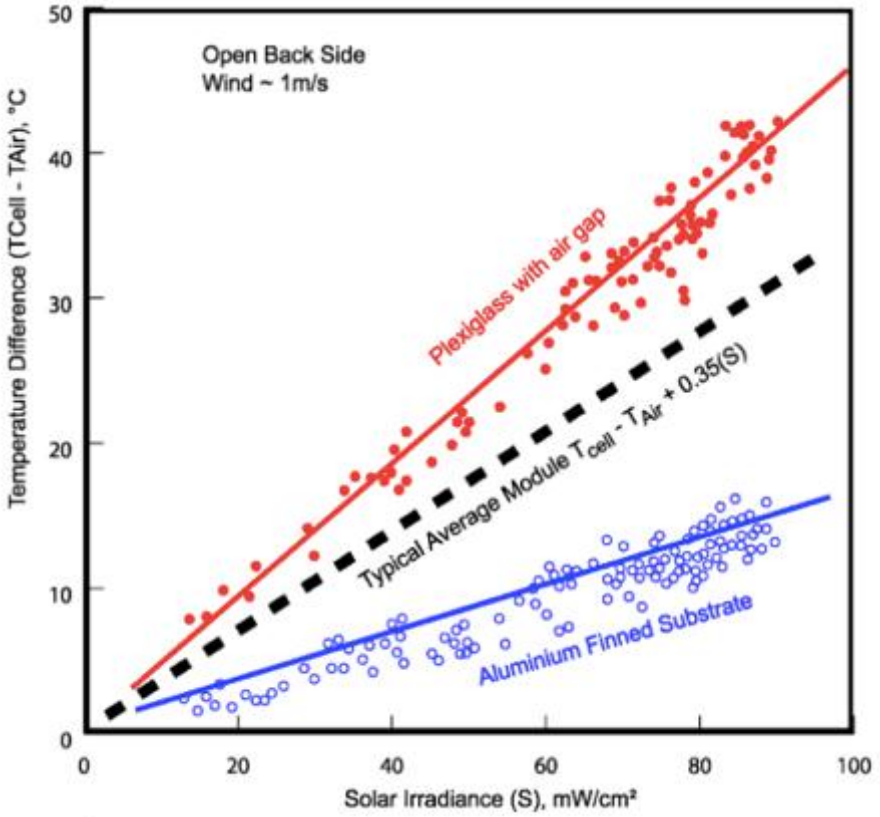
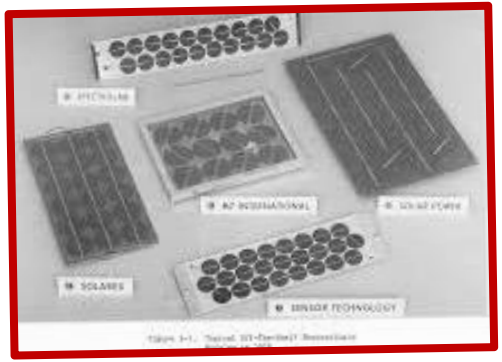
“How Can We Reach 50 Year Solar Module Service Life?”

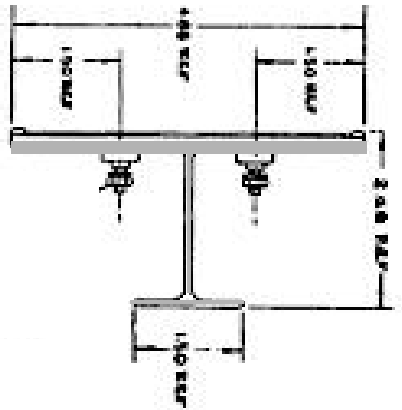
Martin Green, Zibo Zhou, Yajie Jiang, Mark Keevers, Ned Ekins-Daukes

UNSW Sydney

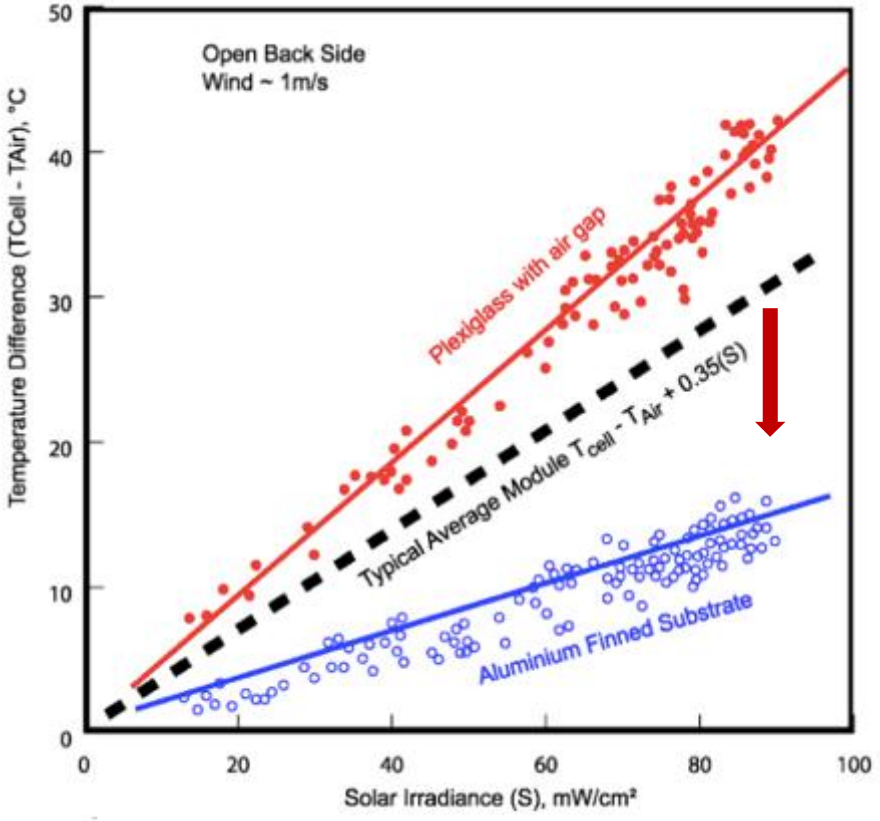
Modules heat up in sunlight







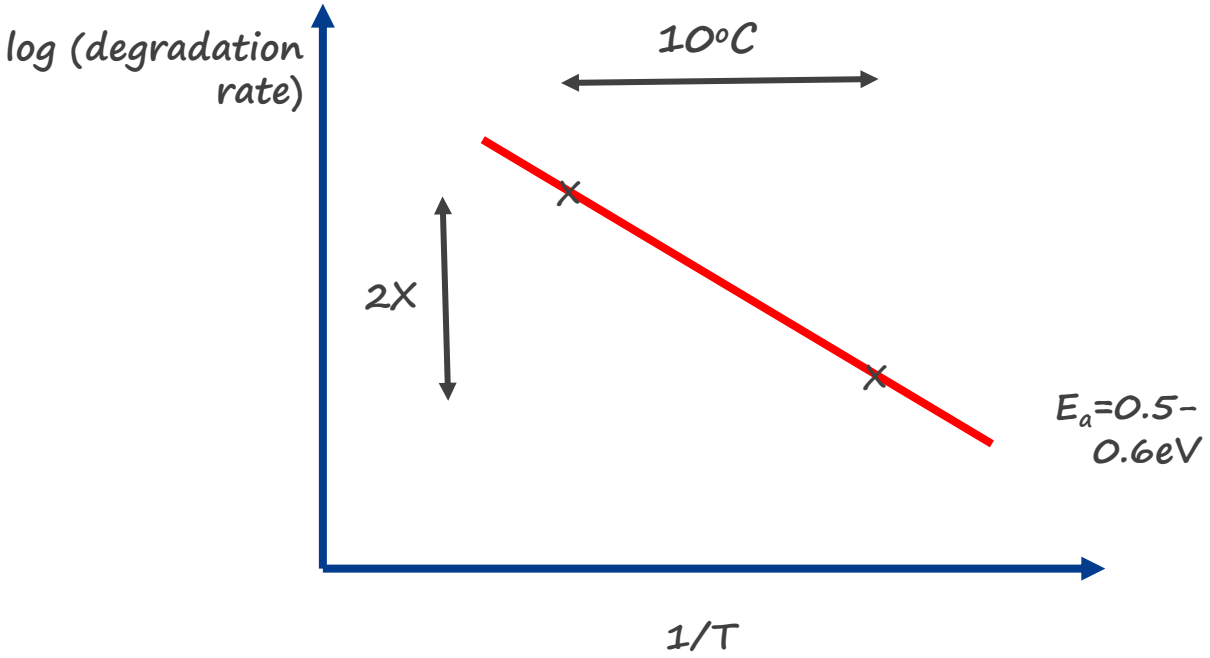
Modules heat up in sunlight



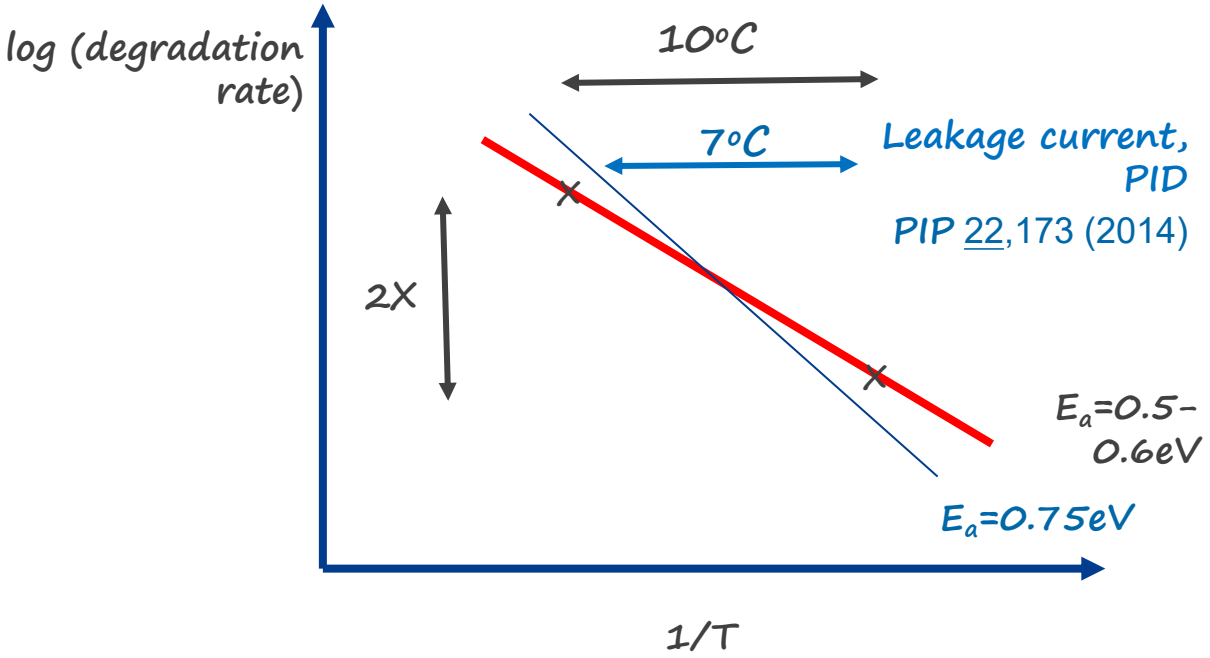
. increases output

. slows degradation!

