



INCREASING THE EFFICIENCY OF SOLAR CELLS USING POROUS SILICON

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OUTLINE

- **Aim of work**
- **Different morphology between silicon and porous silicon**
- ***Silicon (Si)***
- **Crystalline structure of SILICON**
- **Porous silicon (P-Si)**
- **Application of porous silicon according porosity**
- **Scanning electron microscopy**
- **Schematic illustration of the light reflection decrease in PS/(n-p)Si solar cell**
- **Energy band diagram of nPS/(n+-p)Si solar cell**
- **effective reflectance for porous silicon surface**
- **Conversion Efficiency in P-Silicon Solar Cells**
- **Current density in P-Silicon Solar Cells**

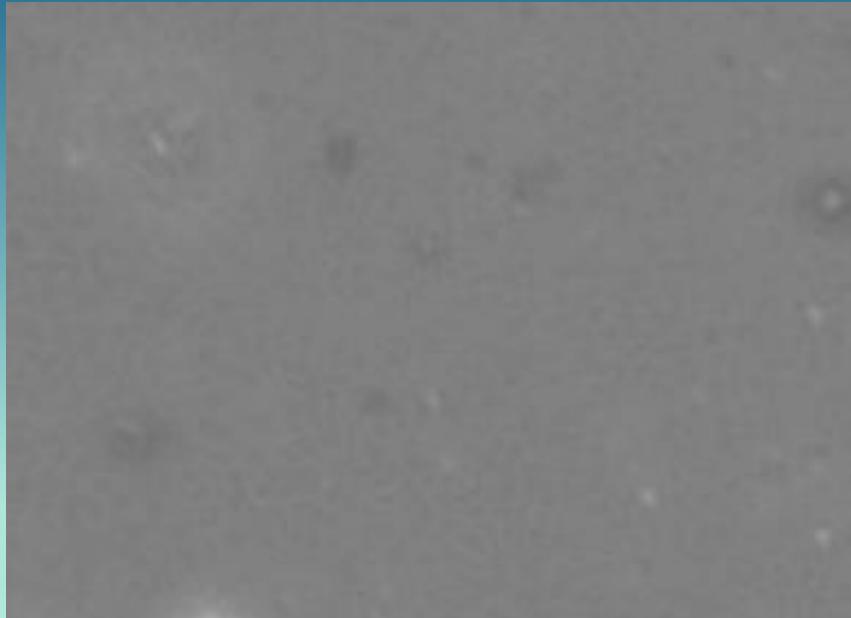
AIM OF WORK

Increasing the efficiency of solar cells by increasing the surface area of the solar cell through the use of porous silicon.

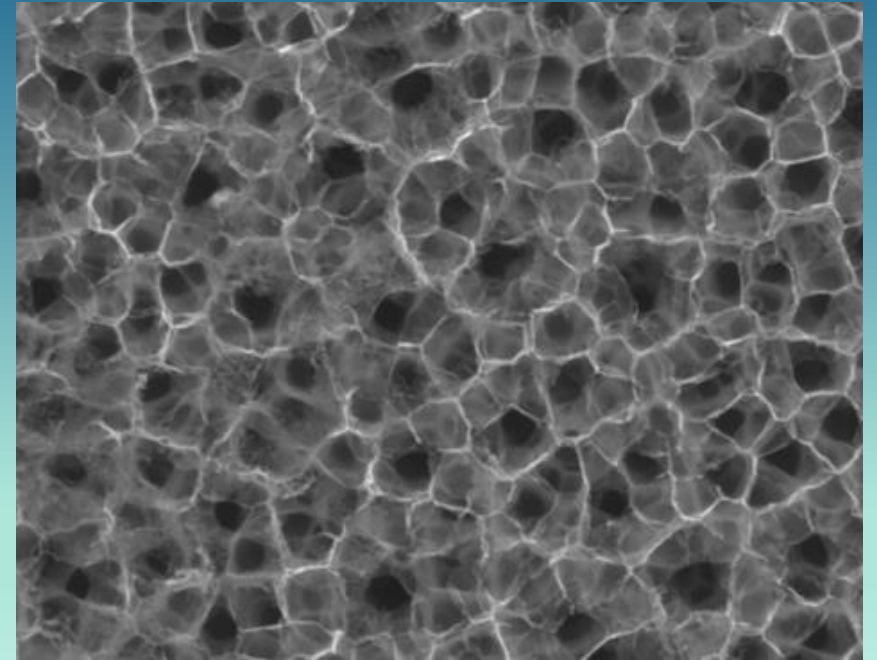
**Different morphology between
silicon and porous silicon**



