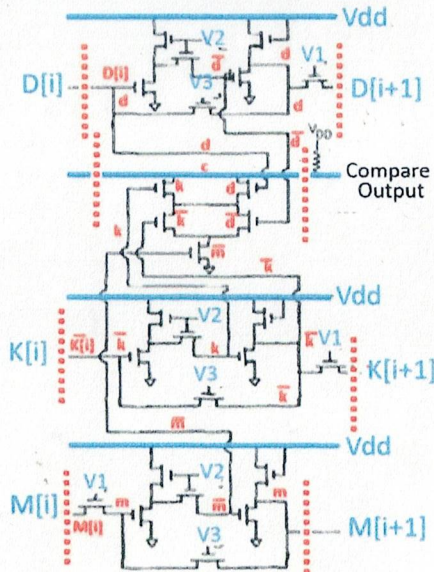


Figure 4. A cross-sectional view of a new AI Robot Vision chip in 3DIC multichip architecture

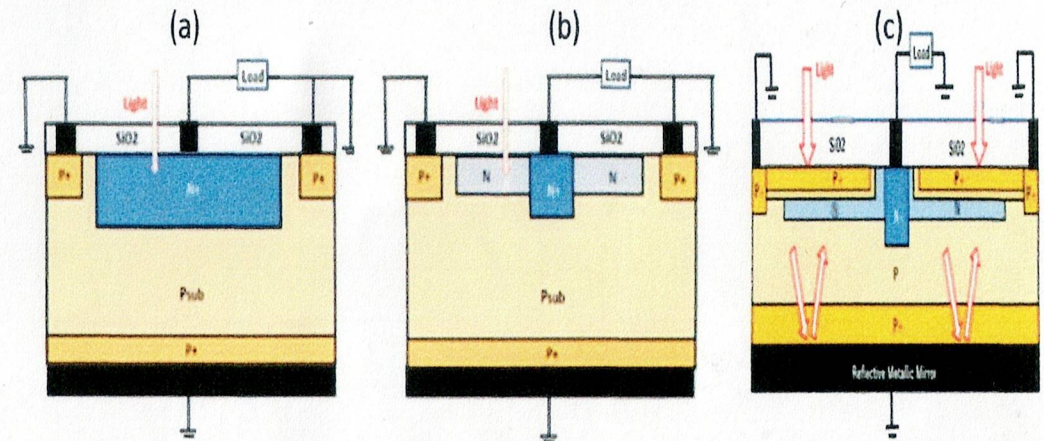


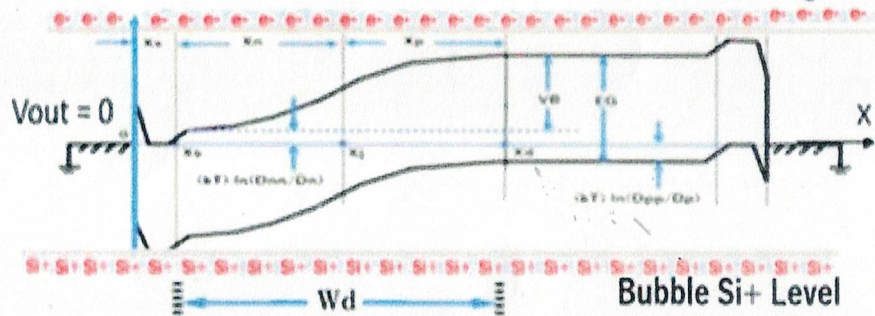
Figure 10. Two types of single junction photodiodes (a) and (b) with a double junction photodiode (c).

The buried N region in Fig.10c is always completely depleted.

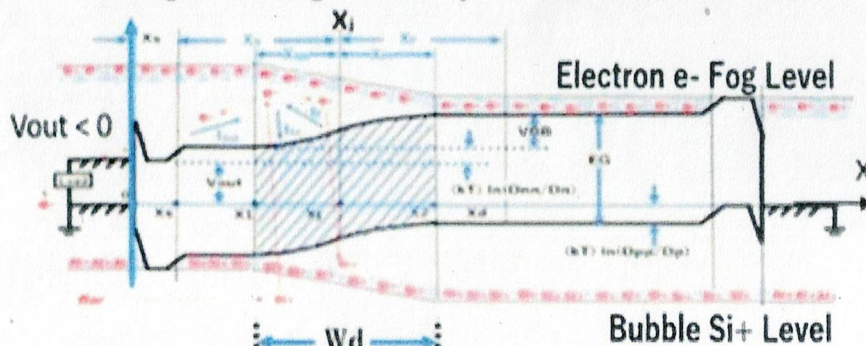
The depletion width (WD) of N+NPP+ Single Junction Solar Cell is limited about 2 μm .