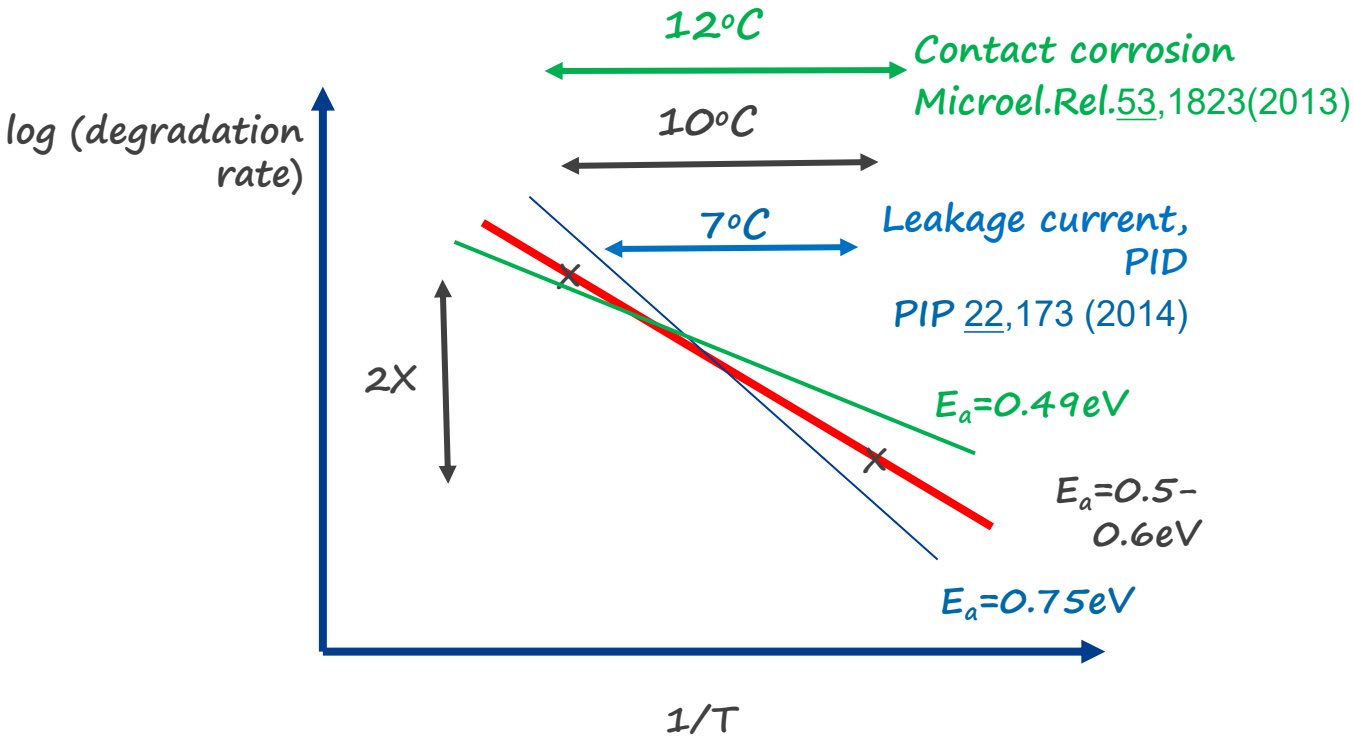
Rule of thumb *(attributed to Linus Pauling)*



