Third bifi PV workshop in Miyazaki, Japan

YINGLI SOLAR

Industrial high efficiency N-type bifacial solar cell with selective back surface field (SBSF)

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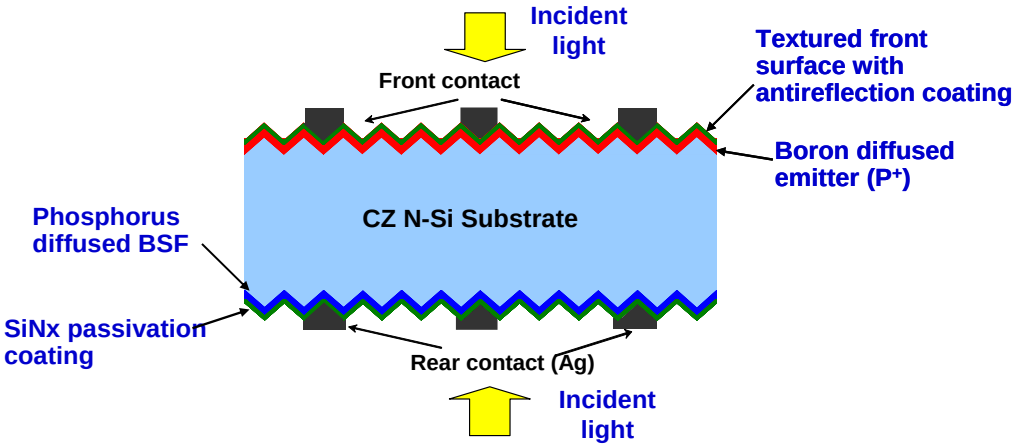
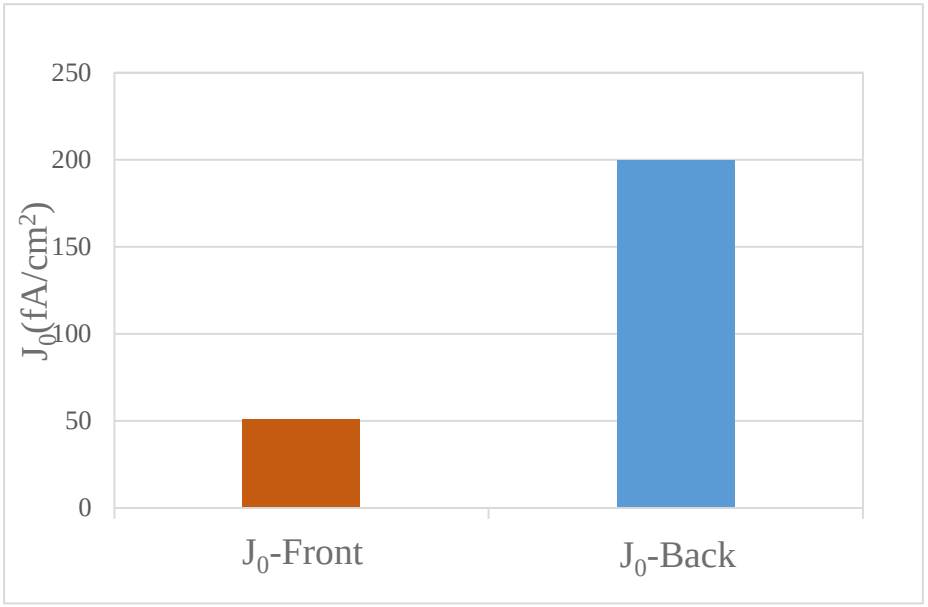
Outline

1. Background-Yingli panda cell
2. Selective Back Surface Field Cell
3. Process Optimazation
4. Cell Results
5. Summary

Background-Yingli Panda Cell



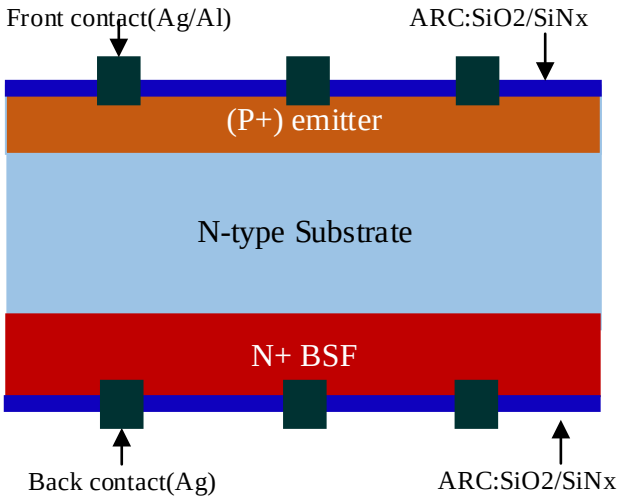
- Emitter&BSF Co-diffusion
- Simple cell structure and easy manufacture
- Enable bifacial modules



- Front surface (P+ emitter) recombiantion≈49fA/cm^2
- Back surface (N++ BSF) recombination≈200fA/cm^2
- Dominant limiting factors by Back surface field