(A) Band Diagram of Single N+NPP+ junction Solar Cell with $V_{out} = 0$

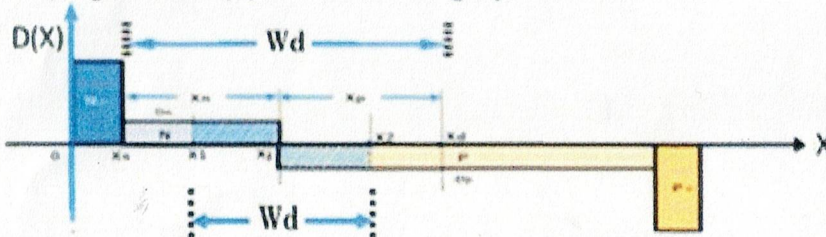
Electron e- Fog Level



(B) Band Diagram of Single N+NPP+ junction Solar Cell with $V_{out} < 0$

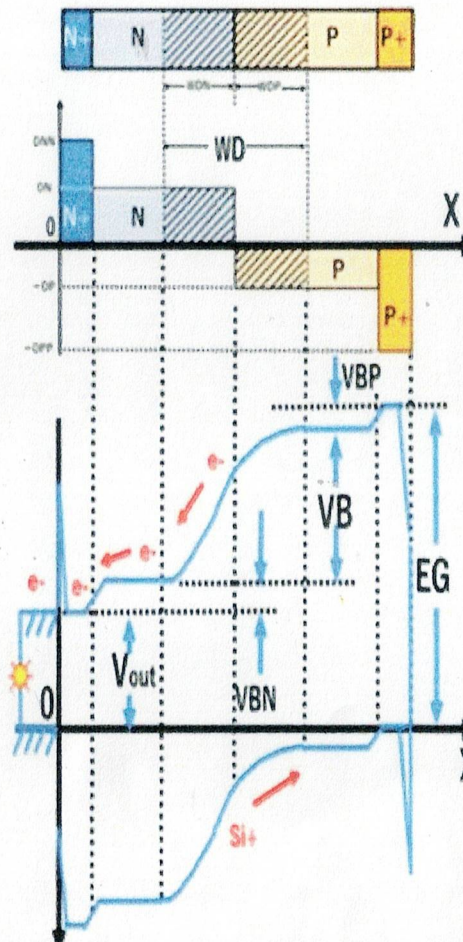


Doping Profile $D(X)$ of N+NPP+ Single junction Solar Cell

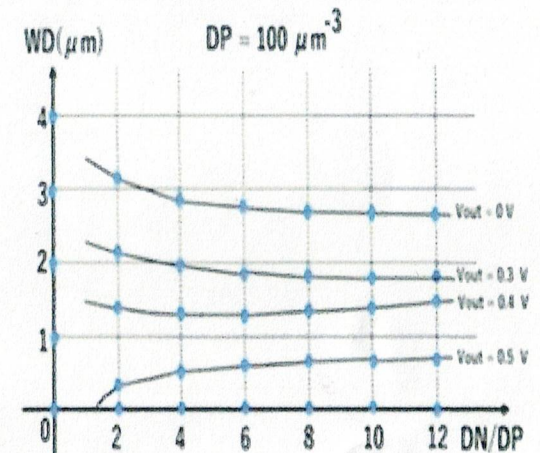


In forward-biased condition, the depletion width WD gets smaller.

$$WD = \sqrt{2 \cdot E_{si} \cdot V_B \cdot D_P \cdot D_N / (D_P + D_N)} < \sim 2 \mu\text{m};$$