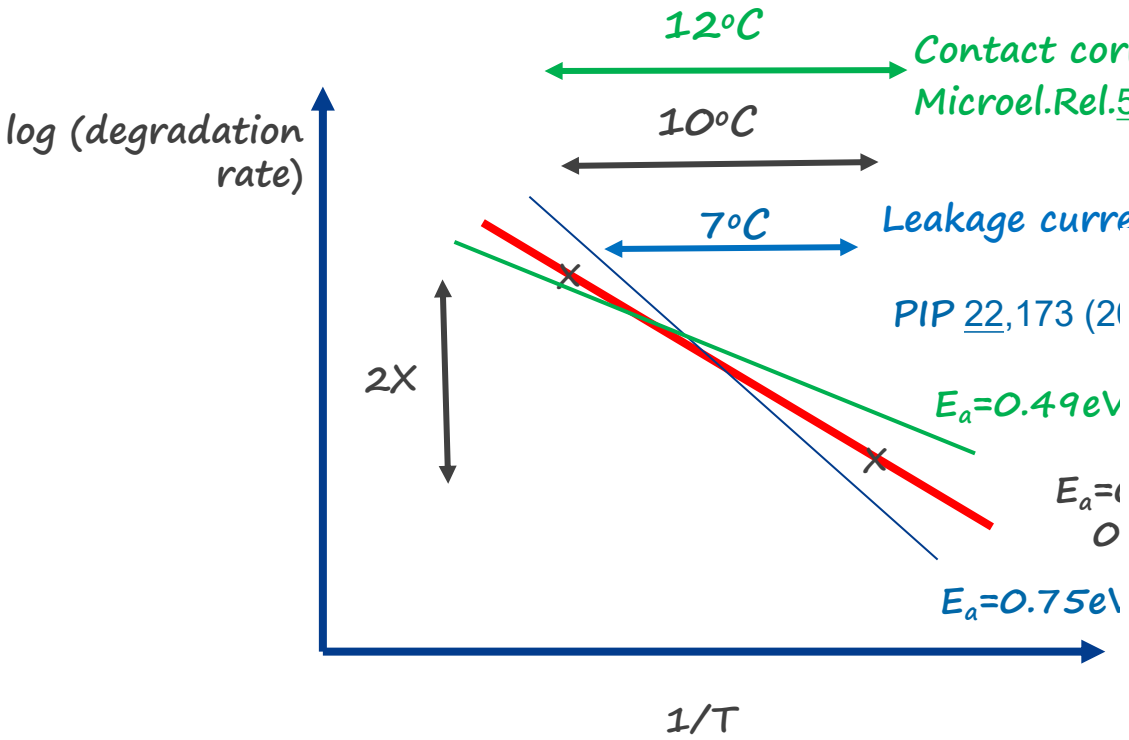
Rule of thumb

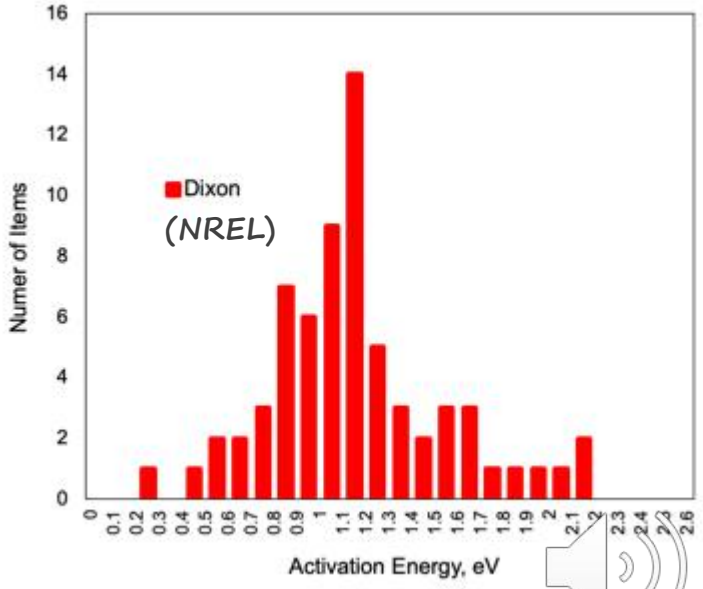


Rule of thumb

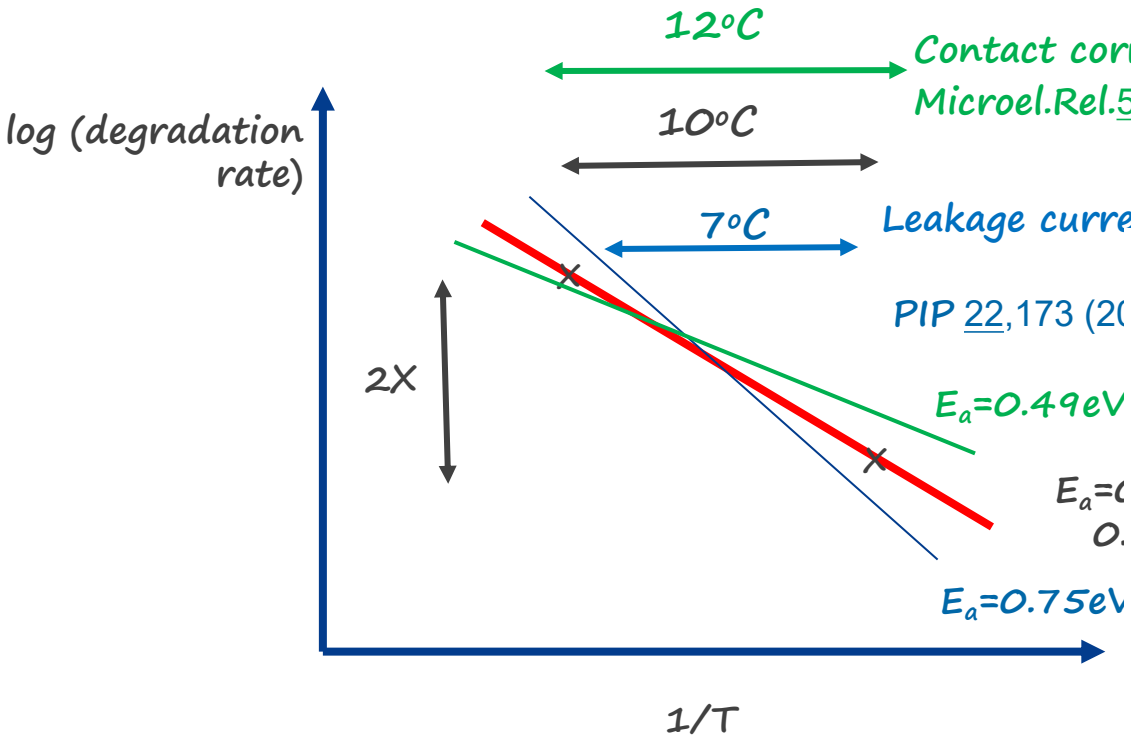


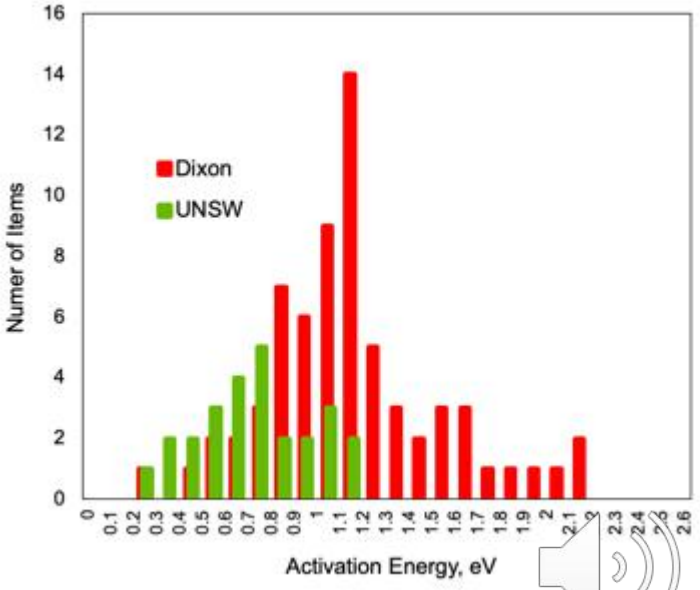
Rule of thumb



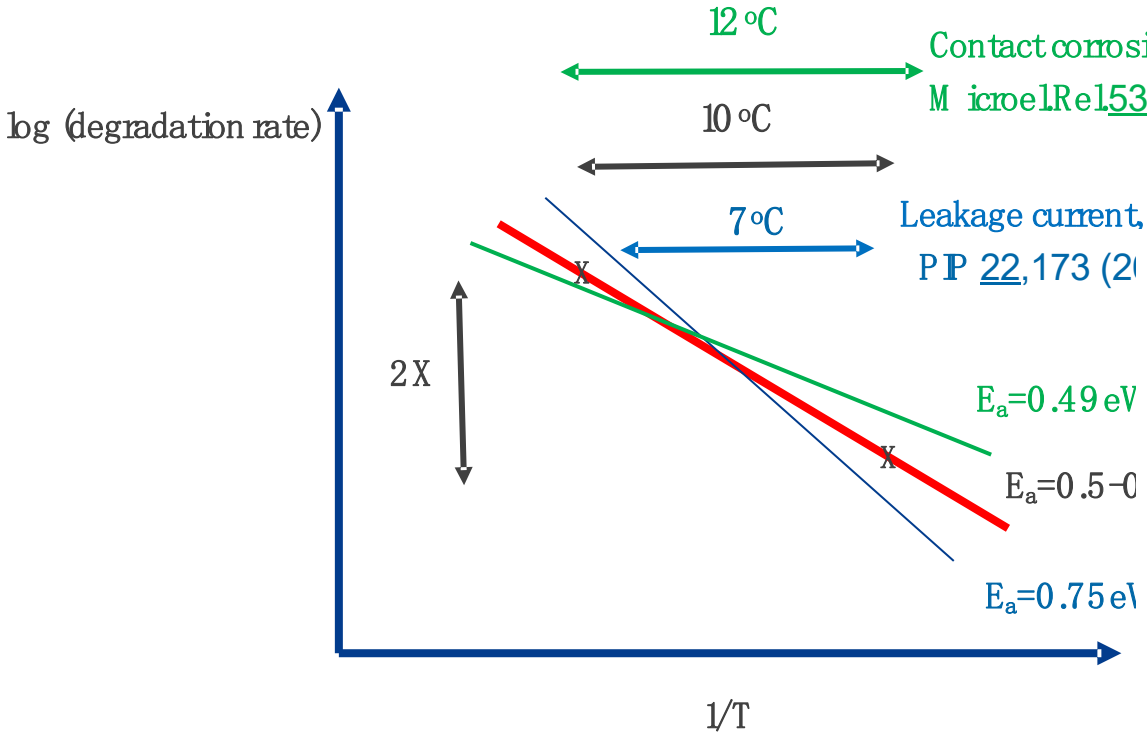


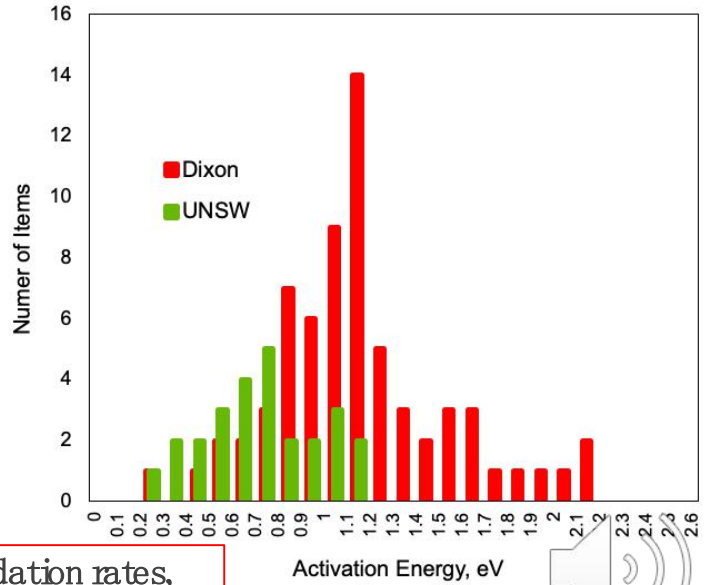
Rule of thumb





Rule of thumb



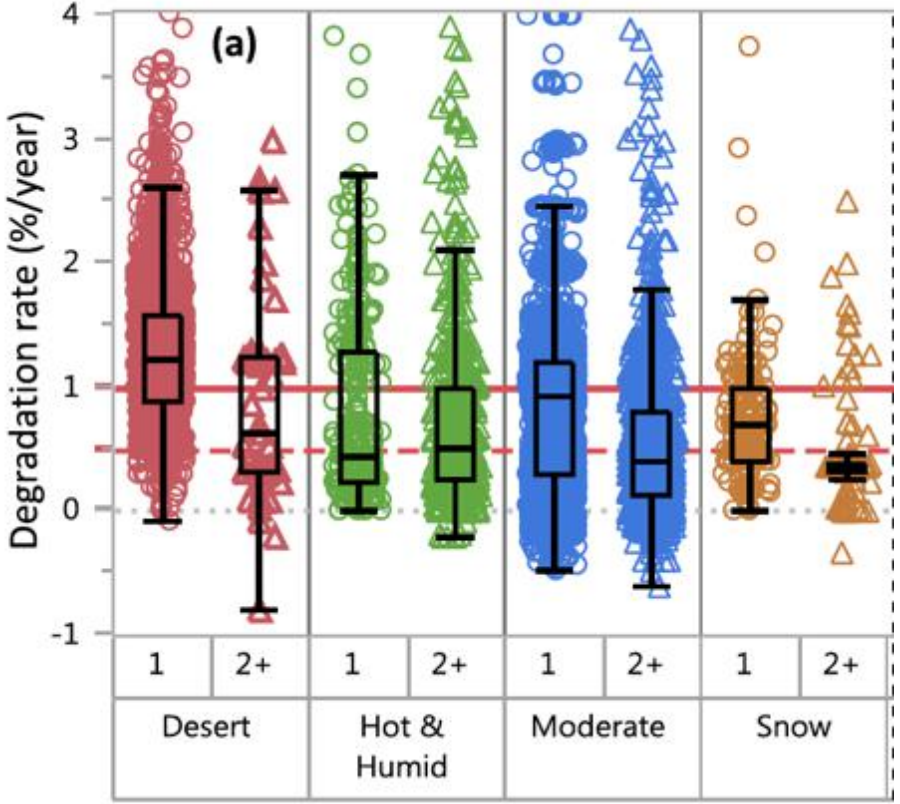


Decrease module T by 10 °C, could increase output by 4-5% , halve degradation rates, double module life and energy output

Compendium of photovoltaic degradation rates

Dirk C. Jordan[1]*, Sarah R. Kurtz[1], Kaitlyn VanSant[2] and Jeff Newmiller[3]