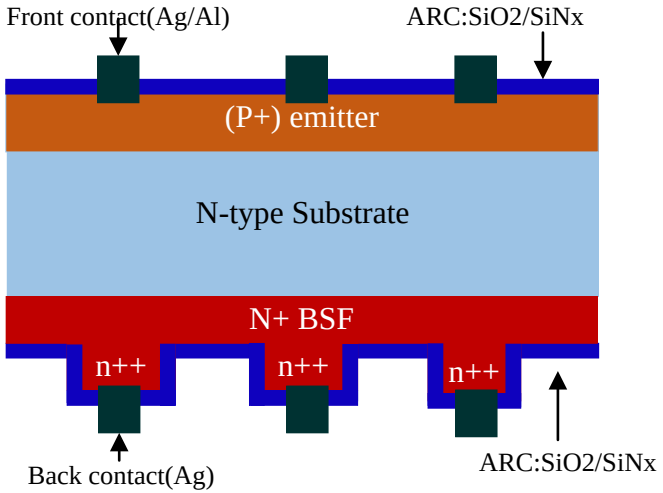
Selective Back Surface Field (SBSF) Cell

Conventional back surface field(BSF)



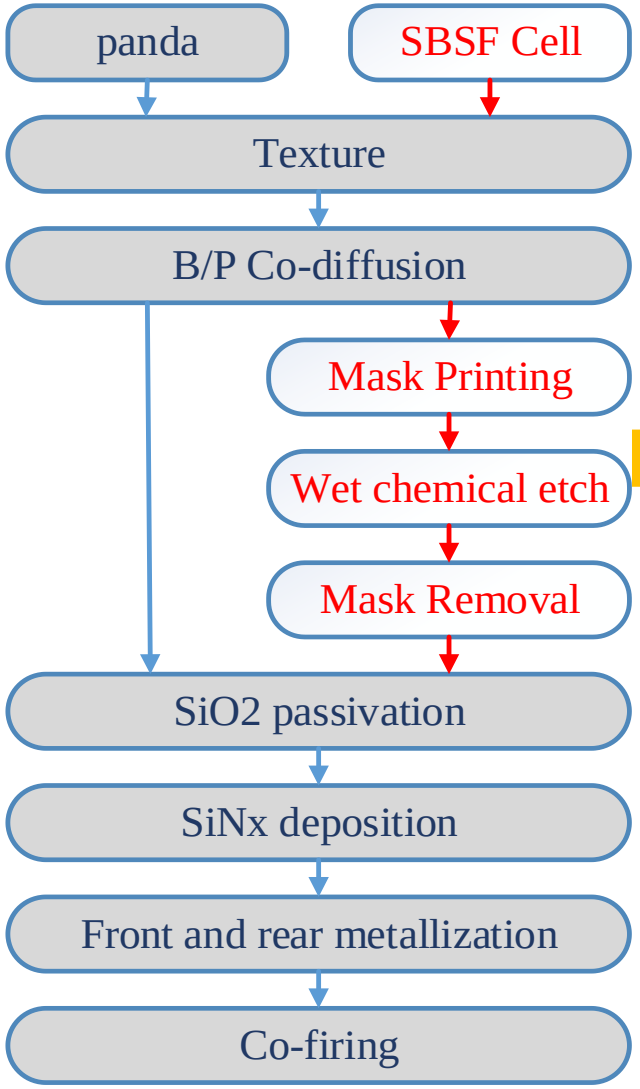
- low contact resistance and good FF
- high back surface recombination
- Cell Efficiency loss

Selective back surface field (SBSF)

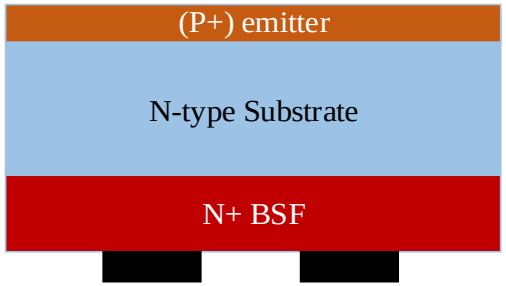


- low contact resistance, FF lose
- lower surface recombination
- better IQE, higher cell efficiency

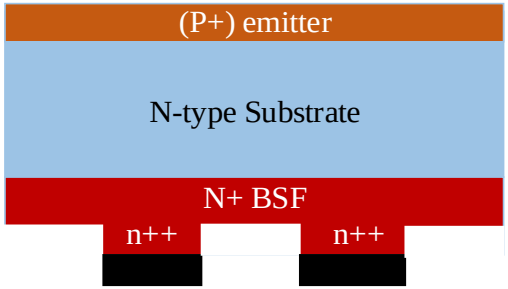
Selective Back Surface Field (SBSF) Cell