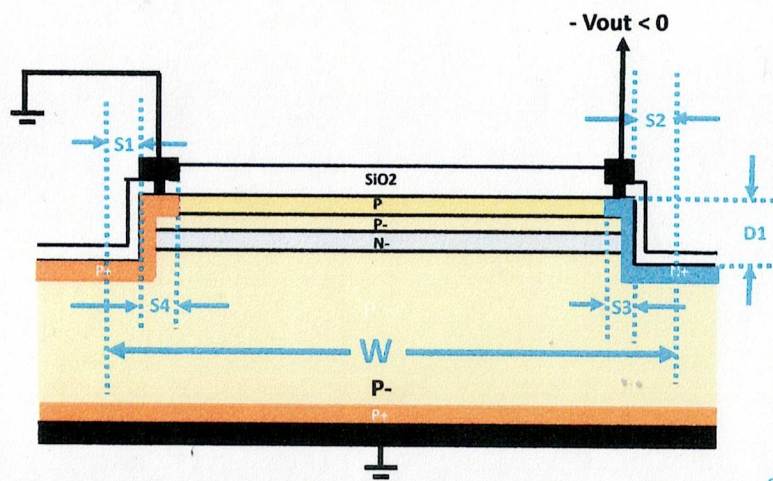


	$V_{out} = 0.0$	$V_{out} = 0.1$	$V_{out} = 0.2$	$V_{out} = 0.3$	$V_{out} = 0.4$	$V_{out} = 0.5$
DN= 100	ND=3 549050	ND=3 162872	ND=2 722455	ND=2 195095	ND=1 490568	—
DN= 200	ND=3 129827	ND=2 802109	ND=2 430600	ND=1 990934	ND=1 421202	ND=0 275348
DN= 300	ND=2 981419	ND=2 675978	ND=2 330849	ND=1 924801	ND=1 406008	ND=0 498858
DN= 400	ND=2 907578	ND=2 614194	ND=2 283421	ND=1 895788	ND=1 404995	ND=0 594888
DN= 500	ND=2 864565	ND=2 578863	ND=2 257284	ND=1 881524	ND=1 408876	ND=0 655539
DN= 600	ND=2 837110	ND=2 556794	ND=2 241694	ND=1 874352	ND=1 414635	ND=0 699424
DN= 700	ND=2 818521	ND=2 542227	ND=2 231989	ND=1 870997	ND=1 421087	ND=0 733720
DN= 800	ND=2 805418	ND=2 532263	ND=2 225839	ND=1 868855	ND=1 427711	ND=0 761812
DN= 900	ND=2 795911	ND=2 525296	ND=2 221963	ND=1 870059	ND=1 434267	ND=0 785570
DN= 1000	ND=2 788880	ND=2 520361	ND=2 219606	ND=1 871110	ND=1 440643	ND=0 806134
DN= 1100	ND=2 783688	ND=2 516874	ND=2 218296	ND=1 872703	ND=1 446790	ND=0 824246
DN= 1200	ND=2 779623	ND=2 514413	ND=2 217725	ND=1 874543	ND=1 452689	ND=0 840419



PP-N-P-P+ Double Junction Solar Cell

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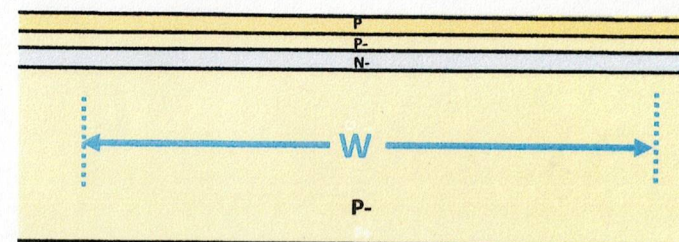