Prog. Photovolt: Res. Appl. 2016; **24**:978–989



Heat flows

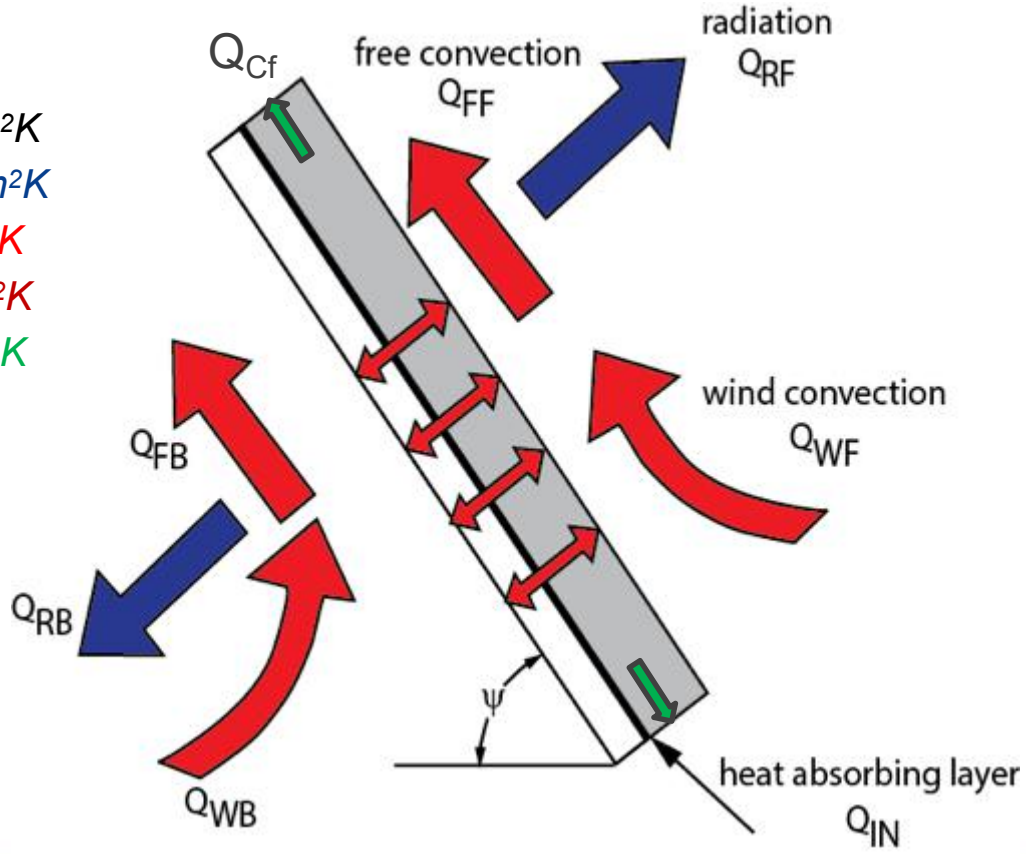
$H = 30\ W/m^2K$

$h_R \sim 15\ W/m^2K$

$h_F \sim 7\ W/m^2K$

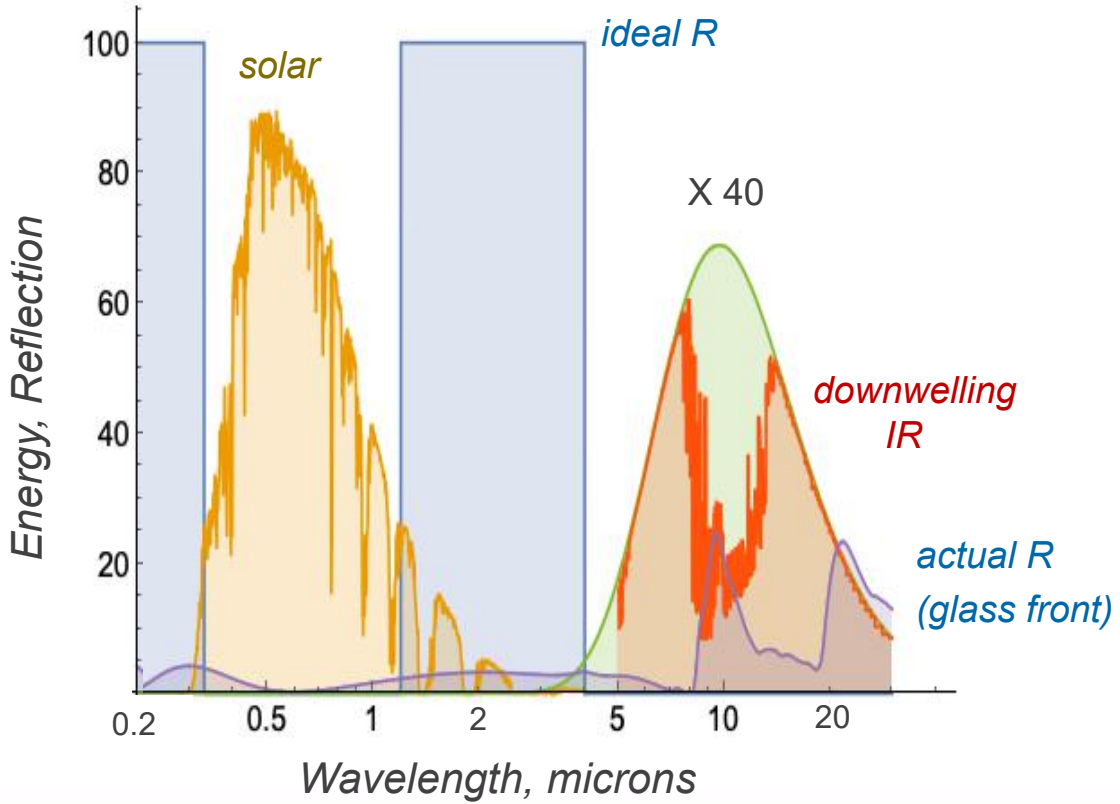
$h_W \sim 7\ W/m^2K$

$h_C \sim 1\ W/m^2K$



UNSW SYDNEY

Ideal reflectivity



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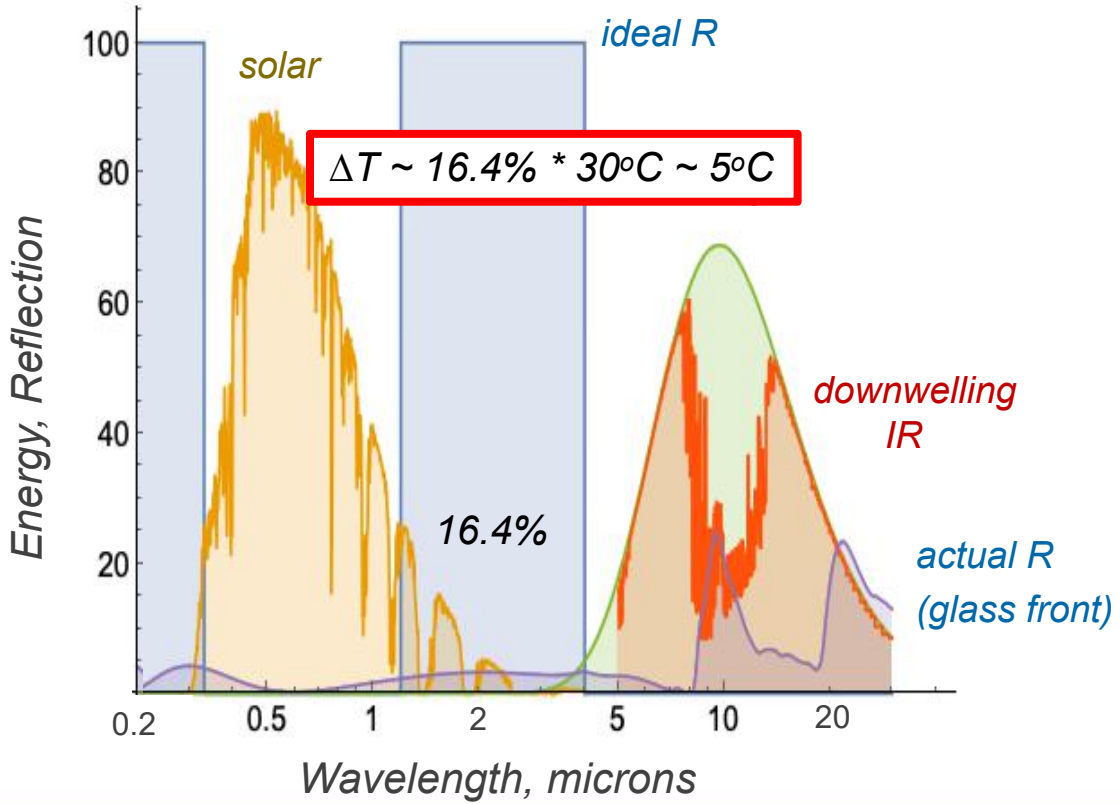

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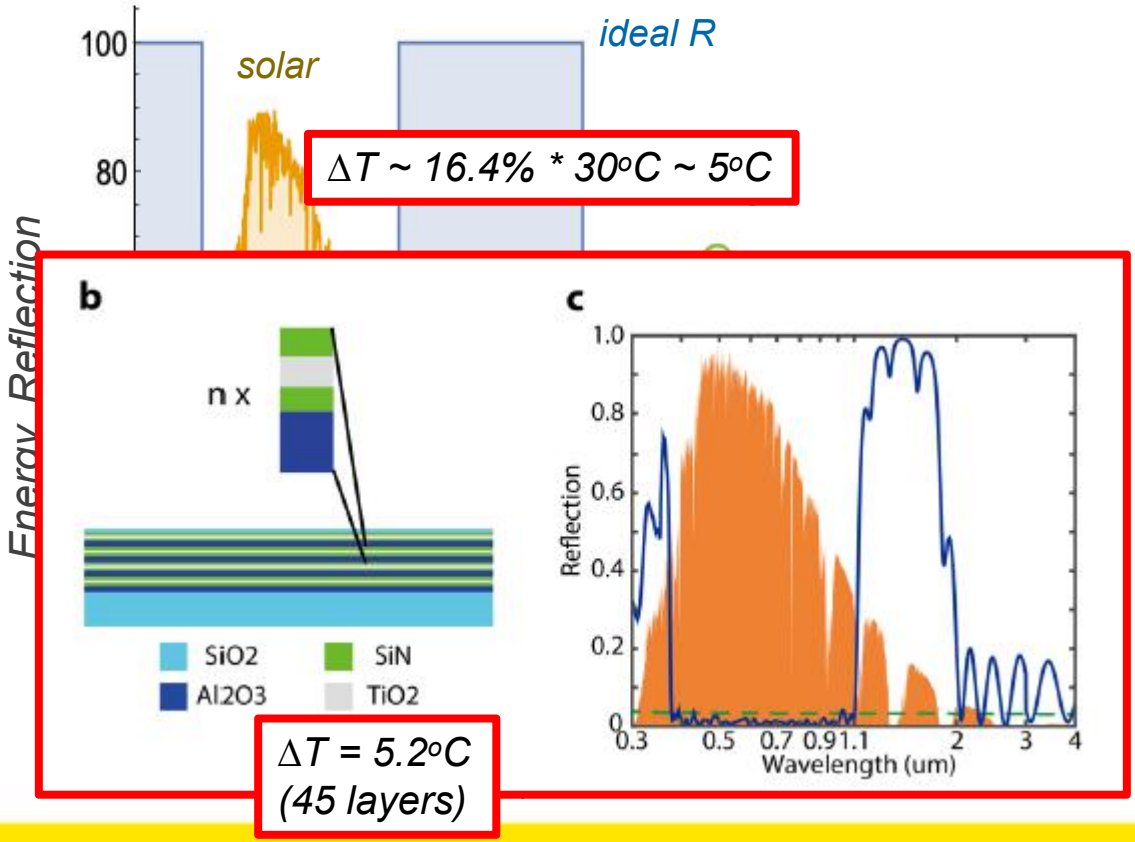
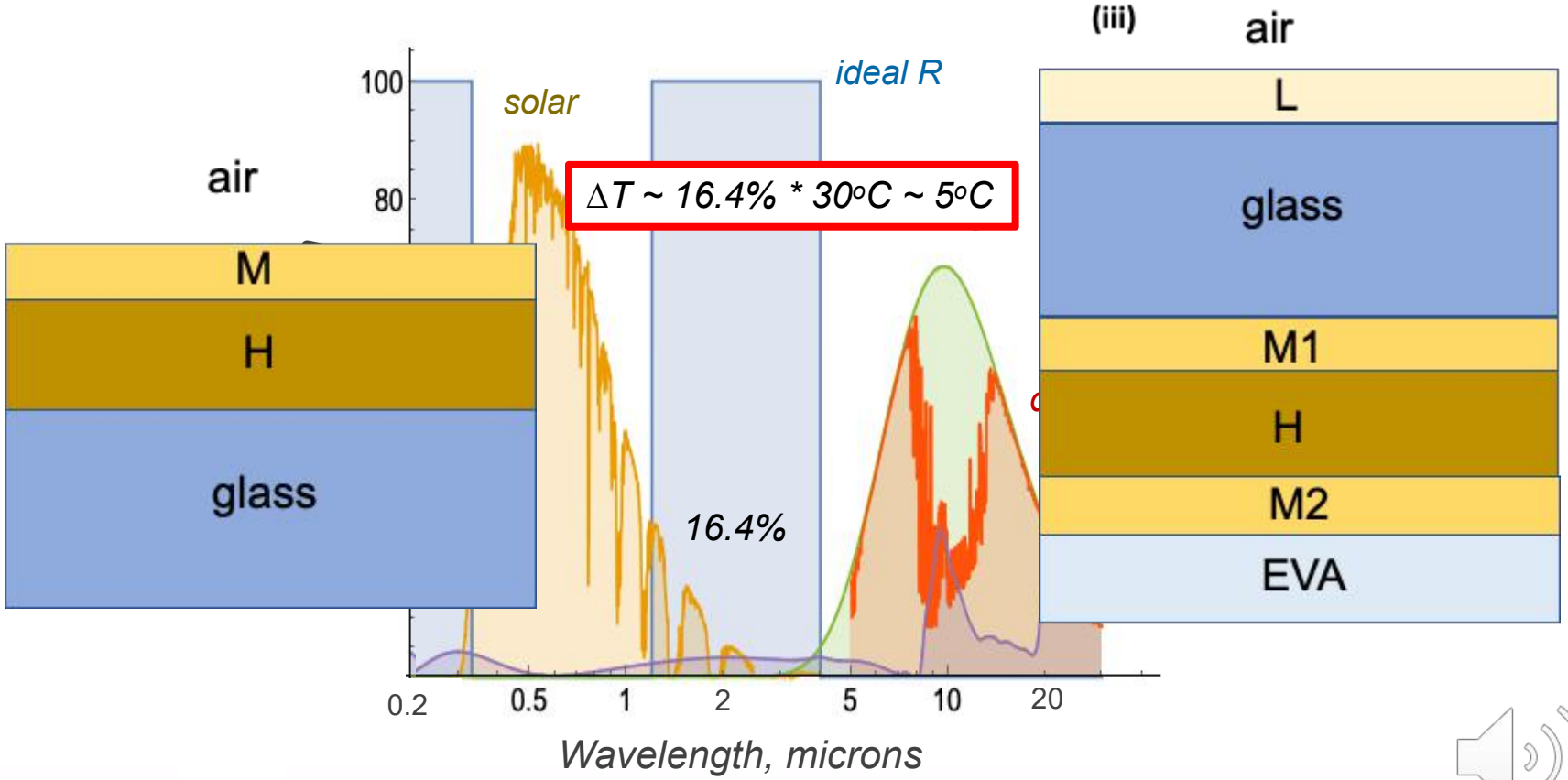