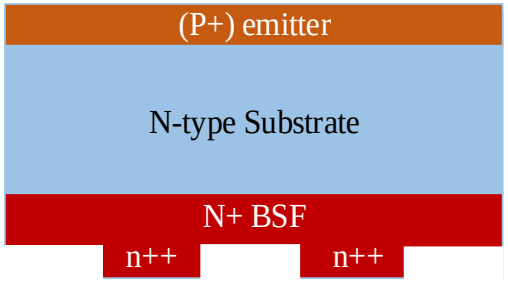
Mask printing



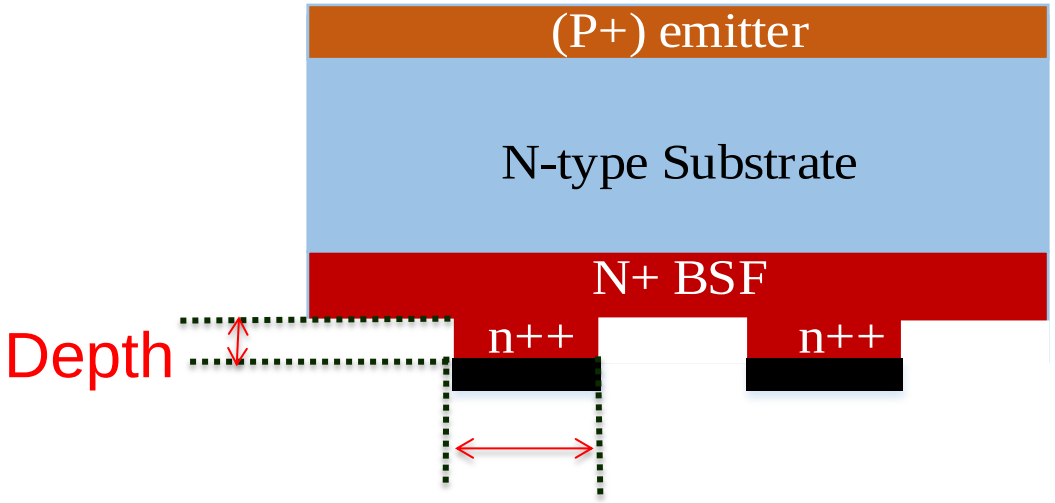
Wet chemical etch



Mask removal



Selective Back Surface Field (SBSF) Cell



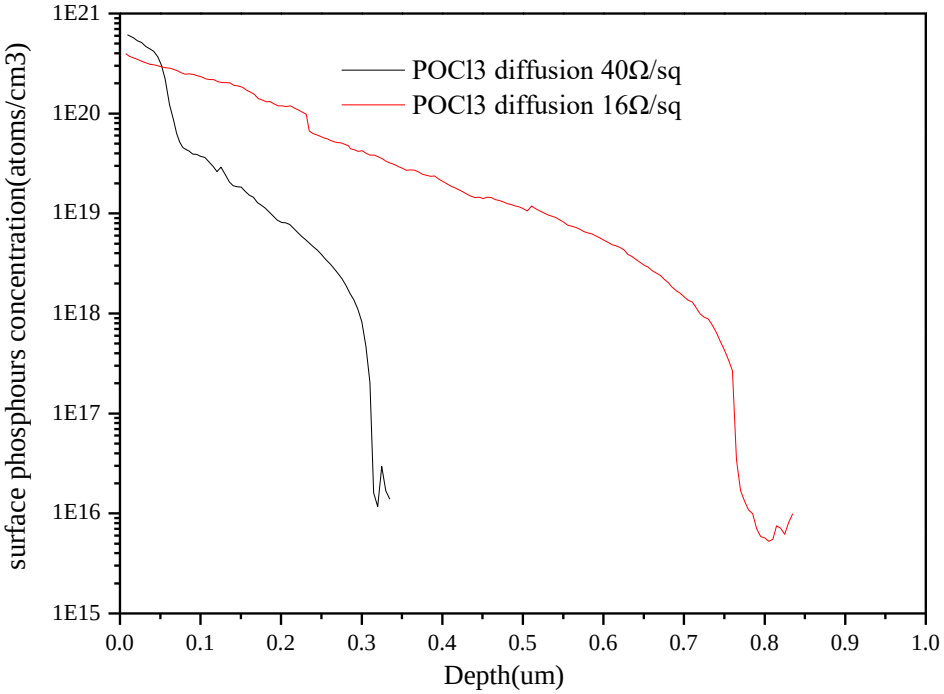
Depth (R_{sh})