01

PP-N-P-P+ Double Junction Solar Cell

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P01 Cleaning Silicon Wafer

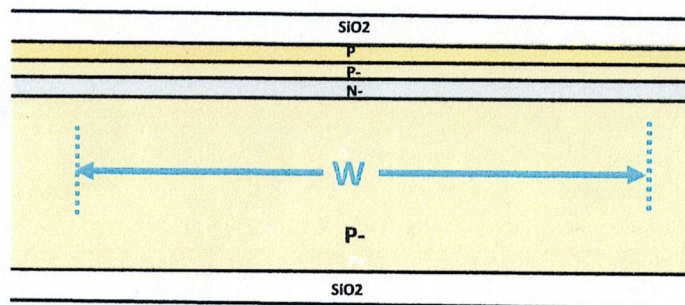


02

PP-N-P-P+ Double Junction Solar Cell

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P02 First Oxidation

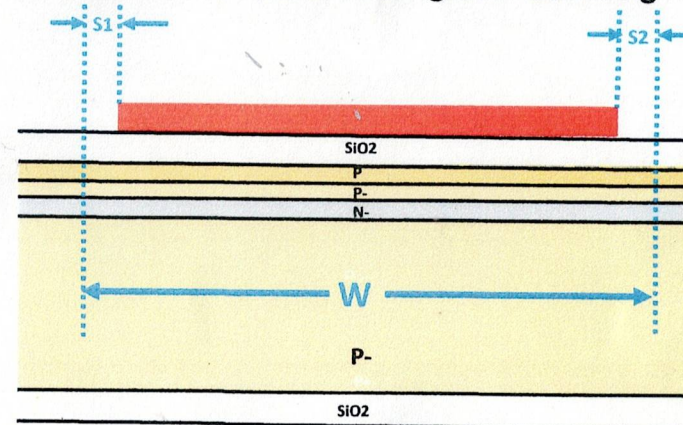


03

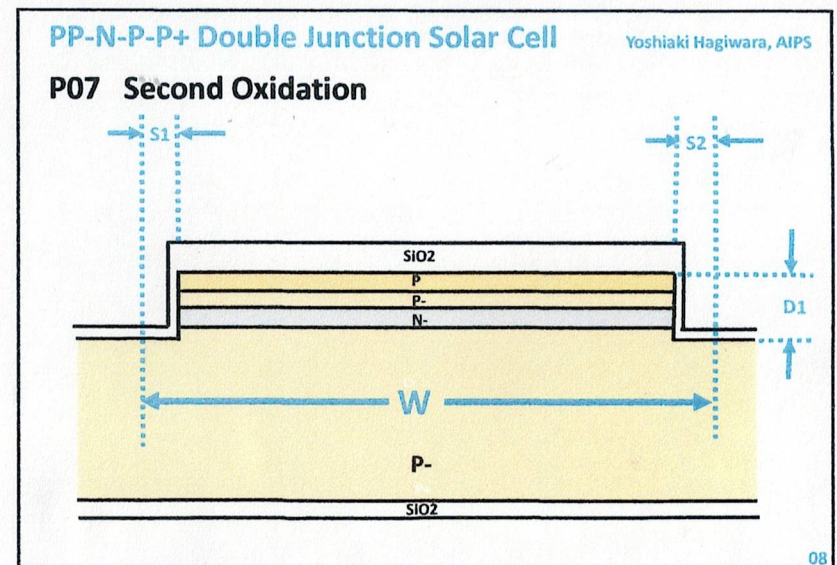
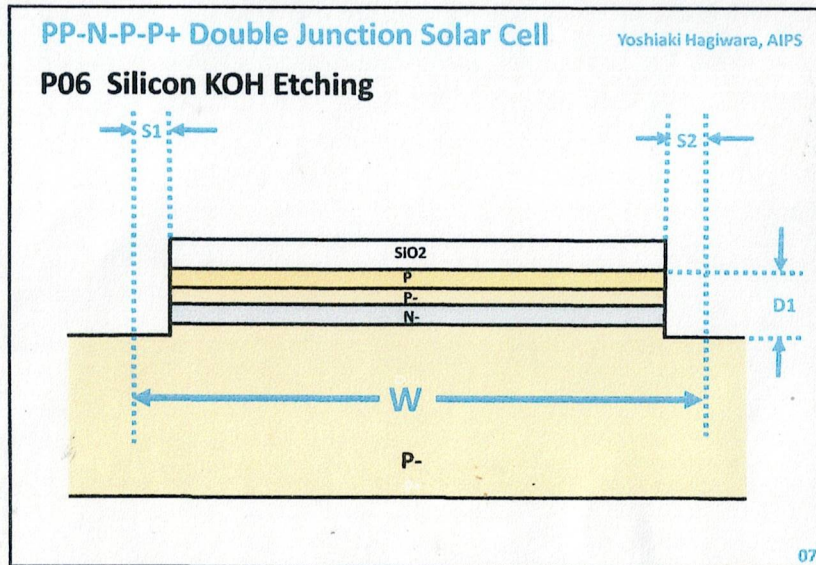
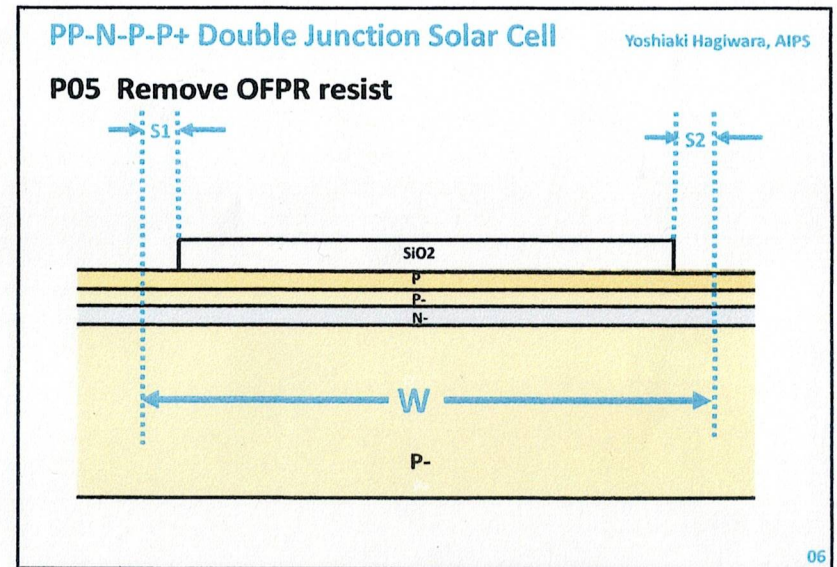
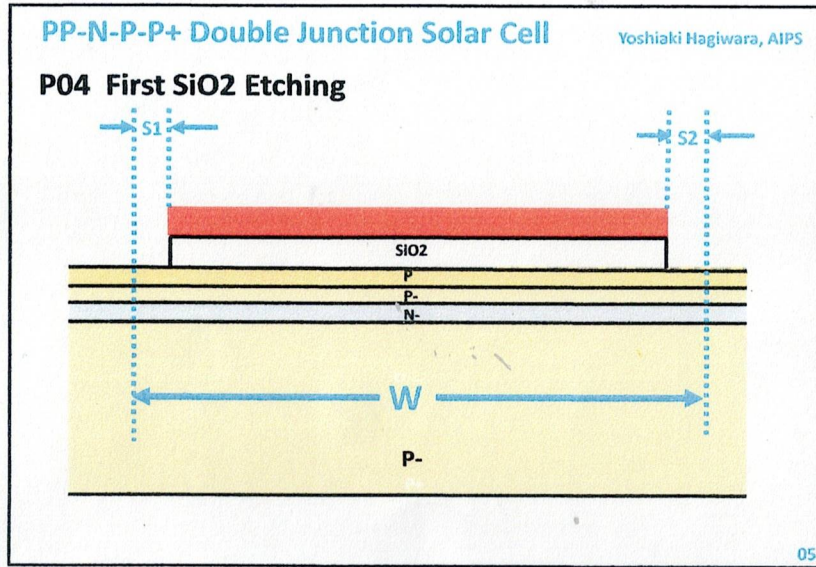
PP-N-P-P+ Double Junction Solar Cell