Silicon



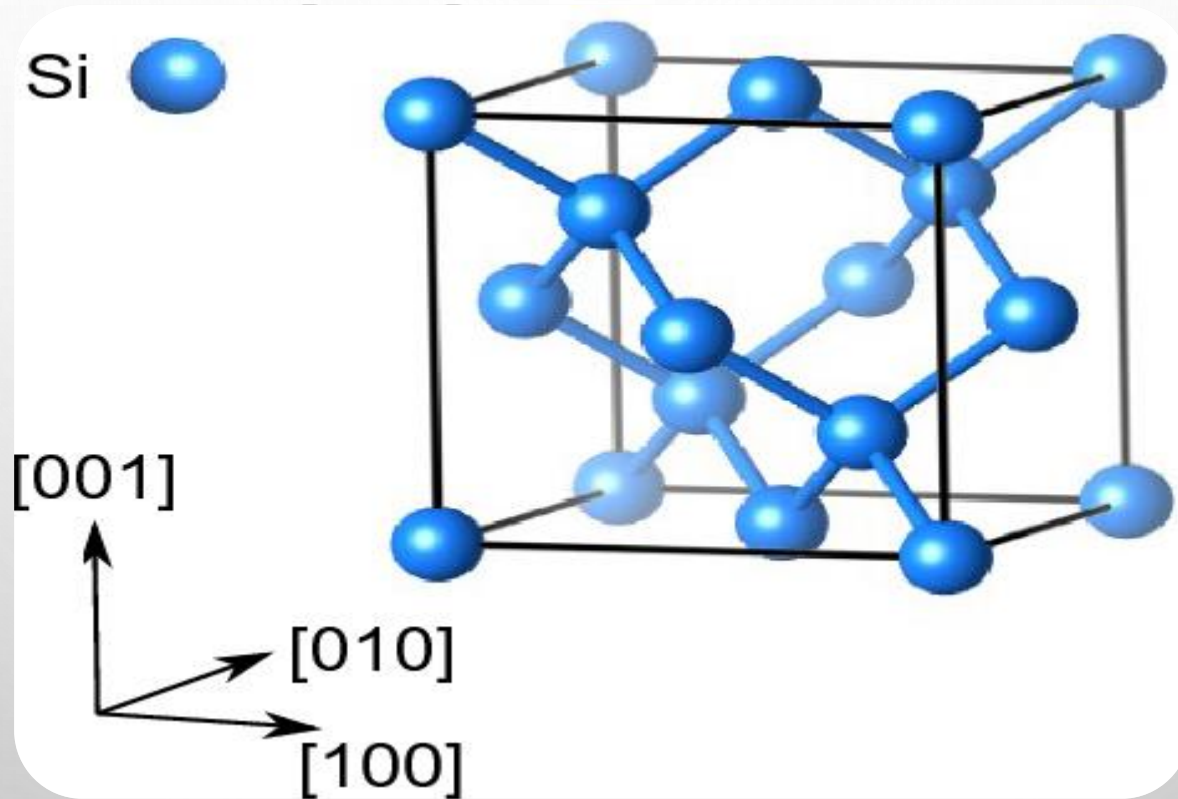
Porous silicon



Silicon (Si)

- **Formula:** Si
- **Composition:** A single silicon atom.
- **Bond Type:** Silicon forms strong covalent bonds, thanks to its four valence electrons.
- **Molecular Structure:** Solid at room temperature, displaying a crystalline structure.
- **Electron Configuration:** 14 electrons, with the configuration $1s^2 2s^2 2p^6 3s^2 3p^2$.
- Band gap of silicon is indirect (1.12)e.v.
- **Significance:** Integral in electronics as a semiconductor material, used in solar cells, and in making glass and building materials.