Fan et al. ACS Photonics 2017, 4, 774−782

Ideal reflectivity



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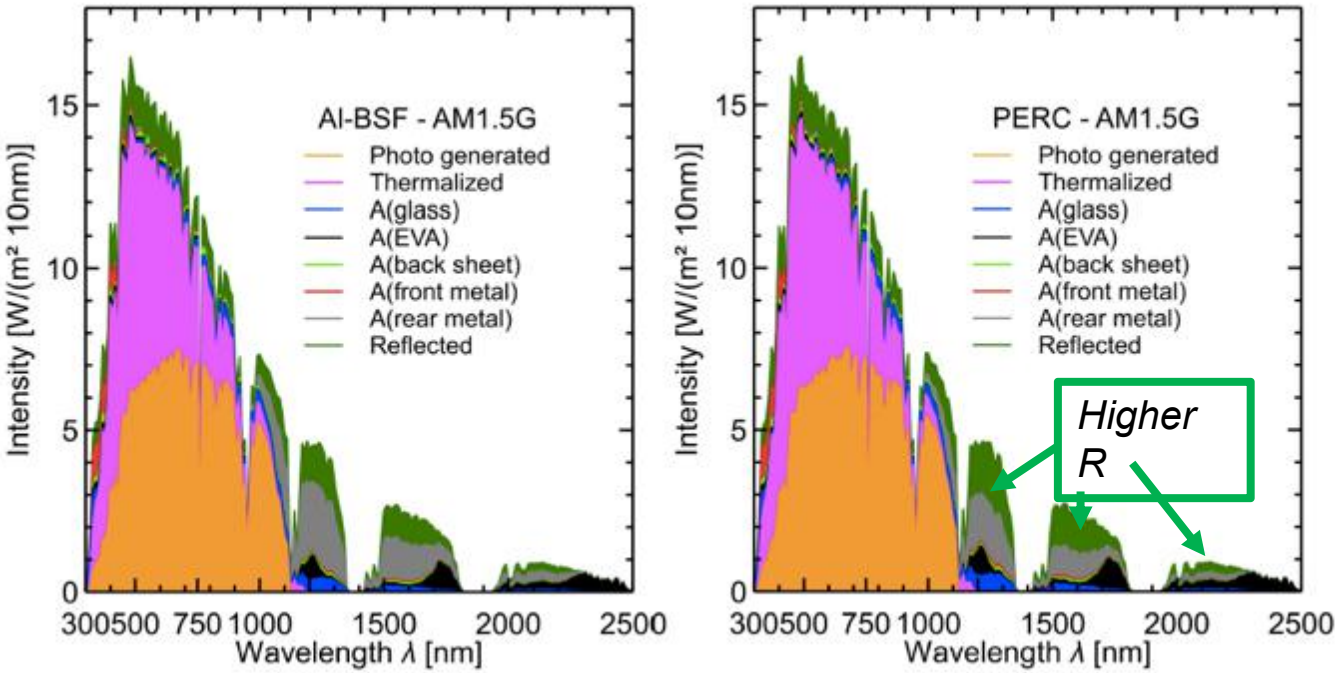
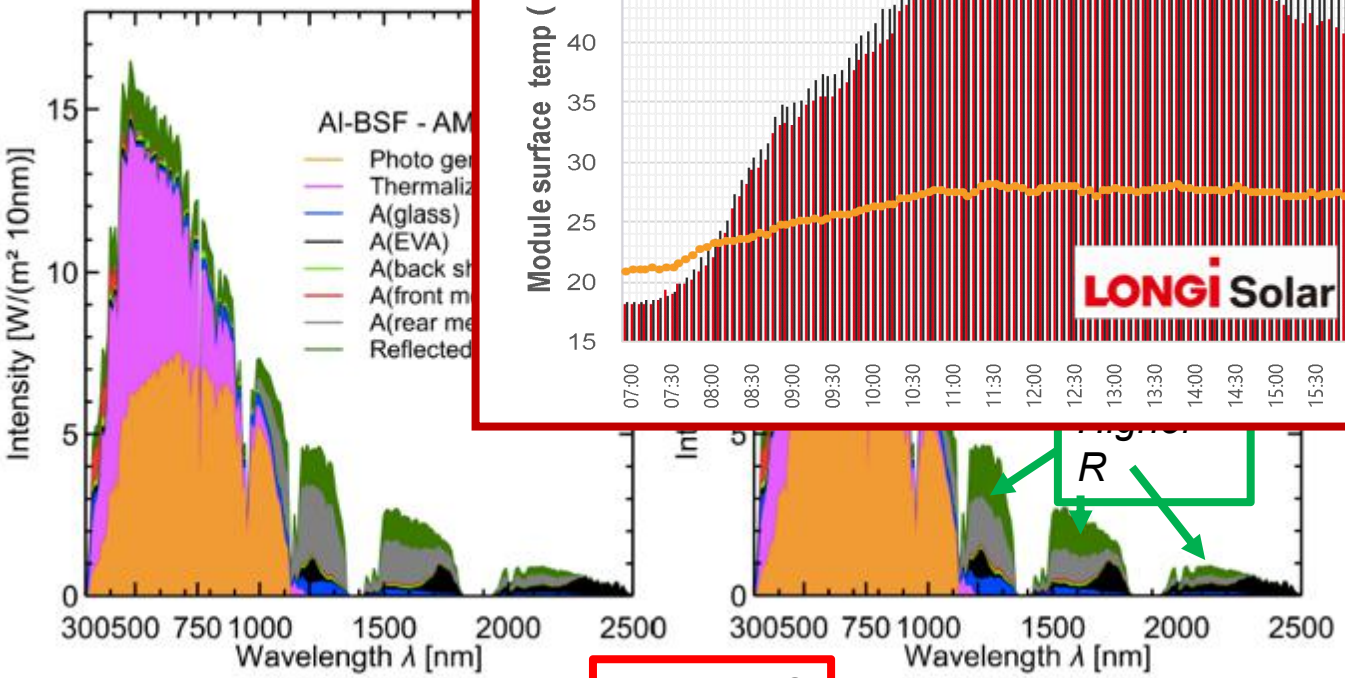
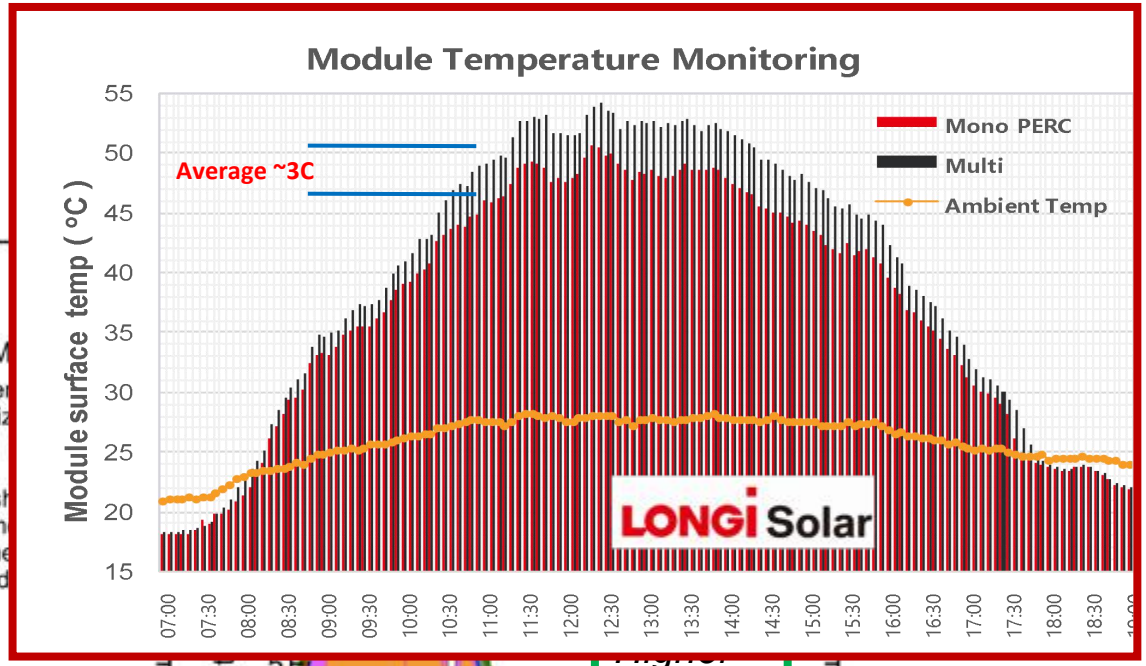


Brendel et al. IEEE J. PHOTOVOLTAICS, VOL. 7, JANUARY 2017, p.44.