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P03 Mask 01 First Resist Coating and Patterning



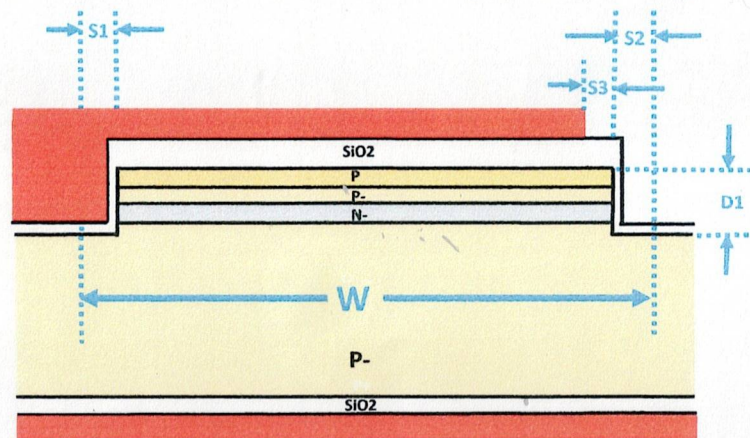
04



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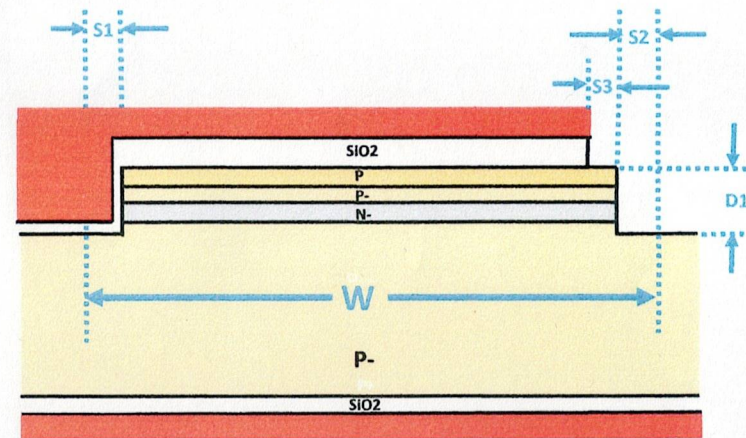
P08 Mask 02 Second Resist Coating and Patterning