- BSF passivation
- Voc Jsc FF
- Efficiency

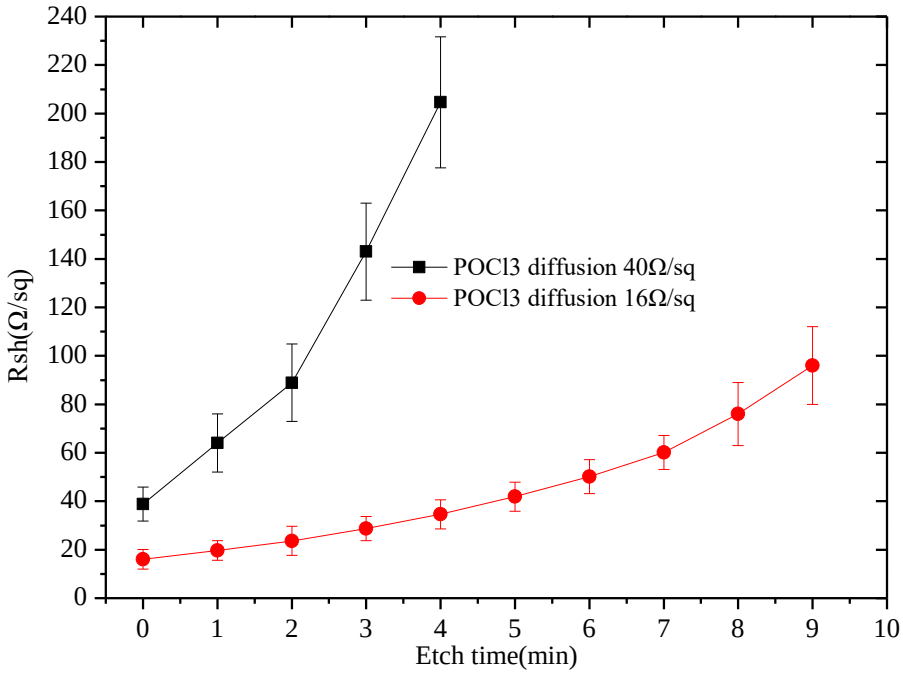
Mask width

- Alignment
- Voc Jsc FF
- Efficiency

Process Optimazation



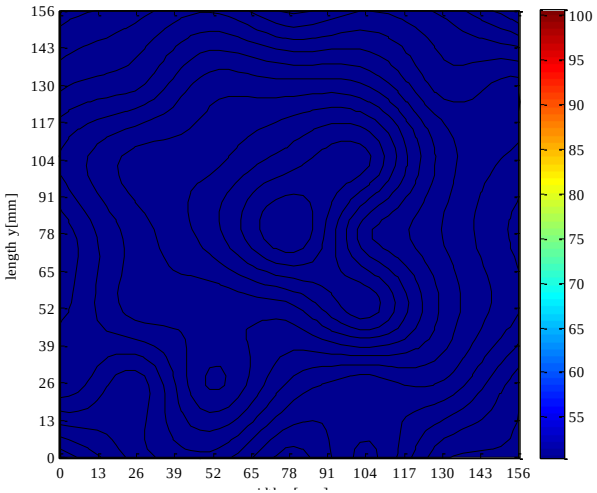
BSF doping profile with different starting diffusion



Sheet resistance Versus etching time

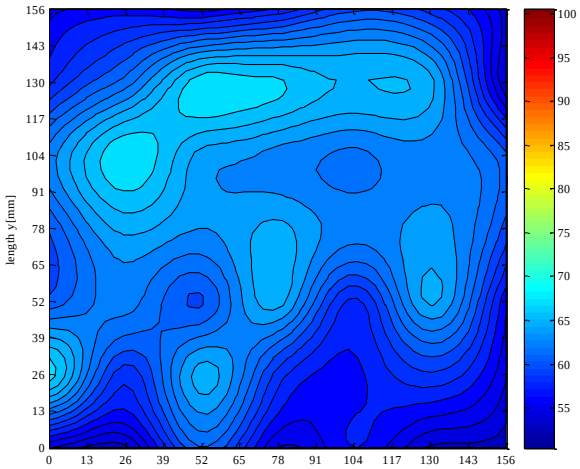
The first parameter to optimise is the etch depth (final Rsh of the etched surface).There are two main factors:starting diffusion and etching time.The etching rate with 40Ω/sq was observed to be faster than 16Ω/sq and the homogeneity is poor.