CRYSTALLINE STRUCTURE OF SILICON



$[100]$
 $[010]$

POROUS SILICON (P-SI)

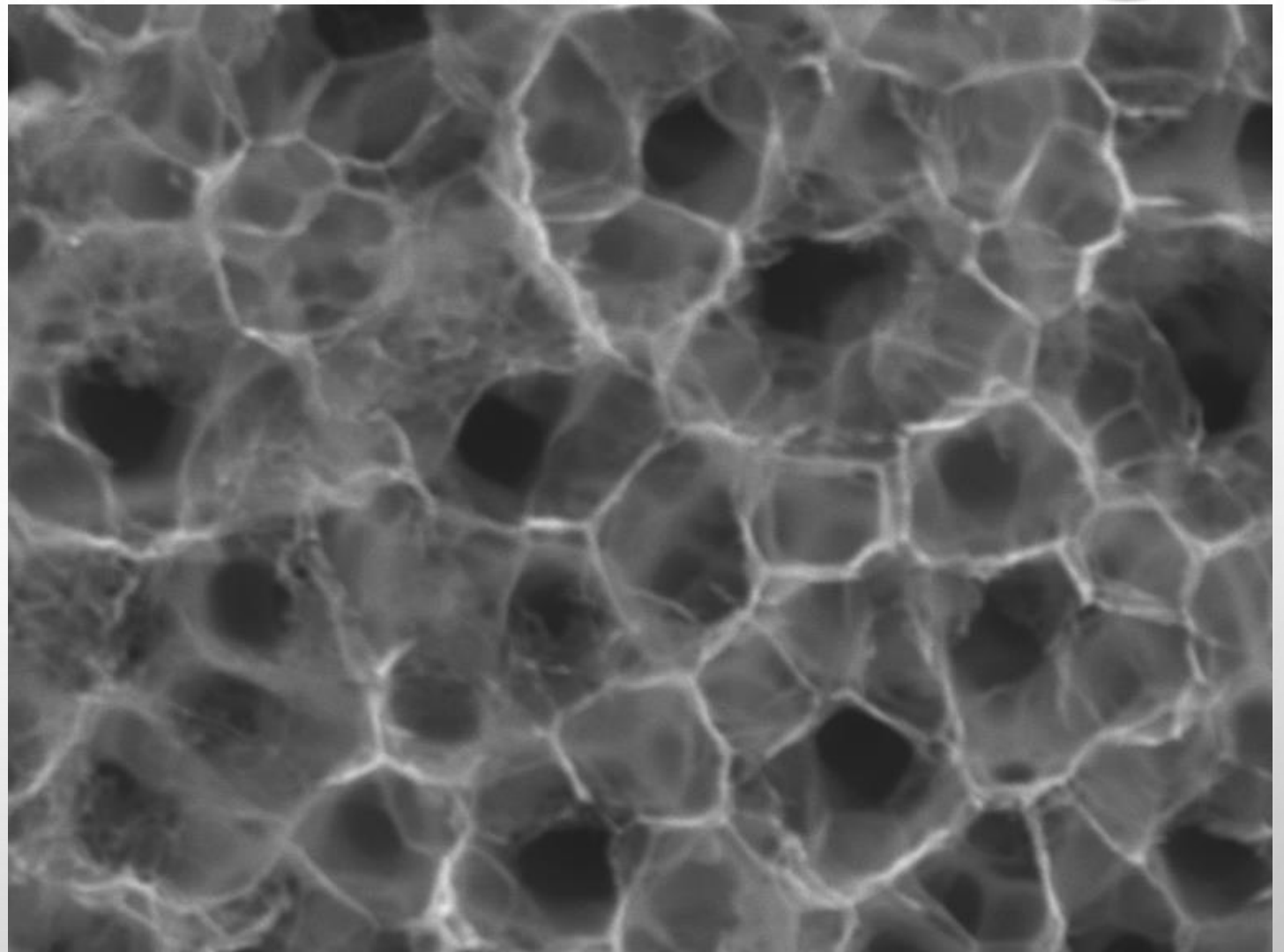
- Crystalline lattice of silicon has a two orientation (100) and (111) .
- Porous silicon is a sponge-like structure of monocrystalline silicon (solid silicon with voids therein).
- porous silicon has a direct band gap $\approx (2)\text{e.v.}$.