09

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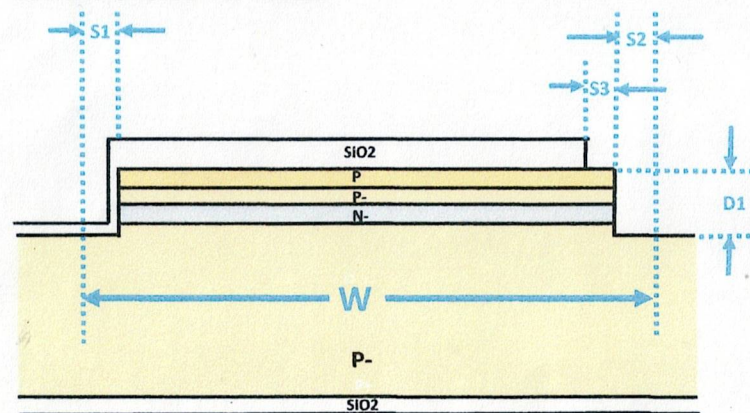
P09 Second SiO₂ Etching

10

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P10 Remove OFPR resist

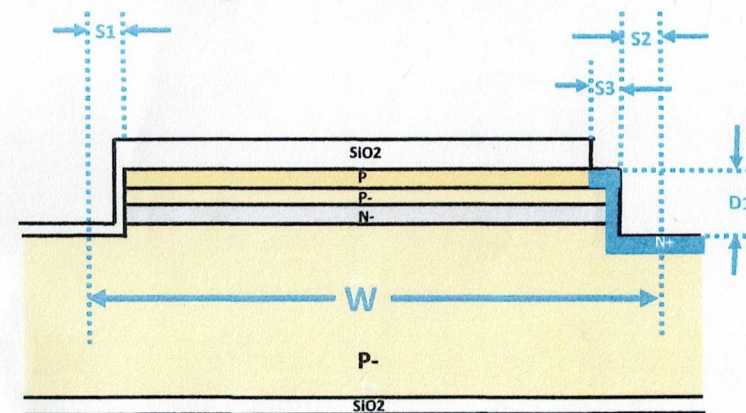


11

PP-N-P-P+ Double Junction Solar Cell

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P11 OCD Coating and Thermal N+ Diffusion

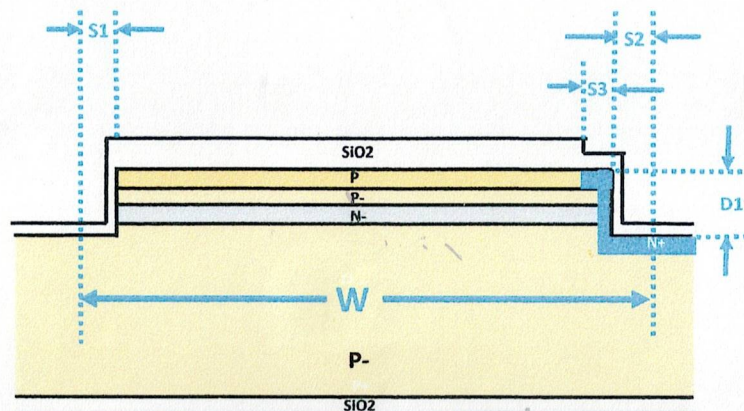


12

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P12 Third Oxidation

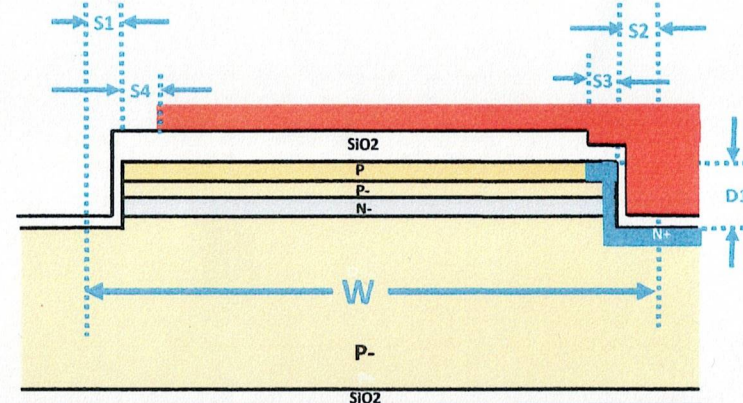


13

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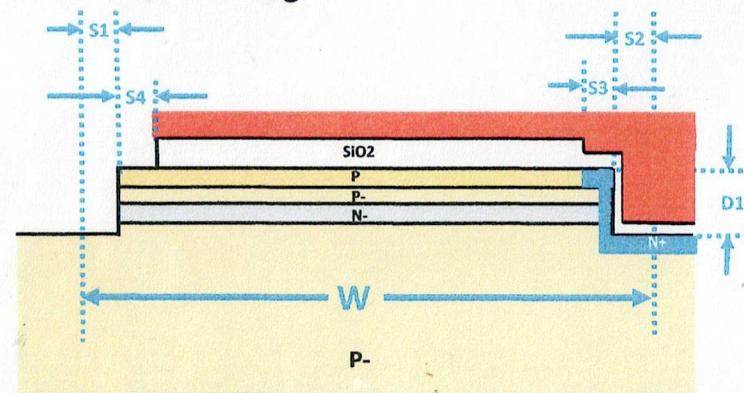
P13 Mask03 Third Resist Coating and Patterning