Process Optimazation



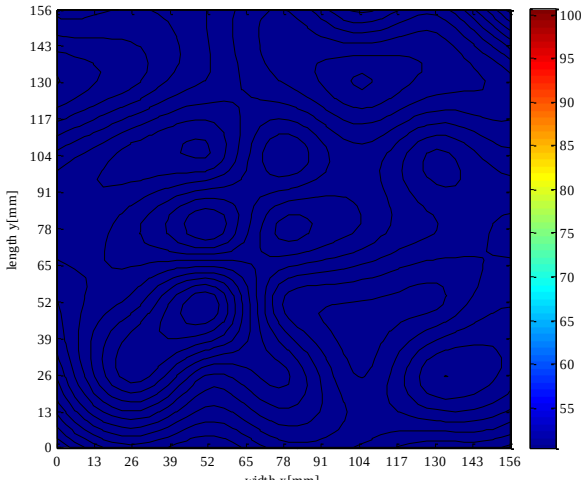
Back surface field 16Ω/sq

std.dev4.89



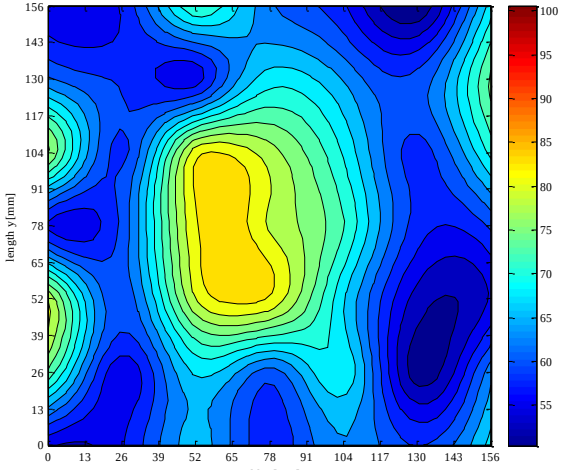
etch back 16Ω/sq to 61 Ω/sq

std.dev 7.23



Back surface field 40 Ω/sq

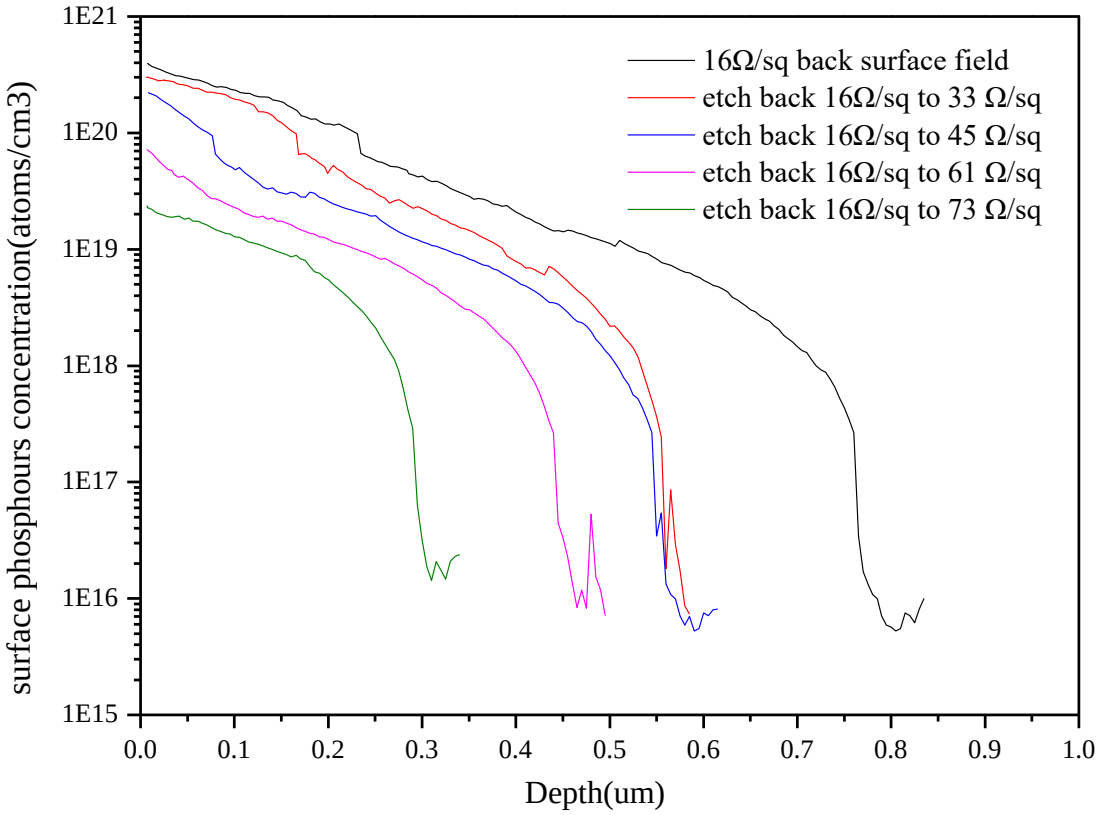
std.dev 5.28



etch back 40Ω/sq to 63 Ω/sq

std.dev 12.23

Process Optimazation

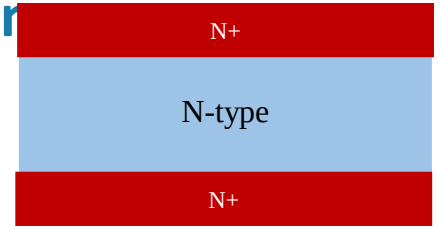


Samples with different Rsh（33Ω/sq，45Ω/sq，61Ω/sq，73Ω/sq）were gotten from wafers with starting BSF 16Ω/sq by etching back process. The corresponding doping profiles were measured. Surface concentration is drop along with the increased Rsh.

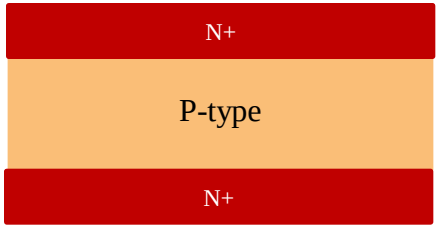
Process Optimazation

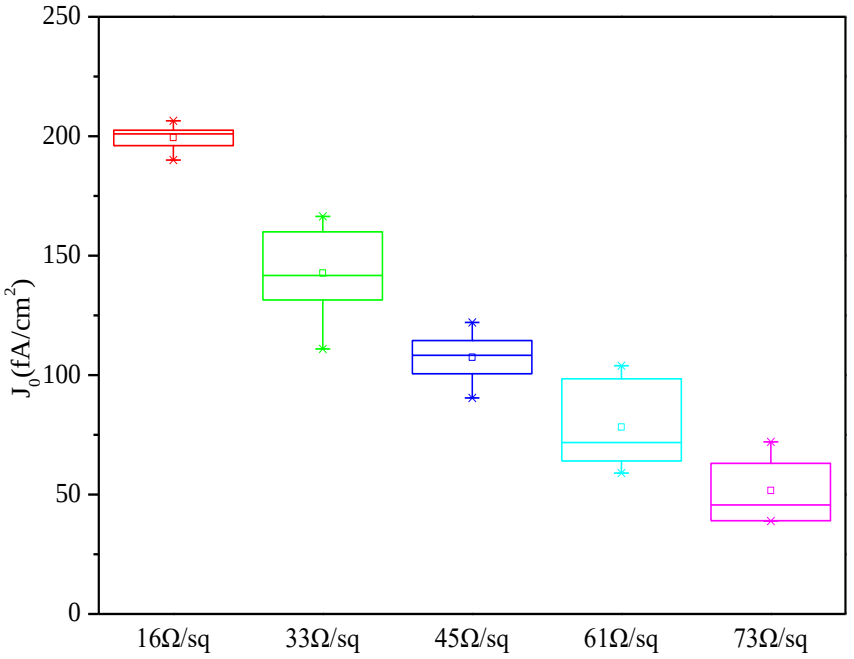
Symmetric structure with etch back different Sheet Resistar