APPLICATION OF POROUS SILICON ACCORDING POROSITY

Porosity (%)	Level of porosity	Applications area for PSi
0-30	Low	Microcapacitor, tissue bonding, wafer bonding
30-70	Medium	Sensors, silicon on insulator, micromachining, solar cells
70-99	High	LED, anti-reflecting coating, nonlinear optics

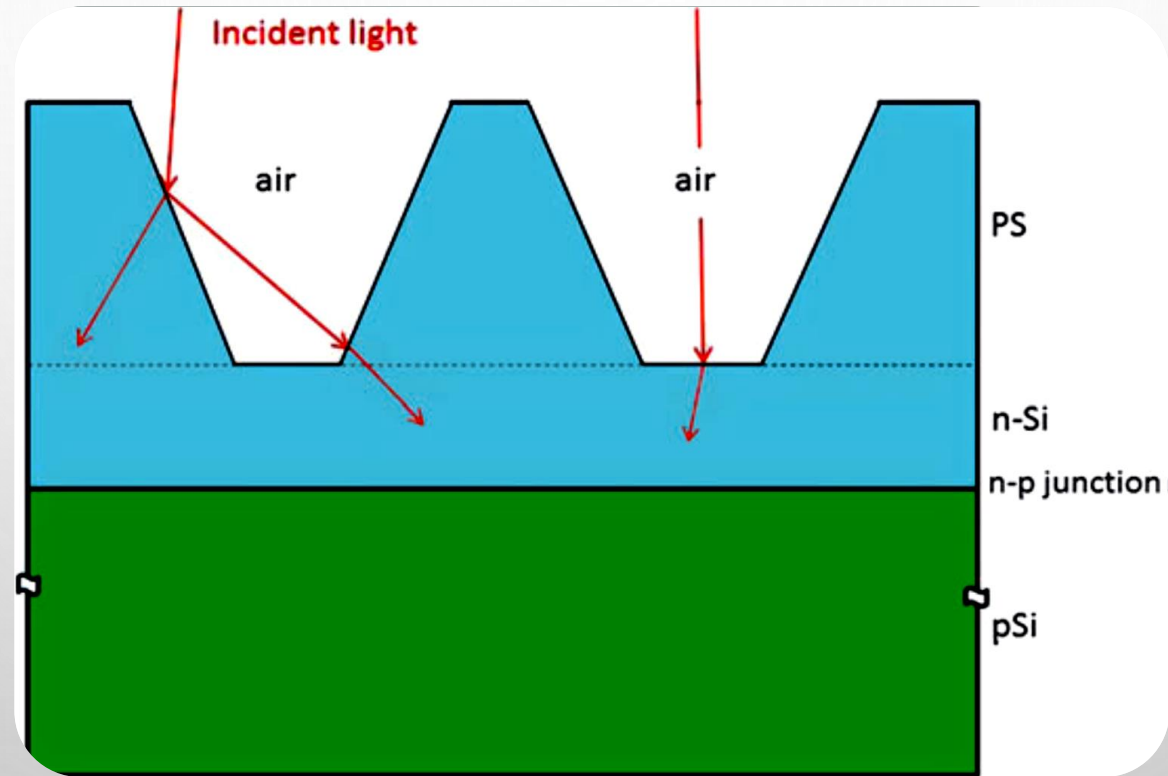
$$\text{Porosity}(\%) = \frac{m_1 - m_2}{m_1 - m_3}$$