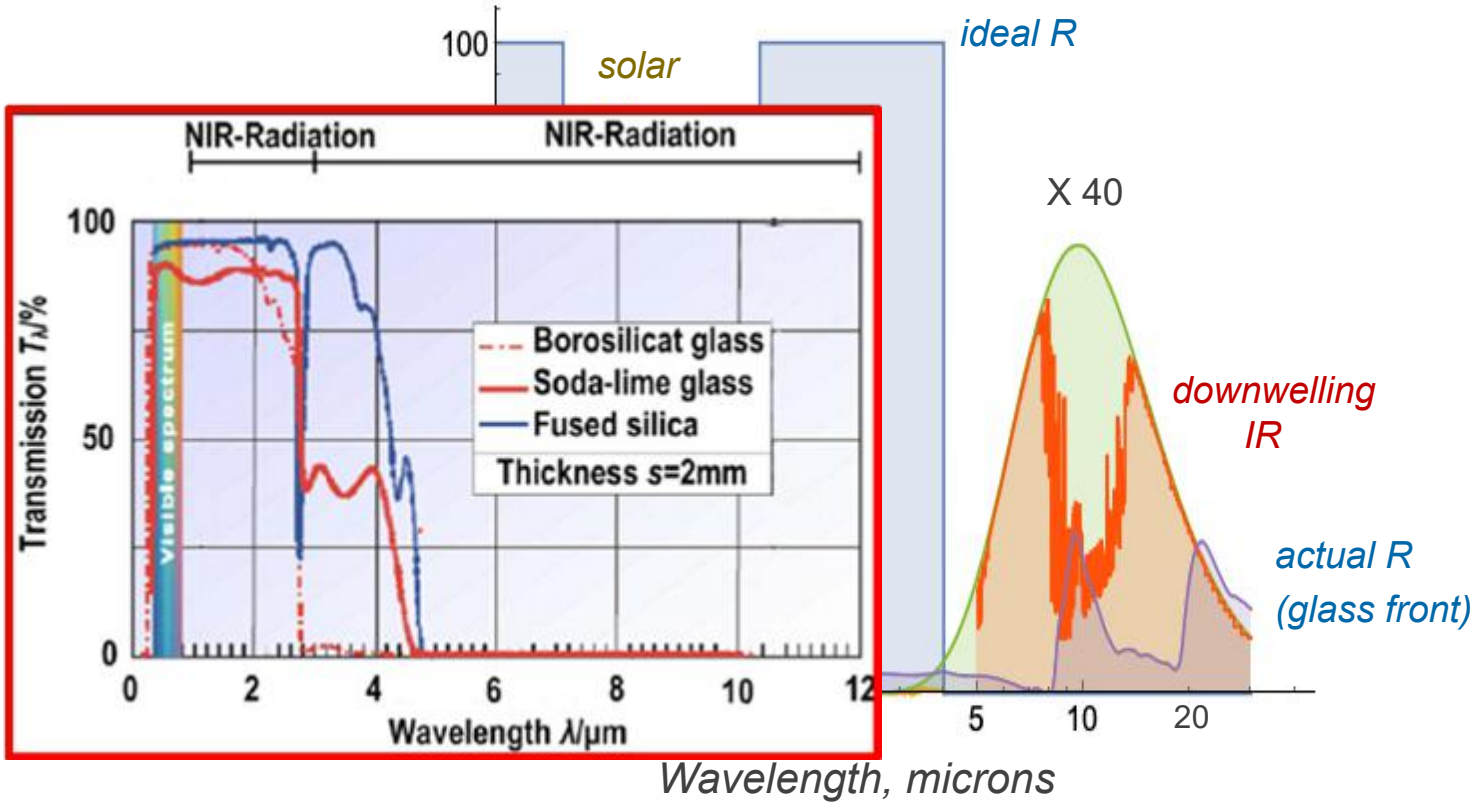
Ideal reflectivity





$\Delta T = 1.7^{o}C$

Ideal reflectivity



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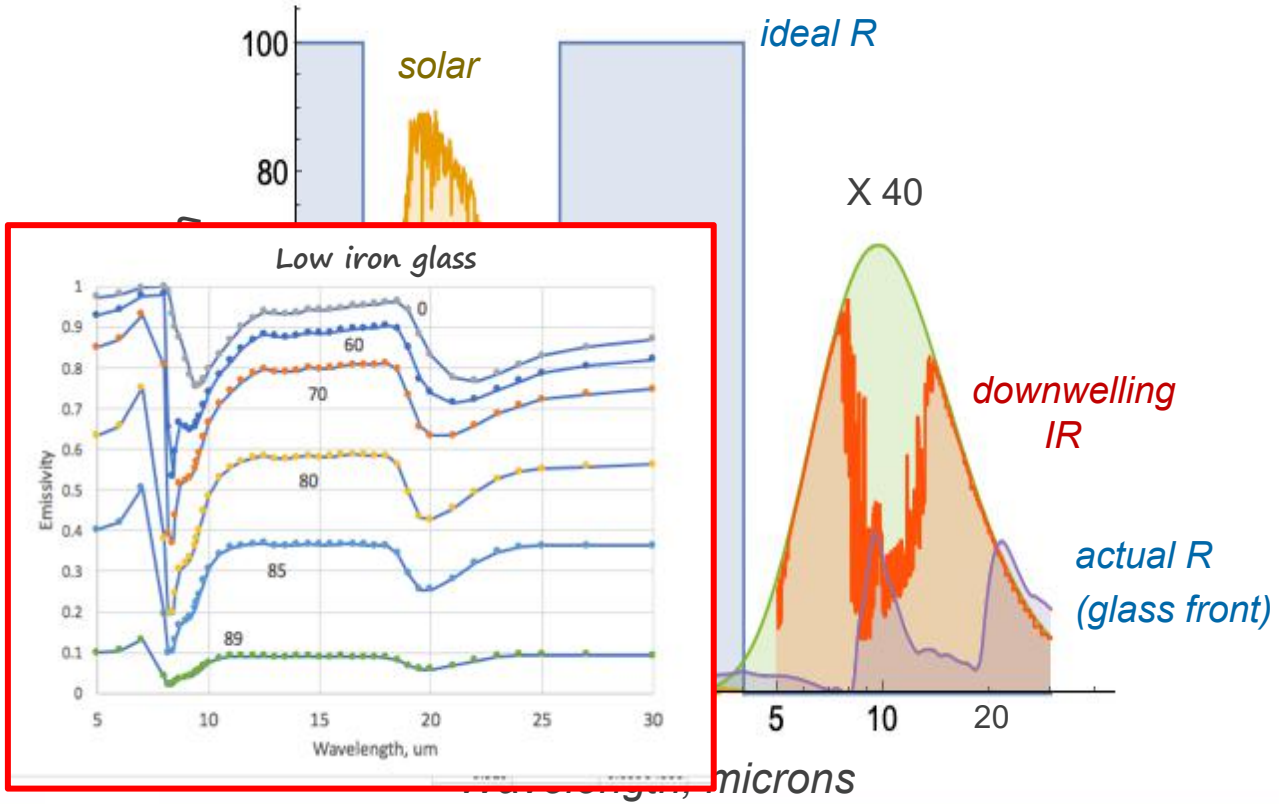

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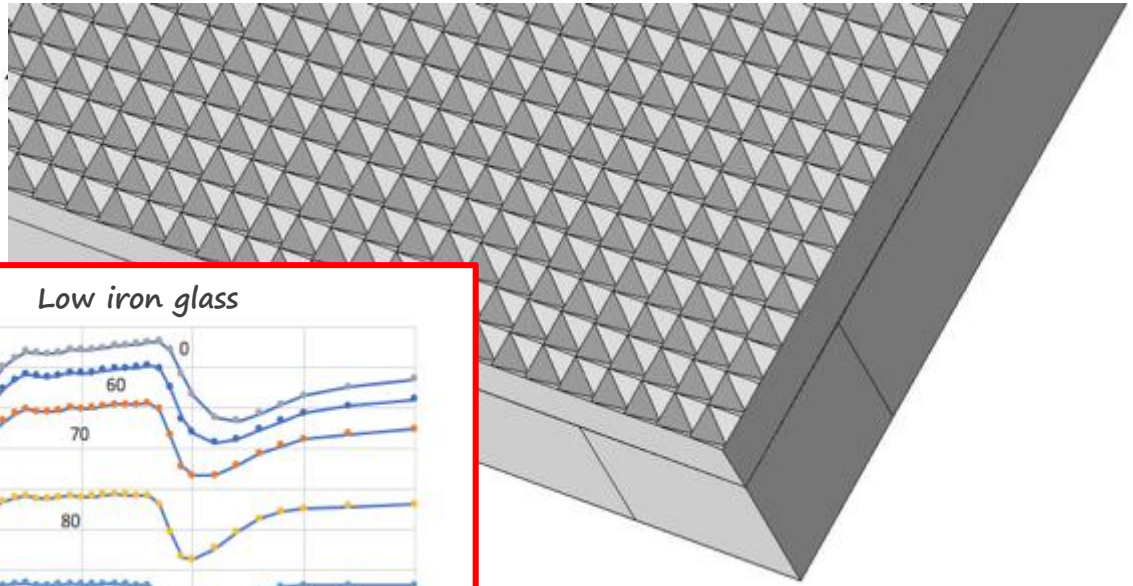
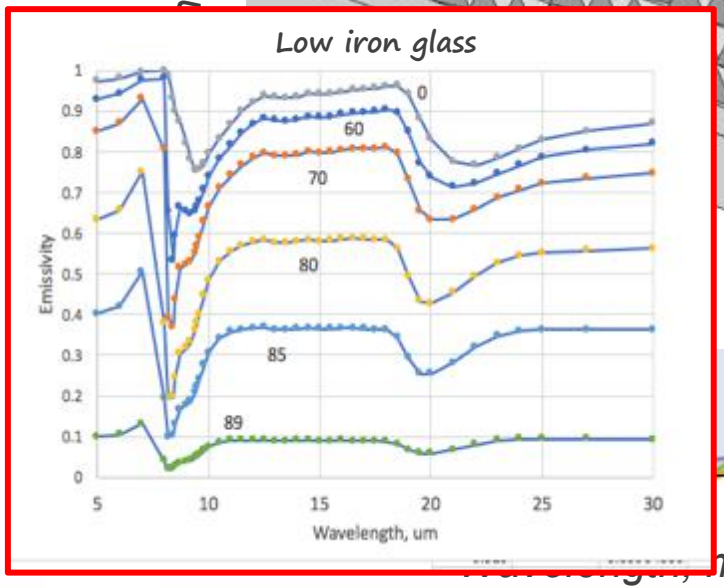
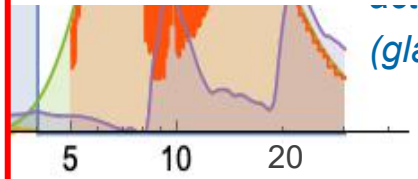


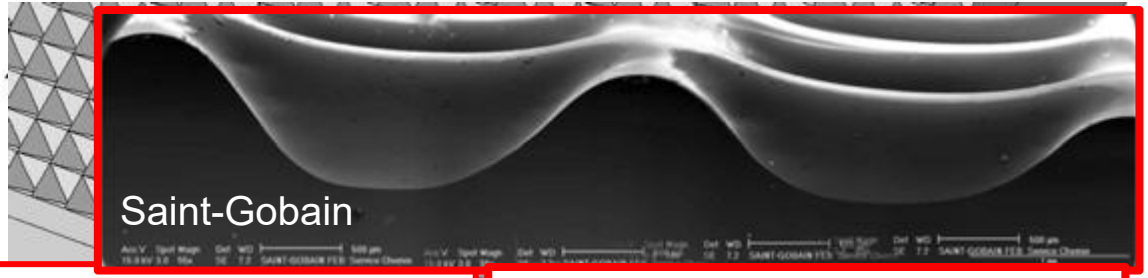


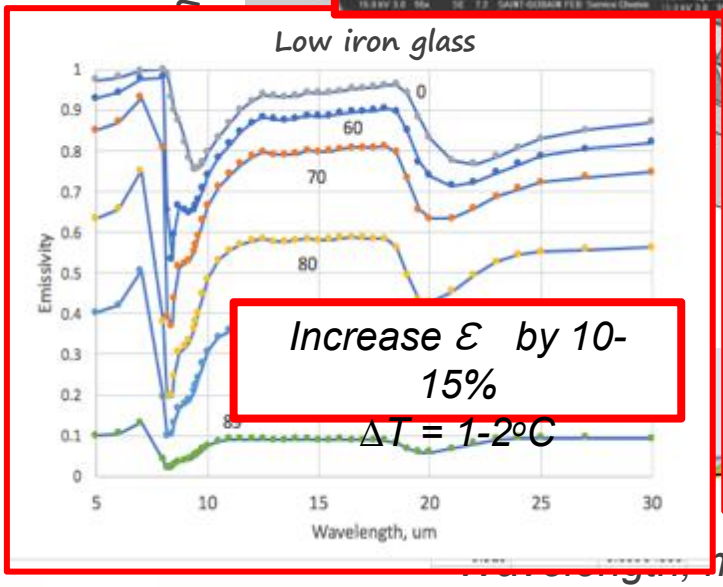


(glass front)