(1) J0



(2)Rsh

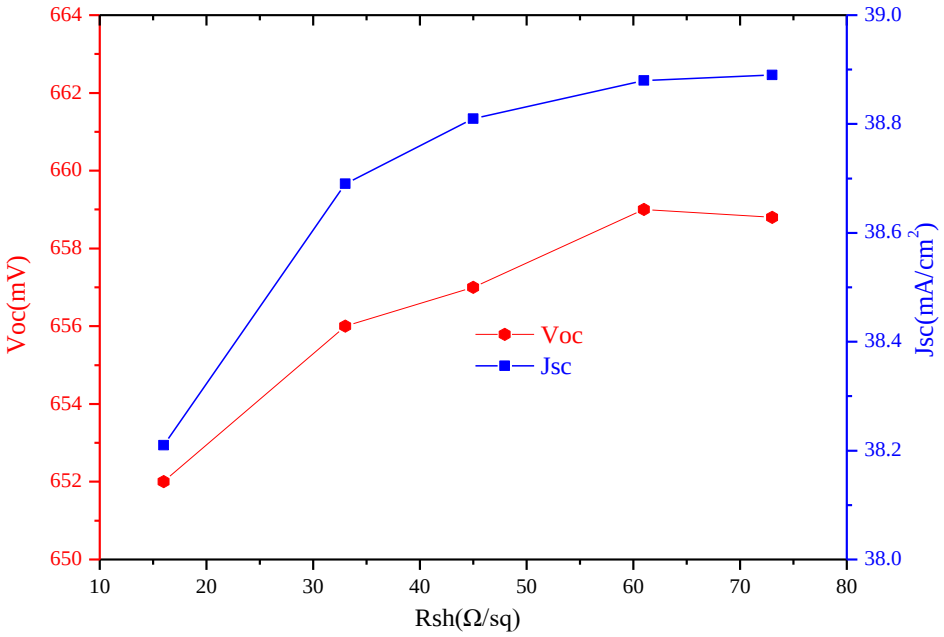


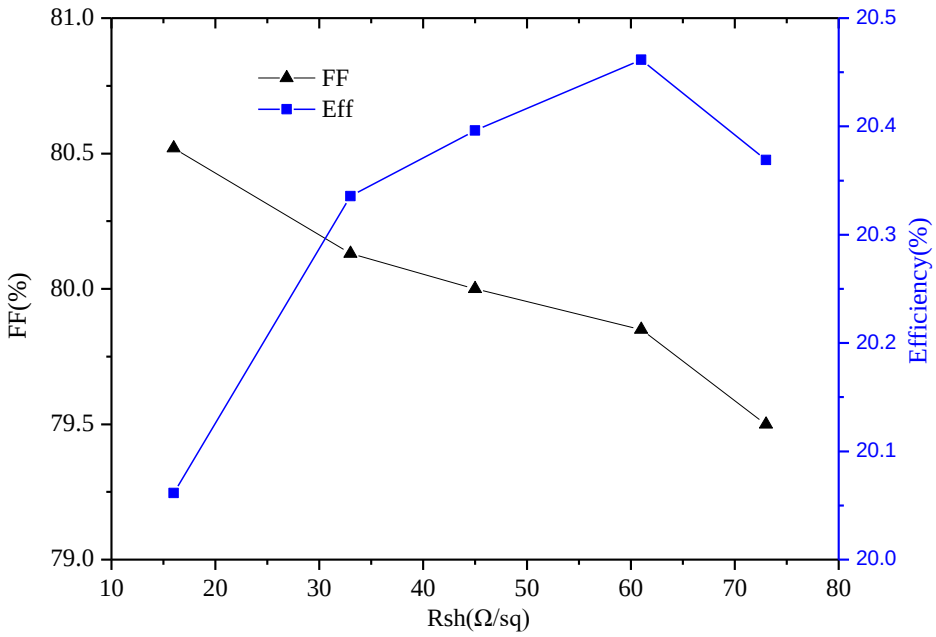


- Texture
- double side POCl3 diffusion
- etch back for different Rsh
- passivation
- ARC+firing
- QSSPC measurement (5X10^{15}cm^{-3})

- Along with the increased Rsheet, J0 is reduced drastically
- Rsh=73Ω/sq， J_0 reach 50 fA/cm^2, same with front surface recombination.