Scanning electron microscopy (SEM) exam

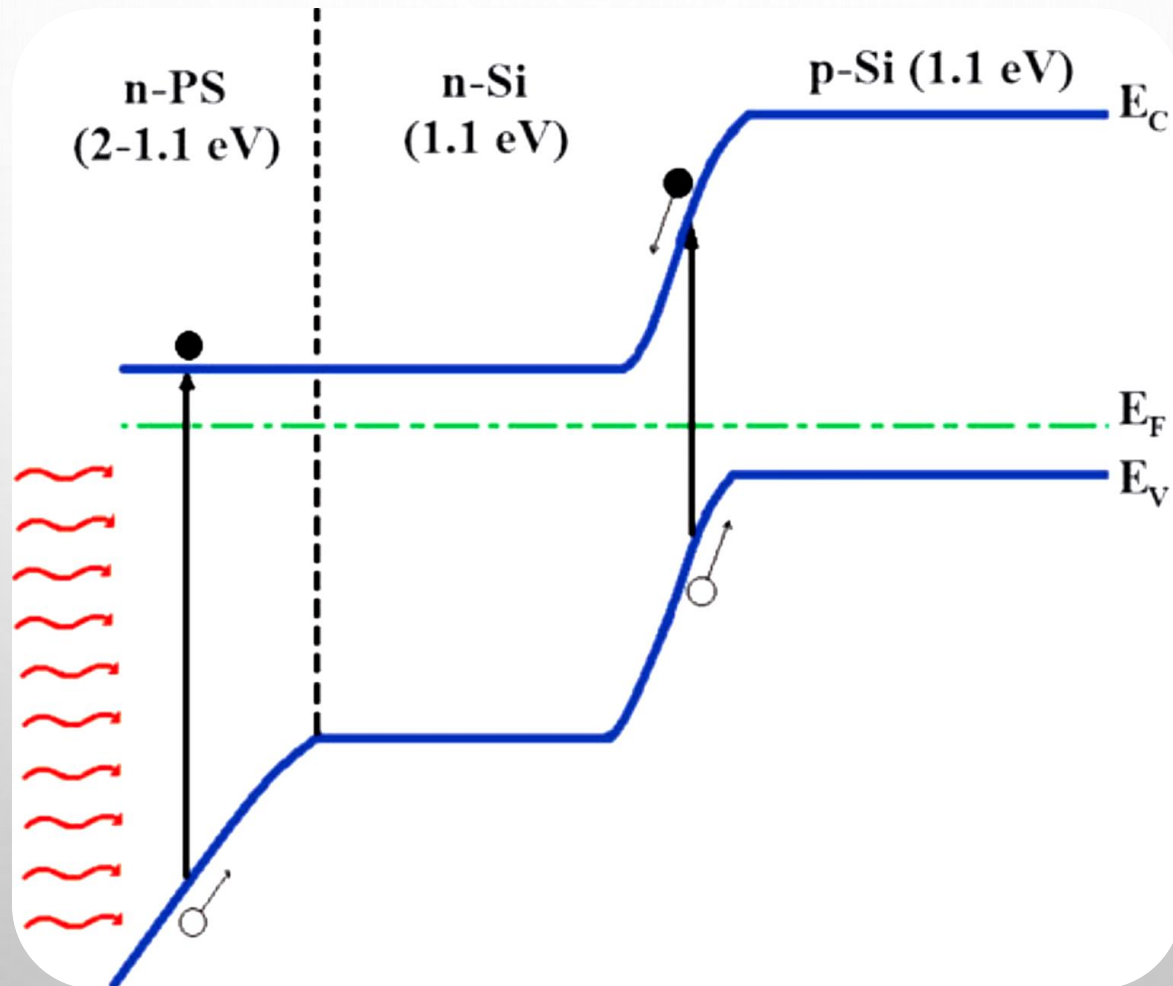


SEM HV: 20.0 kV	Det: SE		NanoLAB-MOST
SEM MAG: 10.0 kx	Date(m/d/y): 01/25/21		