14

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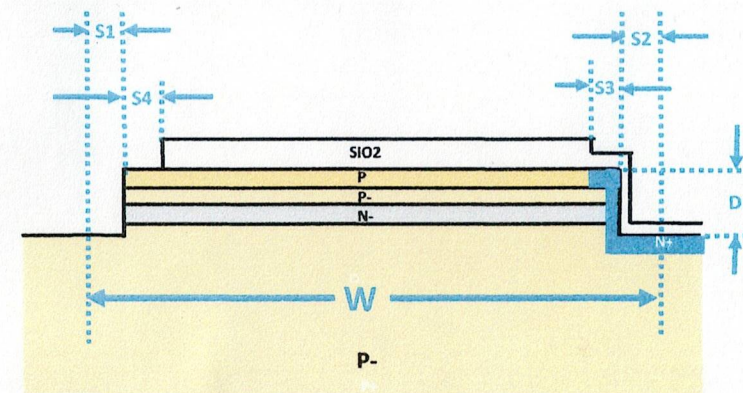
P14 Third SiO₂ Etching

15

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P15 Remove OFPR resist

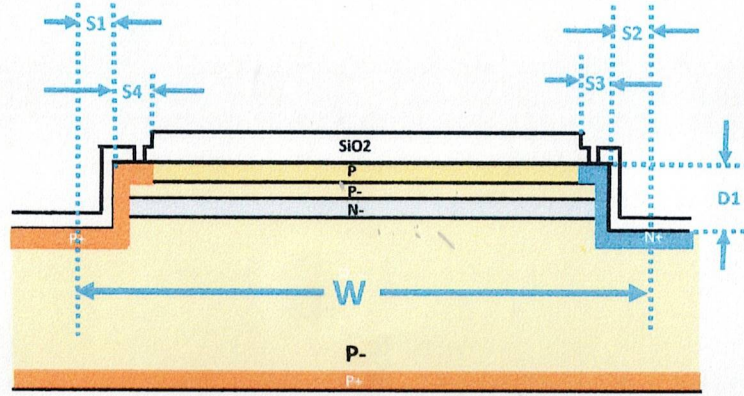


16

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P20 Remove Resist

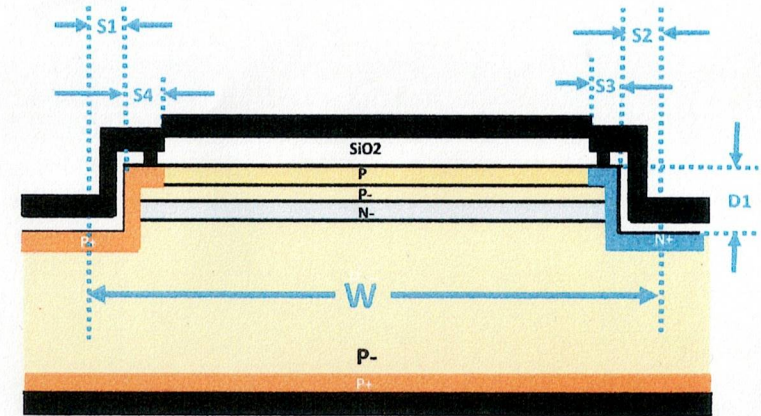


21

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P21 Deposit Metal

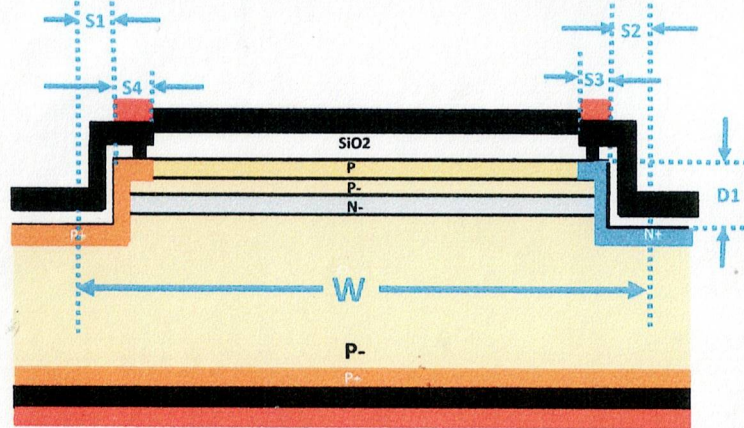


22

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P22 MASK05 Fifth Resist Coating and Patterning