Cell Results

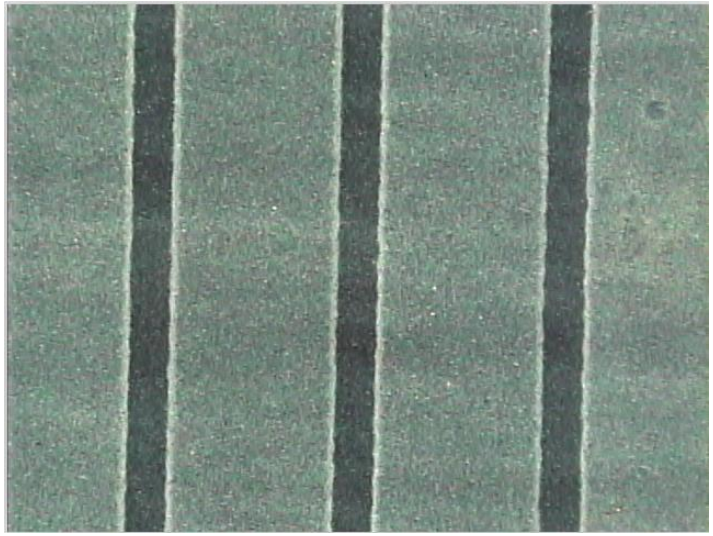




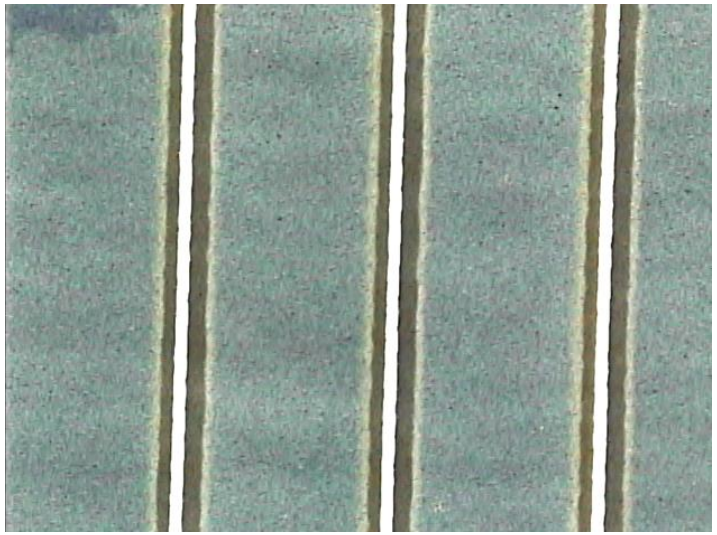
1. SBSF cells are made with different etch back R_{sh} , Voc and Jsc are improved, FF decrease along with the increased R_{sh}.
2. Suitable etching R_{sh} has to be selected for balanceing the Voc, Jsc and FF, and then get better cell performance relatively

Cell results

Group	mask width(um)	Voc(mV)	Jsc(mA/cm^2)	FF(%)	Eff(%)
G1	300	657	39.17	79.93	20.57
G2	250	659	39.21	79.86	20.64
G3	200	661	39.26	79.85	20.71
G4	150	660	39.30	79.82	20.68



Etch back

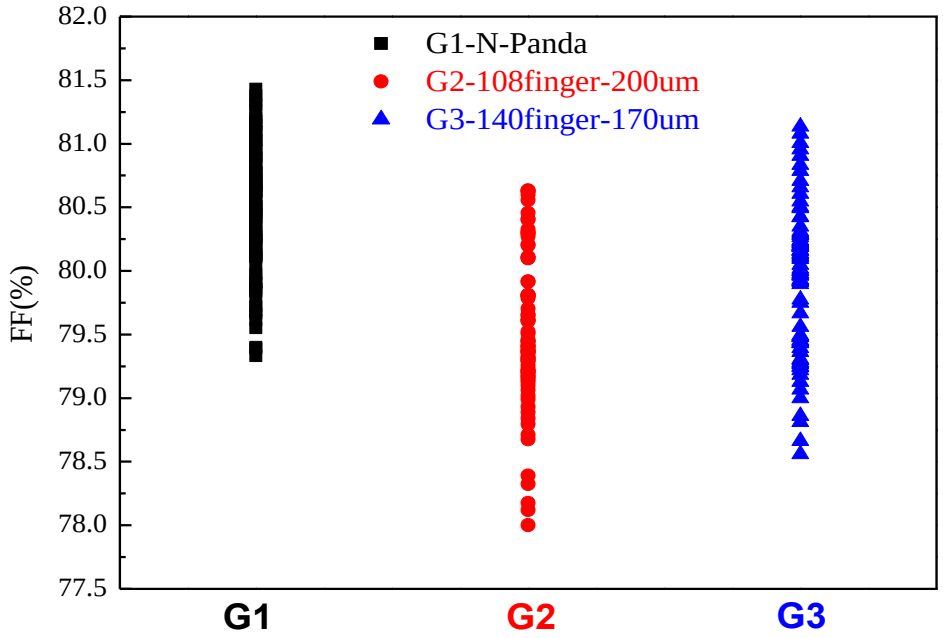


Metalization

Cell results

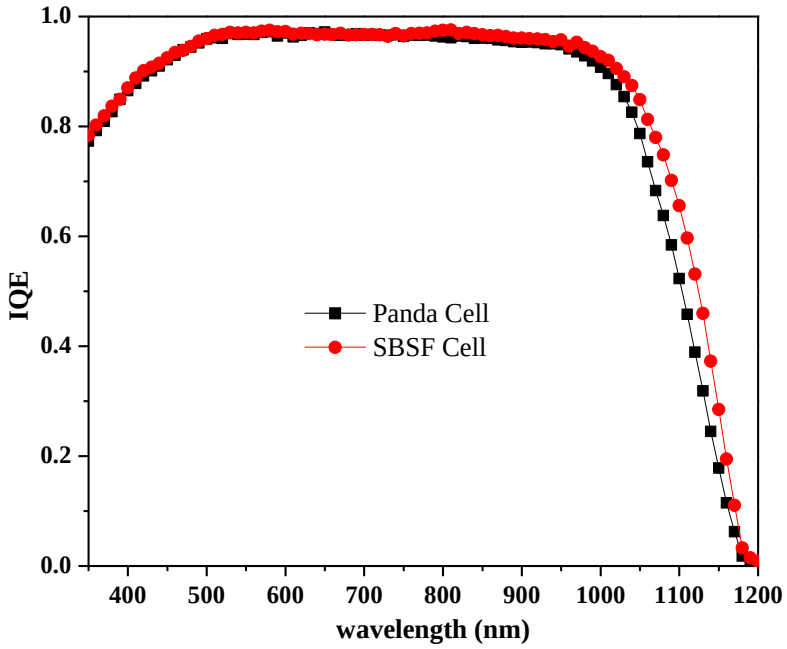
Group	Mask fingers	Mask width(um)	Voc (mV)	Jsc (mA/cm²)	FF (%)	Eff (%)
G1	N-panda		653	38.85	80.43	20.40
G2	108	200	662	39.35	79.54	20.72
G3	140	170	661	39.31	80.12	20.83