SCHEMATIC ILLUSTRATION OF THE LIGHT REFLECTION DECREASE IN PS/(N-P)SI SOLAR CELL



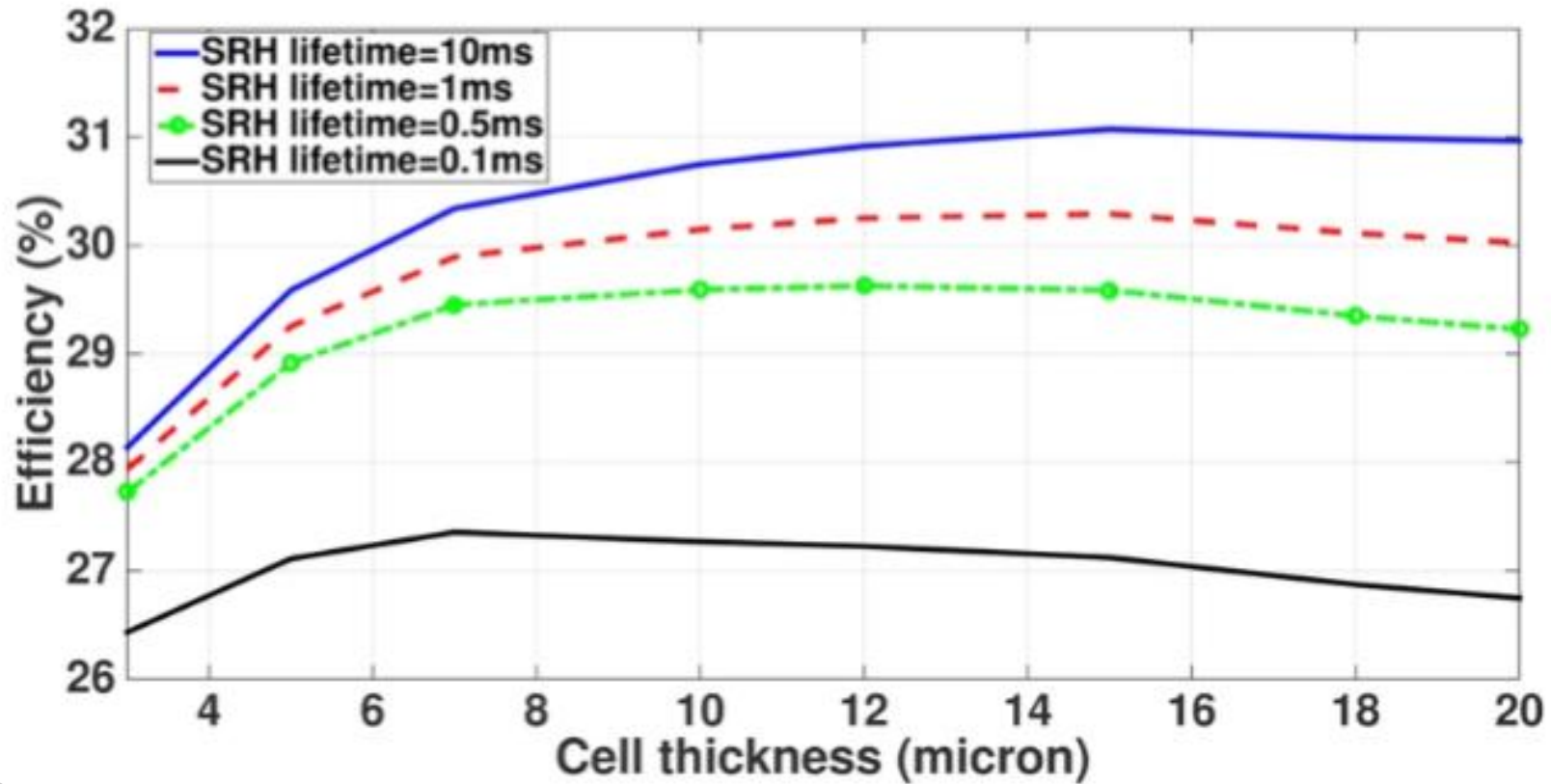
ENERGY BAND DIAGRAM OF NPS/(N+-P)SI SOLAR CELL