microns

Ideal reflectivity



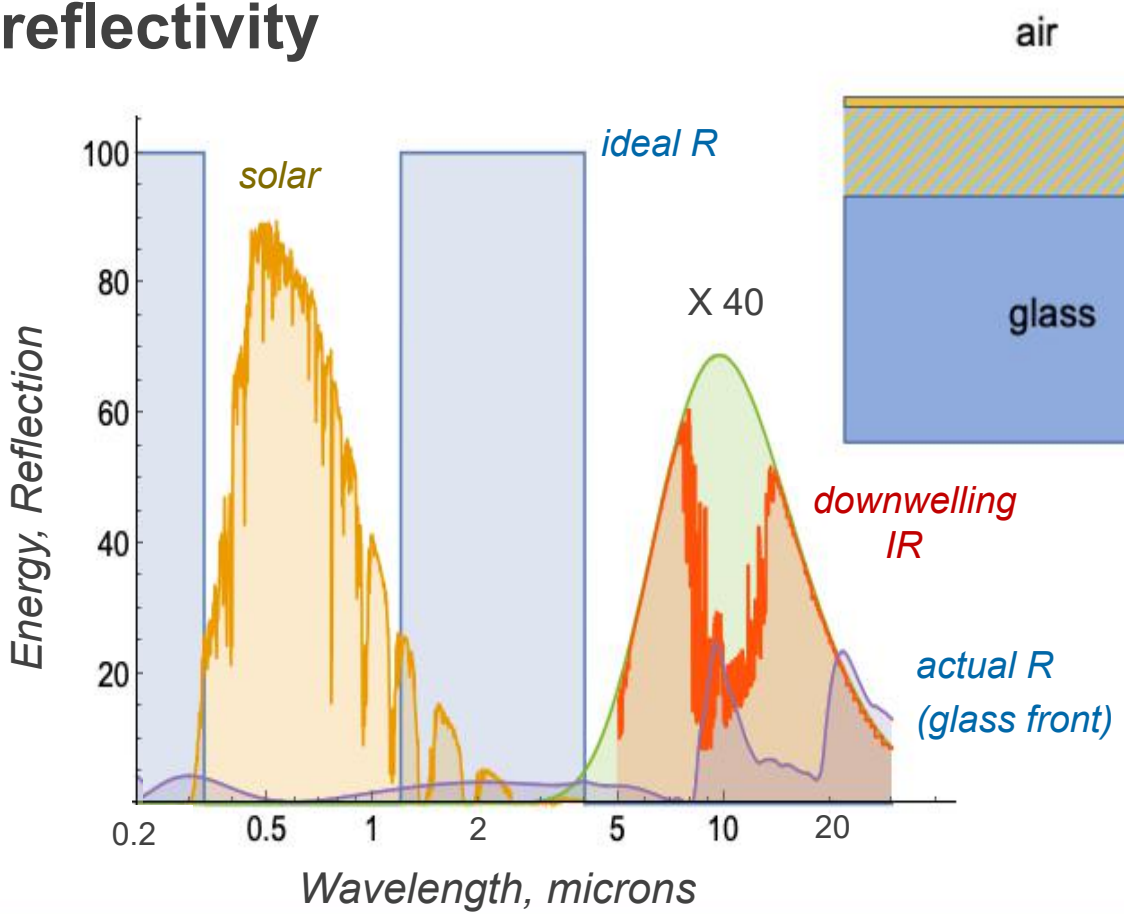


Increase $\mathcal{E}$ by 10-15%

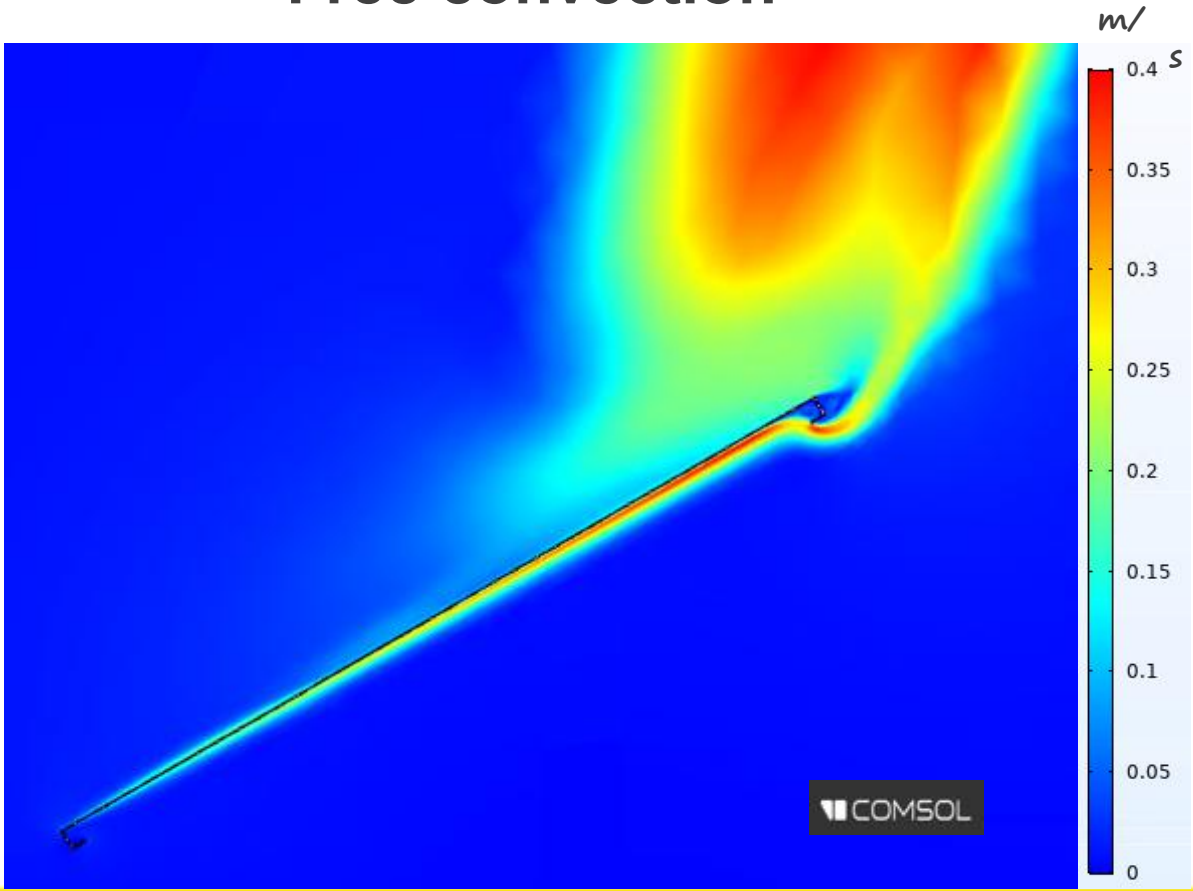
ΔT = 1-2°C

Wavelength, microns

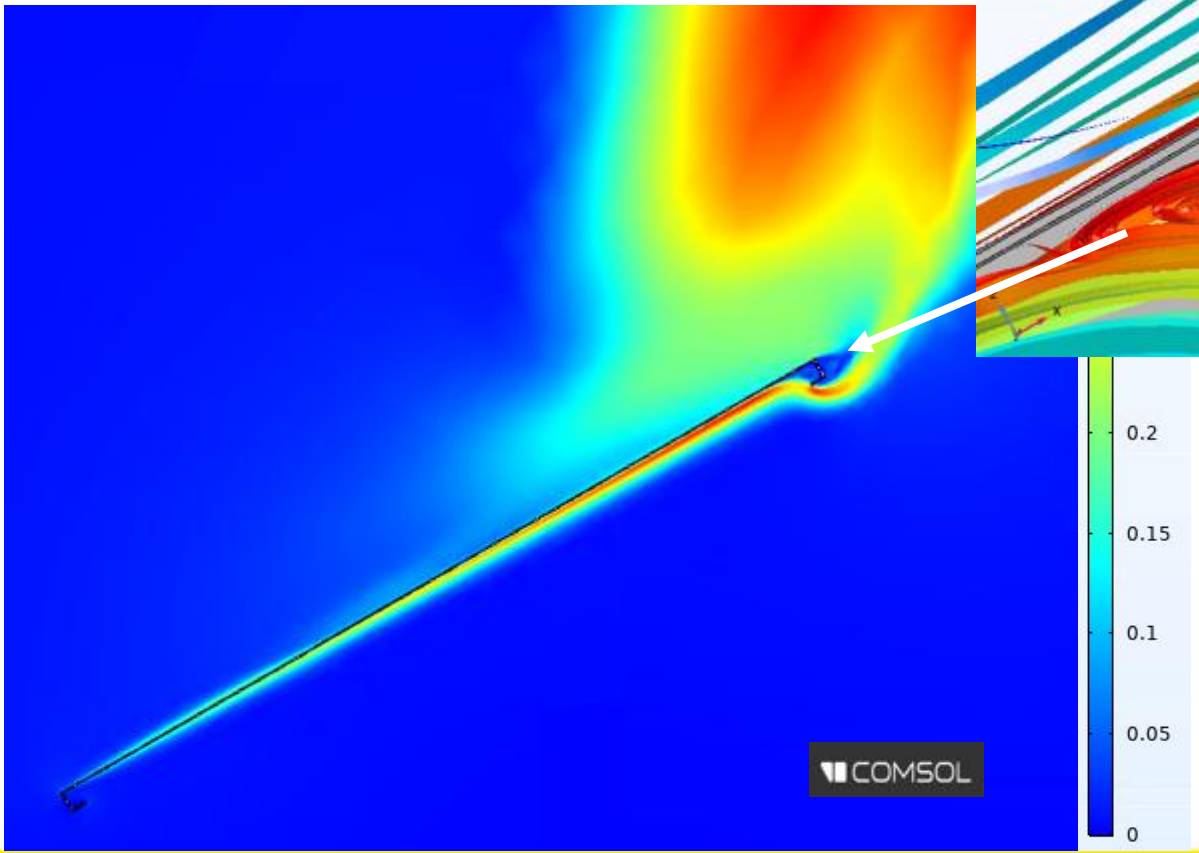
Ideal reflectivity

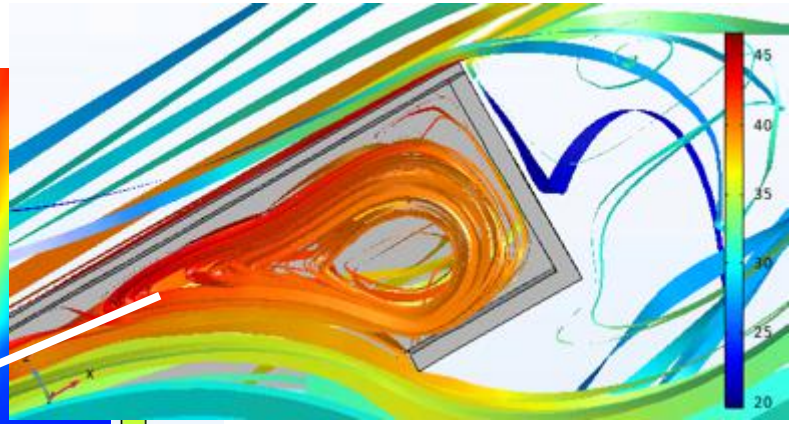


Free convection



Free convection

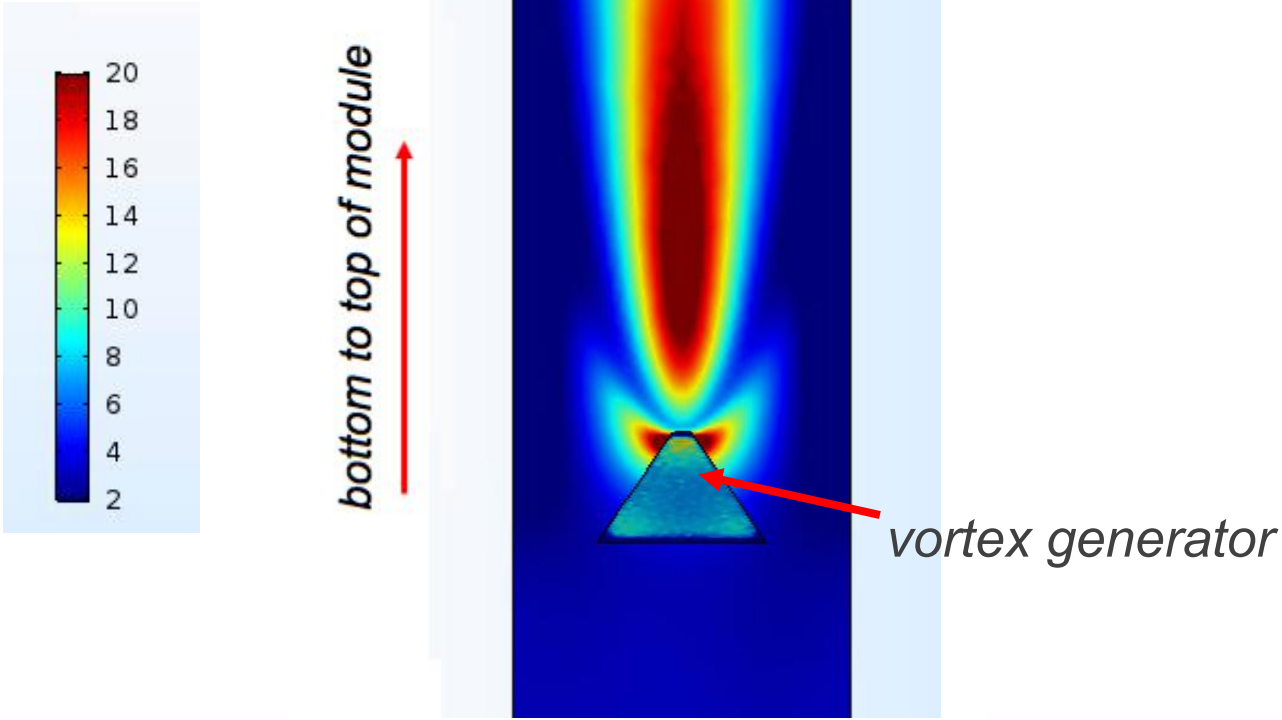




. recirculation in frame cavity