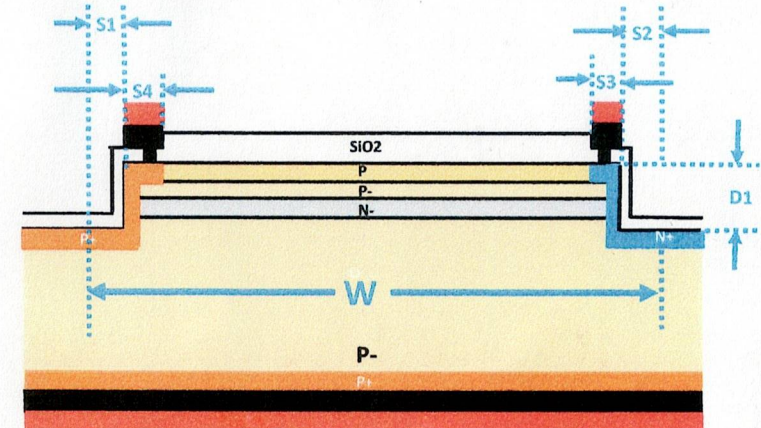


23

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P23 Metal Etching

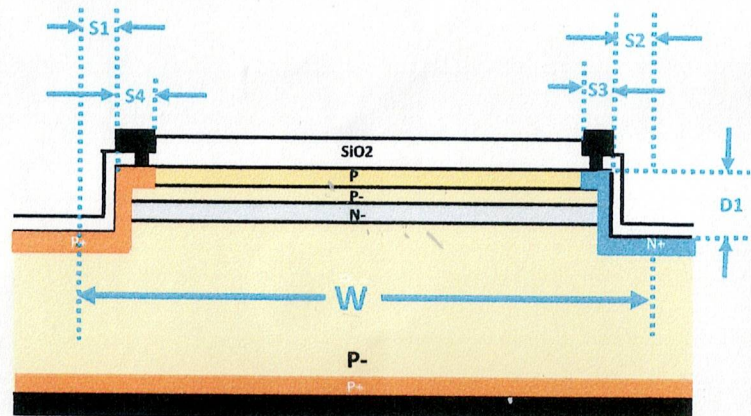


24

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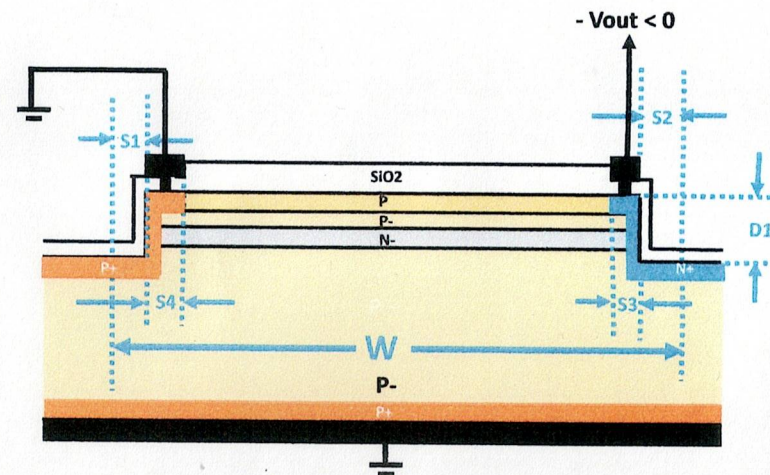
P24 Remove Resist



25

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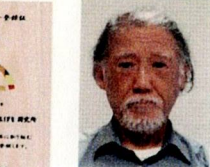
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Pinned Photodiode type Solar Cell (JPA2020-131313)

Japanese Patent Application (JP2020-131313)

Gate Oxide thickness: 0.13 μm

Surface P region: $1 \times 10^{17} \text{ cm}^{-2}$ Buried N region: $4.28 \times 10^{17} \text{ cm}^{-2}$ P substrate region: $1 \times 10^{16} \text{ cm}^{-2}$ Backside N+ region: $1 \times 10^{17} \text{ cm}^{-2}$

Sony SSDM1977/1978 Photo Sensor Device

Gate Oxide thickness: 0.13 μm

Surface P region: $2 \times 10^{17} \text{ cm}^{-2}$ Buried N region: $1.7 \times 10^{17} \text{ cm}^{-2}$ P substrate region: $5 \times 10^{16} \text{ cm}^{-2}$ Backside N+ region: $1 \times 10^{17} \text{ cm}^{-2}$

Hagiwara SSDM1978 Paper on Pinned Buried Photodiode.pdf

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