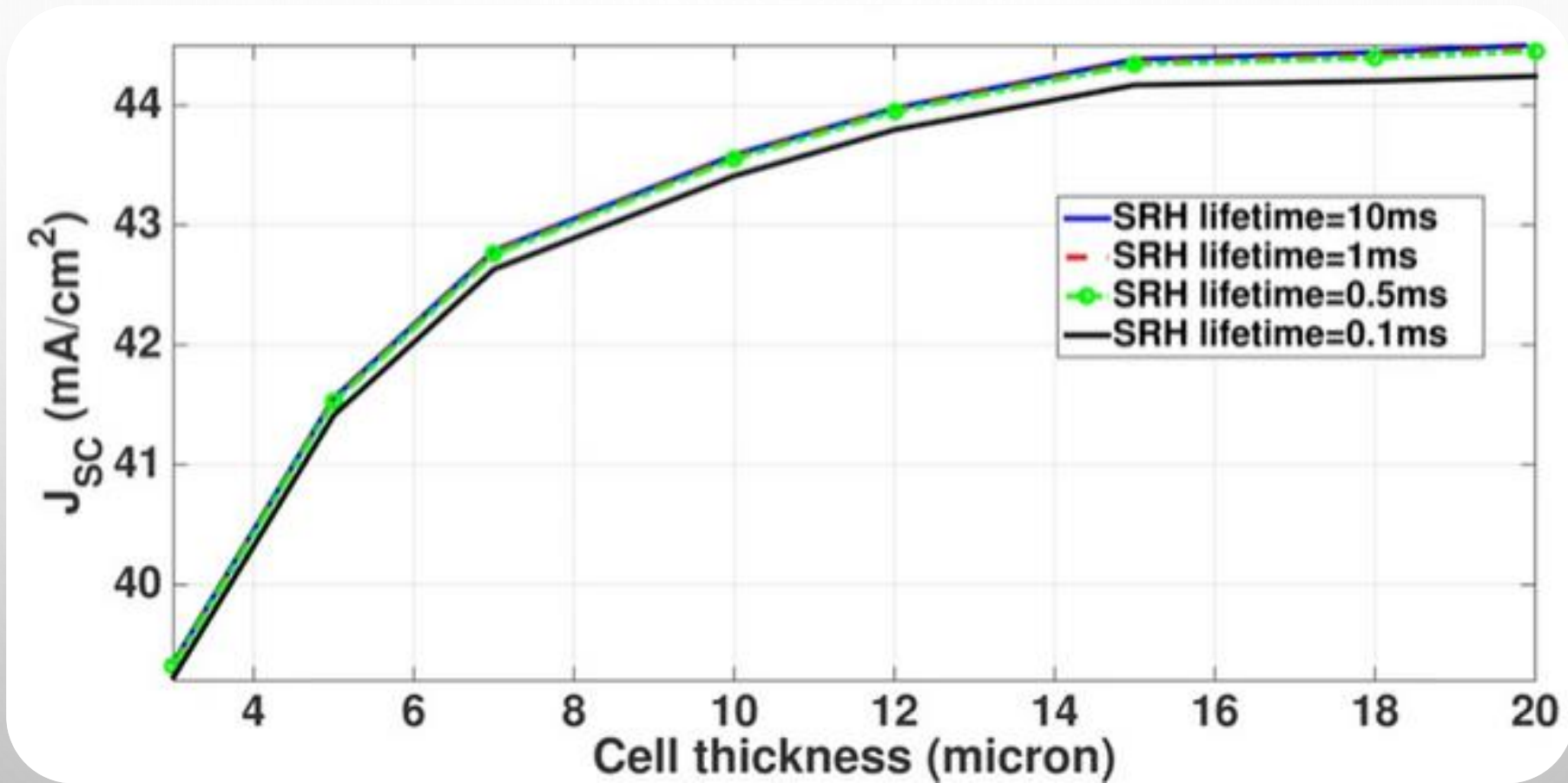
Effective reflectance for silicon surface with different treatments

