Photonic nanostructures for Si solar cells: two etching techniques and their impact on lifetimes and contacting

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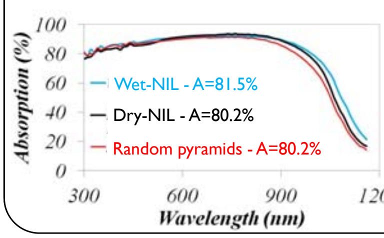
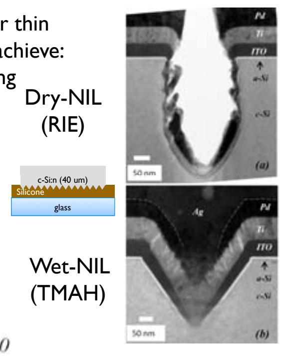
1. Photonics for thin c-Si cells[1,2]

The idea: 2D photonic nanostructures for thin crystalline silicon solar cells in order to achieve:

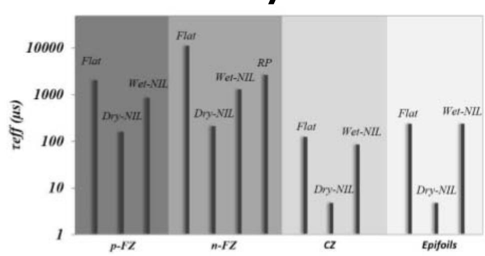
- Minimal material waste during texturing
- Absorb light more efficiently
- Harvest long wavelength photons





Two etched profiles

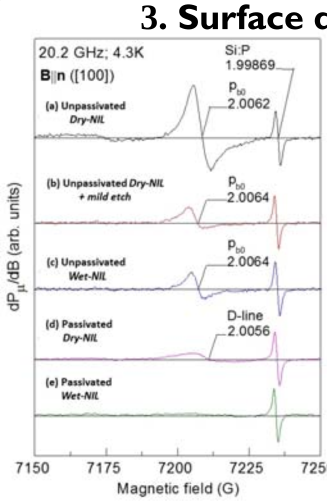
2. Minority carrier lifetimes[3]



Passivation by PECVD a-Si:H

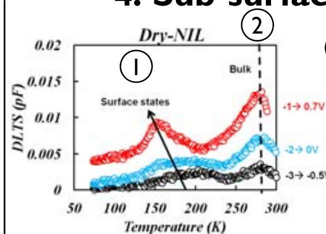
- Severe lifetime degradation for dry-etched parabolic profiles (Dry-NIL)
- High lifetimes for wet-etched inverted nanopyramids (Wet-NIL)

3. Surface defects (ESR)



- High plasma damage after Dry-NIL
$P_{b0} = (1.1 \pm 0.1) \times 10^{13}$ cm^{-2}
- Restoring surface quality
$P_{b0} = (2.0 \pm 0.2) \times 10^{12}$ cm^{-2}
- Less degradation after Wet-NIL
$P_{b0} = (2.0 \pm 0.2) \times 10^{12}$ cm^{-2}
- Insufficient surface passivation
$P_{b0} = (3.1 \pm 0.8) \times 10^{12}$ cm^{-2}
- Sufficient surface passivation
$P_{b0} < 6 \times 10^{10}$ cm^{-2}

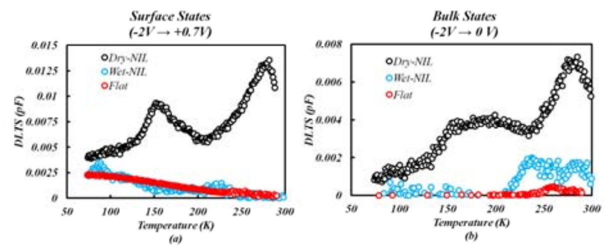
4. Sub-surface defects (DLTS)



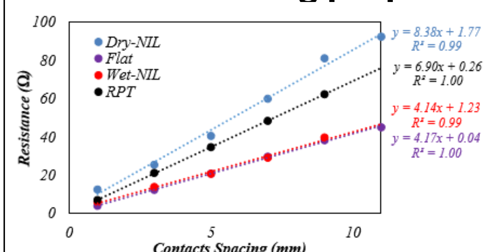
(1) The shape and position of the broad DLTS peak at lower temperatures reveals the presence of interface states.

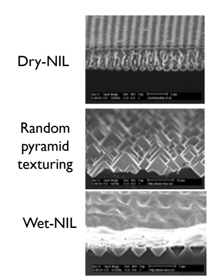
(2) The position of the DLTS peak near room temperature is independent of the pulse and is related to bulk traps.

Less surface and subsurface defects for Wet-NIL



5. Contacting properties (TLM)[4]





	Flat	Dry-NIL	Wet-NIL	Random pyramids
R_{sh} (Ω/■)	41.7	83.8	41.4	69.0
R_c (Ω)	<0.1	0.89	0.62	0.1

Better contacting for Wet-NIL

Summary

Wet vs Dry surface nanotexture etching:

- Better optical performance for Wet-NIL
- High plasma damage for Dry-NIL: surface and subsurface defects
- Better contacting properties for Wet-NIL

Outlook

Inverted nanopyramids could enable integration of nanophotonics into high-efficiency thin crystalline Si solar cells

1. C. Trompoukis et al., Appl. Phys. Lett. 101, 103901 (2012)
2. C. Trompoukis et al. Phys. Status Solidi (a) 212, 140-155 (2015)
3. C. Trompoukis et al. Progr. Photovolt. Res. Appl. 23, 734-742 (2015)
4. I. Abdo et al., IEEE J. Photovolt 5, 1319 (2015)

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