Renewable Energy Research Center

Towards 22% high-efficiency p-type PERC solar cells

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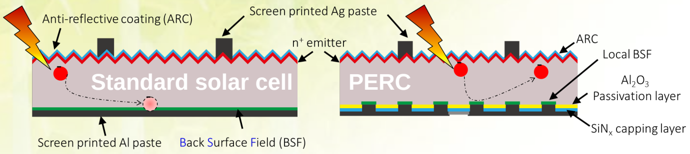
Passivated Emitter and Rear Cell (PERC)

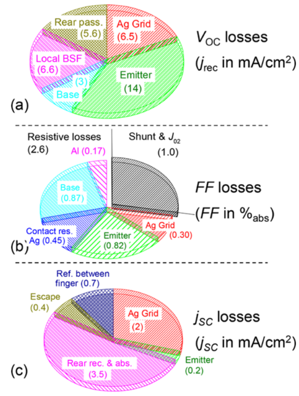


The concept of advanced Si-based solar cells with a dielectric passivation layer at the rear of the cell is one of the most promising structures for changing the std. cell into a more-efficient PERC. The presence of a passivation layer at the rear of the cell permits low surface-recombination velocities, a steadier flow of electrons, and an improved performance. Consequently, excellent rear-surface passivation is one of the most important issues in improving the efficiency of PERC structures.

Loss analysis of PERCs

Saint-Cast et al. [1] conducted a loss analysis of PERCs and reported that

- more than half of the recombination events occur in the emitter and under the front contacts,
- second important loss channel is associated with passivation at the rear surface.



[1] P. Saint-Cast et al., Phys. Status Solidi A 214, 1600708 (2017).
[2] A. Rohatgi et al., Proc. 17th EUPVSEC, 1307-1310 (2001).
[3] B. Min et al., Energy Procedia **55**, 115–120 (2014).

Ways towards 22% high-efficiency PERC

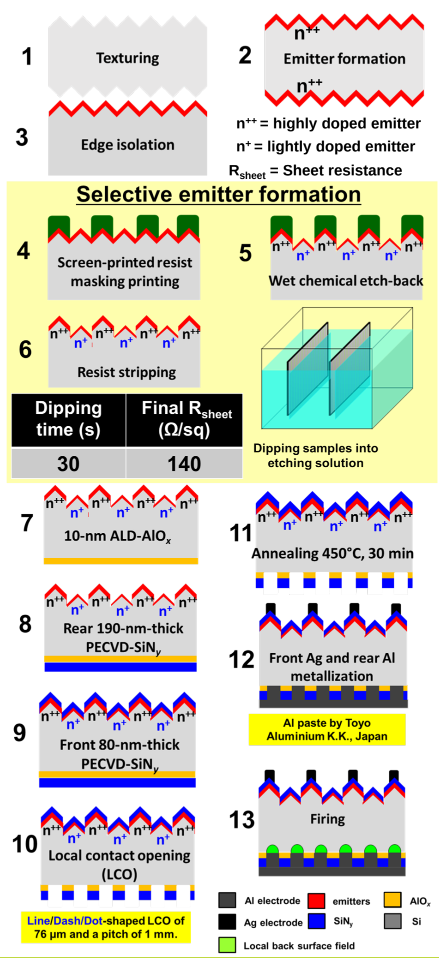
❑ Reducing recombination on the emitter and front metal grid by the implementation of a selective emitter (SE) structure [2, 3].

1. Selective emitter (SE) formation by wet chemical etch-back process
2. Rear surface passivation schemes

❑ Reducing recombination at rear structure

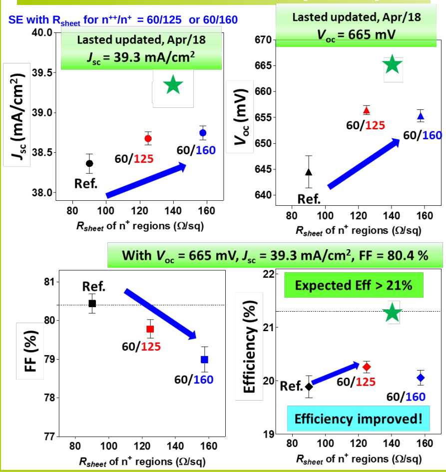
1. Local contact opening (LCO)
2. Rear surface passivation
3. Metallization material (Si-free Al paste, Al paste with Si)

SE PERC by etch-back



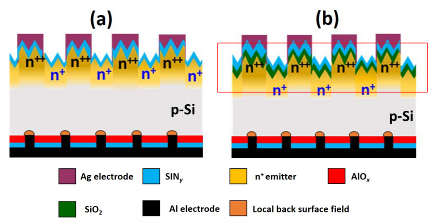
Dipping time (s)	Final R_{sheet} (Ω/sq)
30	140

Effect of SE structure (Front)



[4] S. Joonwichien et al., IEEE J. Photovolt. **8**, 703-709 (2018).

Effect of surface passiv. (Front)



A chemically grown SiO_2 layer by NAOS method

NAOS = Nitric acid oxidation of Si

	J_{sc}	V_{oc}	FF	Eff
Ref	38.4	651	79.6	19.9
With SiO_2	38.5	↑ 5 mV 656	79.2	20.0

[5] S. Joonwichien et al., Sol. Energy Mater. Sol. Cells **186**, 84-91 (2018).

Effect of LCO (Rear)

LCO shape	J_{sc}	V_{oc}	FF	Eff
Line	38.6	646	80.8	20.2
Dash	39.5 ↑	651 ↑	79.7	20.5
	0.9 mA/cm²	5 mV		

Dash-shaped LCO increases the passivation areas, thereby improved V_{oc} and J_{sc}.

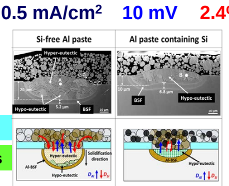
Dot-shaped LCO for PERC can provide an additional 5 mV.

Effect of Si in Al paste (Rear)

All *I-V* improved | Voids reduced 5 times (25% > 5%)

Al paste	J_{sc}	V_{oc}	FF	Eff
Si-free paste	37.8	**635**	78.7	18.9
Al paste + Si powder	38.3 ↑	**645** ↑	81.1 ↑	**20.1** ↑
	0.5 mA/cm²	10 mV	2.4%	1.2%

Hypo-alloys
Hyper-alloys



Hypo-alloys

[6] S. Joonwichien et al., IEEE J. Photovolt. **8**, 54-58 (2018).