※Same mask area for G2 and G3



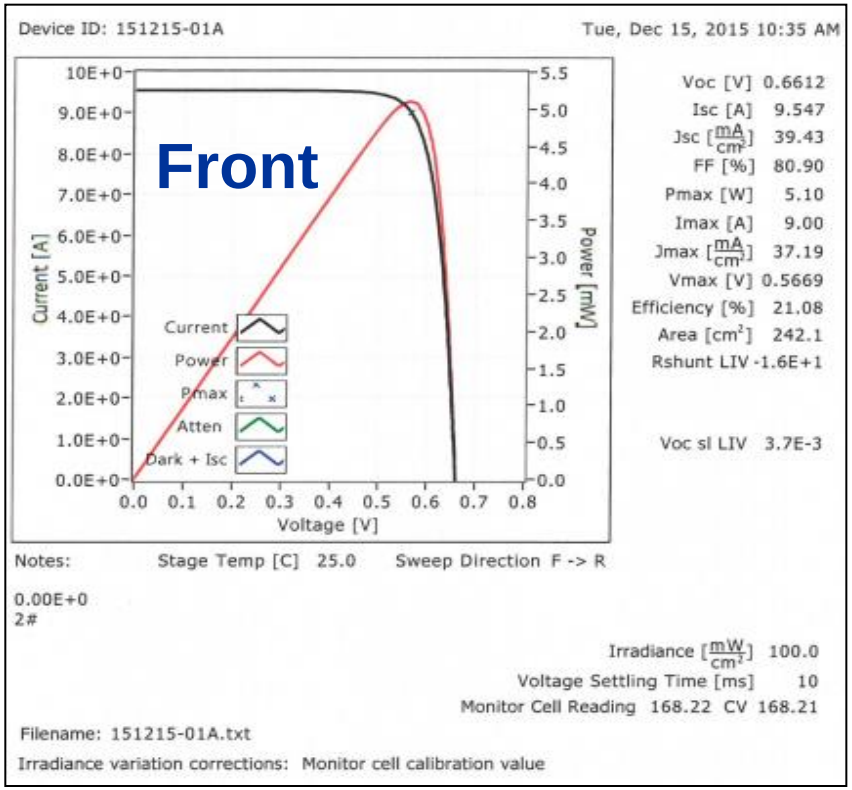
Cell results

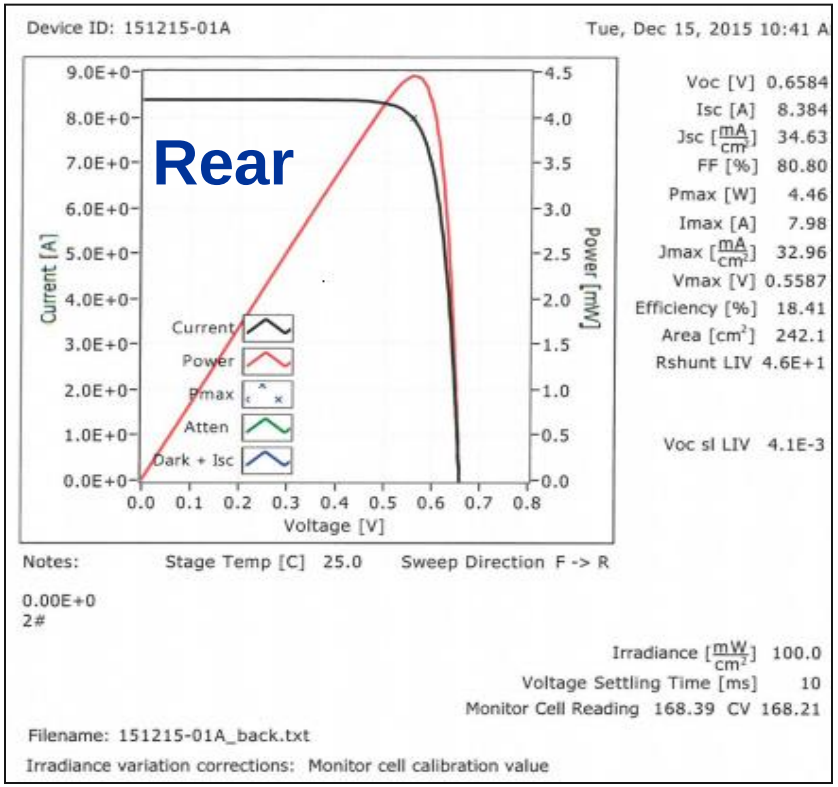
Group	Voc (mV)	Jsc (mA/cm^2)	FF (%)	Eta (%)
Panda Cell	653	38.79	80.93	20.50
SBSF Cell	661	39.44	80.23	20.93



- Voc was increased 8mV
- Jsc was increased 0.65mA/cm^2
- Better IQE in wavelength of 950-1200nm
- Average Efficiency of 20.9%

Cell results





Side	Area(cm^2)	V_{oc} (mV)	J_{sc}(mA/cm^2)	FF(%)	Eff. (%)
Front	242.1	661.2	39.43	80.90	21.08
Rear	242.1	658.4	34.63	80.80	18.41

*** Tested in calibration lab: National Physical and Chemical Power Products Testing Center**

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Summary

- We developed an industrially feasible etch back process to fabricate selective back surface field (BSF) for N-type bifacial Si cell.
- Etching back process were optimized and has been proved to be controllable and stable.
- Average efficiency above 20.9% demonstrated

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Thank you for your attention