Solar cell	J_{sc} (mA/cm ²) or I (mA)	V_{oc} (mV)	FF	Eff. (%)	R(%) ($\lambda = 650$ nm)
(n ⁺ -p) Si	23.1	500	0.74	12.1	28
PS/(n ⁺ -p) Si	34.2	520	0.75	14.5	4
(n ⁺ -p) Si	21.5	580	0.55	7.5	12
PS/(n ⁺ -p) Si	28.4	585	0.74	12.5	3
(n ⁺ -p) Si	95 mA	580	–	10.3	–
PS/(n ⁺ -p) Si	137 mA	570	–	13.5	–
(n ⁺ -p) Si	17.2	598	0.74	7.6	–
PS/(n ⁺ -p) Si	20.1	606	0.75	9.5	7
Text. (n ⁺ -p) Si	23.3	592	0.70	9.6	12
PS/Text. (n ⁺ -p) Si	25.5	595	0.74	11.2	3
(n ⁺ -p) Si	18.5	580	0.73	7.85	–
PS/(n ⁺ -p) Si	27.2	601	0.77	12.54	7
PS/(n ⁺ -p) Si	33.4	460	–	–	9
SiO ₂ /(n ⁺ -p) Si	34.8	530	–	–	3.8
(p ⁺ -n)PS/Si (100)	15.9 mA	480	0.81	15.4	7
(p ⁺ -n)PS/Si (111)	12.4 mA	440	0.82	11.2	16
(n ⁺ -p)PS/Si (111)	12.4 mA	440	0.82	11.2	15
SiO ₂ /(n ⁺ -p)Si (111)	5.1 mA	340	0.77	3.3	–
(ZnO-TiO ₂)/(n ⁺ -p)Si	6.0 mA	370	0.79	4.4	–
(p ⁺ -n)PS/Si	8.8 mA	430	0.78	7.4	16
PS on one side	12.4 mA	490	0.84	12.75	6
(p ⁺ -n)PS/Si/PS					
PS on both sides					
(n ⁺ -p)PS/Si	28.9	627	0.76	13.8	9
PS/(n ⁺ -p) Si	26.3	602	0.76	12	10
SiN/(n ⁺ -p) Si	28.4	606	0.75	13	–
(n ⁺ -p) mc-Si	26.6	572	0.75	11.3	15
PS/(n ⁺ -p) mc-Si	28.9	582	0.76	12.7	5
(n ⁺ -p) mc-Si	29.8	577	0.75	12.9	8
(n ⁺ -p)PS/mc-Si	30.2	587	0.76	13.5	–
(n ⁺ -p) Si	12.5 mA	480	0.61	–	–
PS/(n ⁺ -p) Si	21.2 mA	530	0.65	–	12
PS/ (n ⁺ -p) mc-Si	27.2	592	0.75	12.1	6
(n ⁺ -p) mc-Si	22.4	588	0.69	9.0	–
PS/ (n ⁺ -p)Si (100)	30.1	571	0.70	12.1	3.1
(n ⁺ -p) Si (100)	23.8	573	0.69	9.4	12.6
(n ⁺ -p) Si (100)	130 mA	560	0.55	9.55	14
textured	150 mA	560	0.64	10.52	5
PS/(n ⁺ -p) Si (100)	160 mA	570	0.66	11.28	4
PS/(n ⁺ -p) Si (100)					
textured					

BEYOND 30% CONVERSION EFFICIENCY IN P-SILICON SOLAR CELLS



Current density in P-Silicon Solar Cells



The background is a light gray gradient. In the top-left and bottom-right corners, there are several realistic water droplets of various sizes, rendered with soft shadows and highlights to give them a three-dimensional appearance. The text 'THANK YOU' is centered in the middle of the page.

THANK YOU