. trailing behind frame

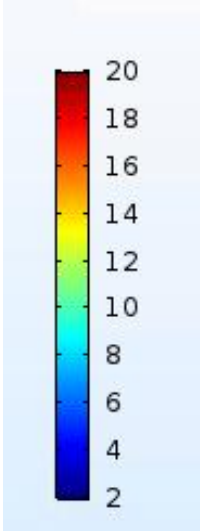
Free Convection

h W/m²K

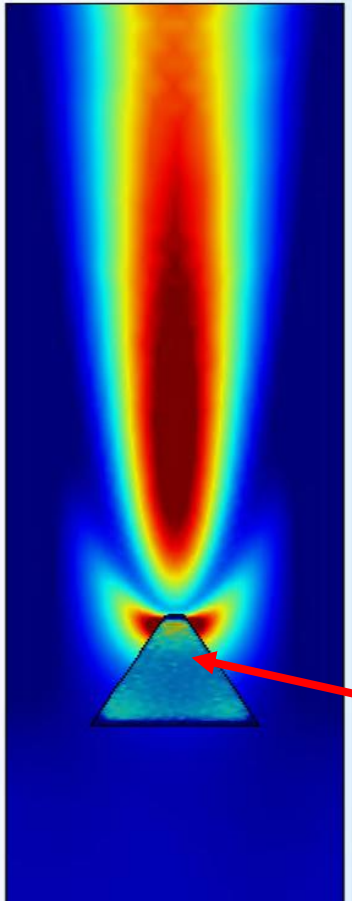


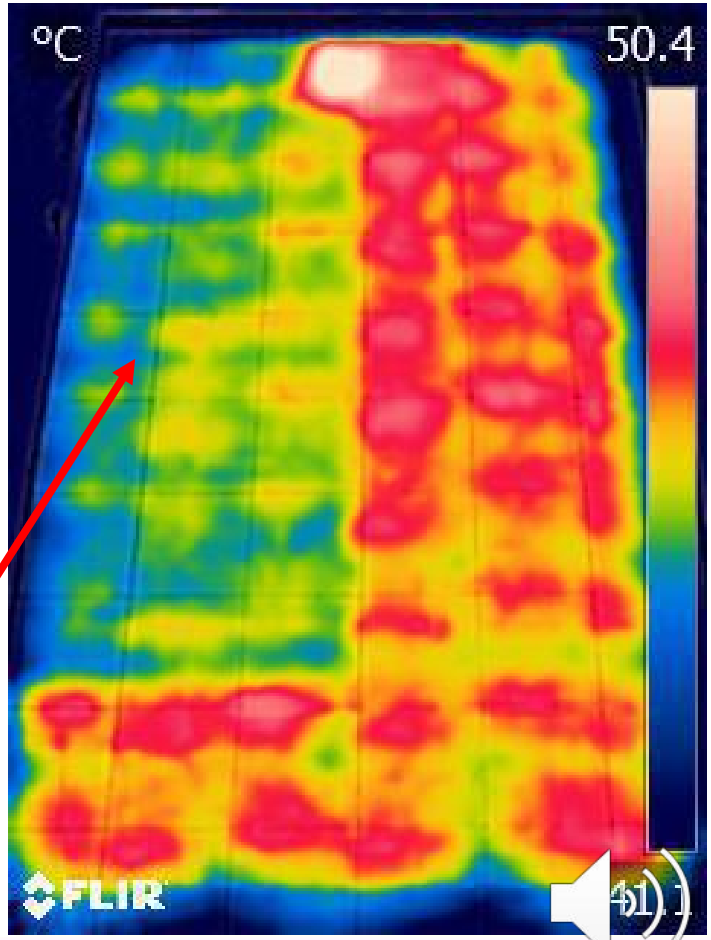
Free Convection

h W/m²K

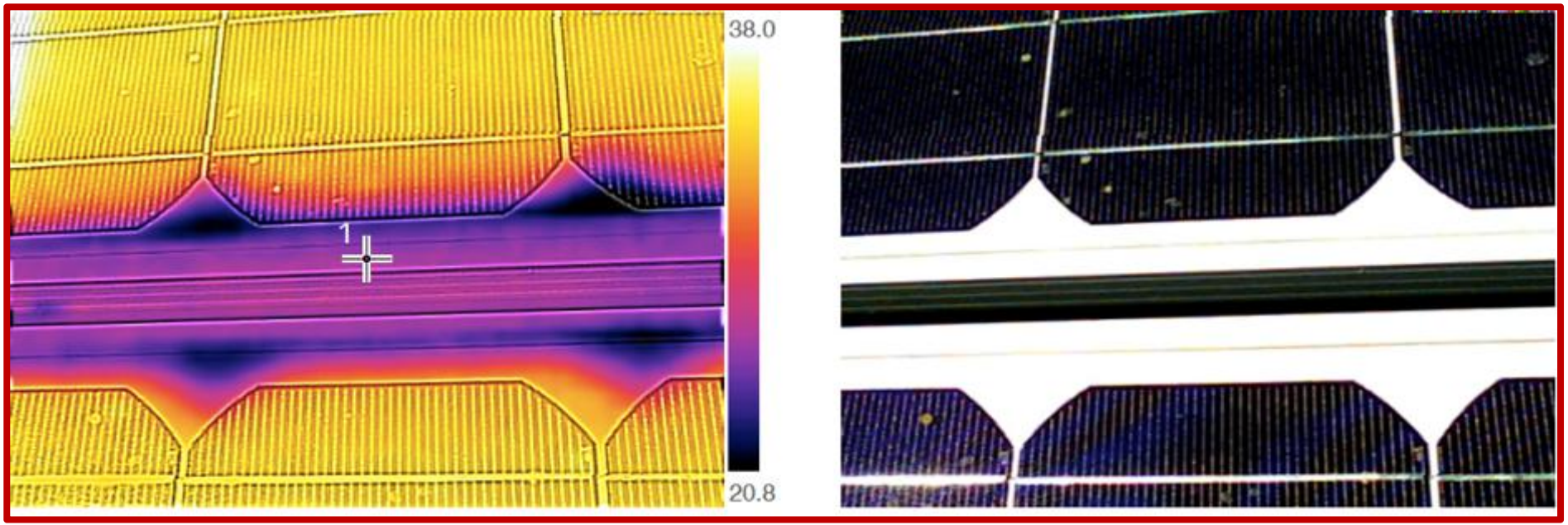


bottom to top of module





Module frame



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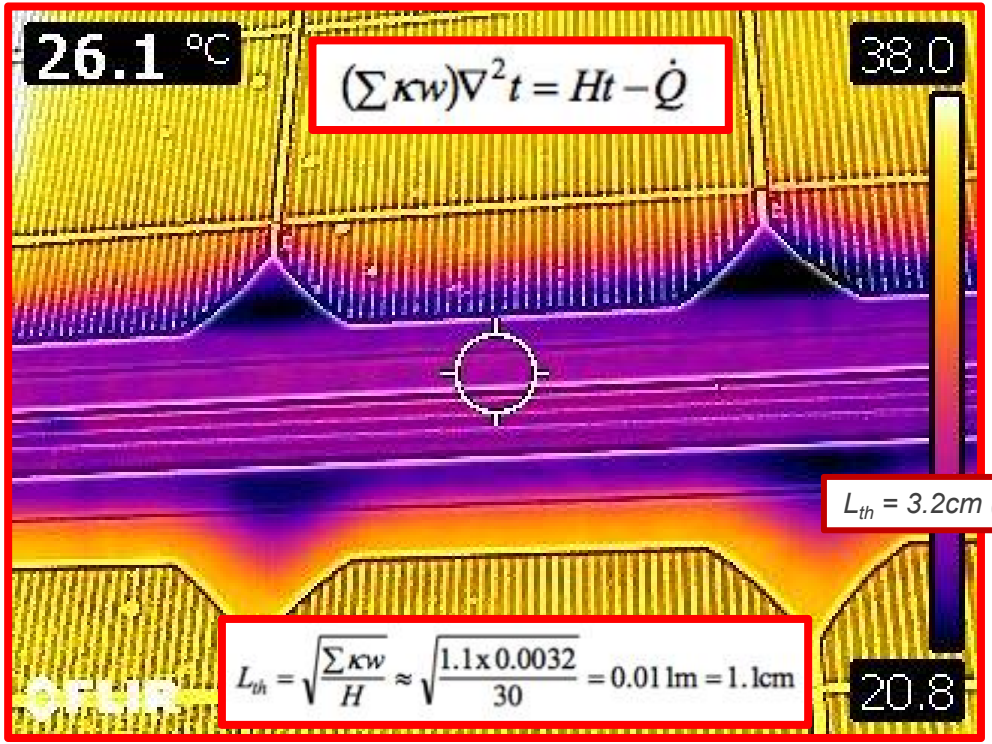
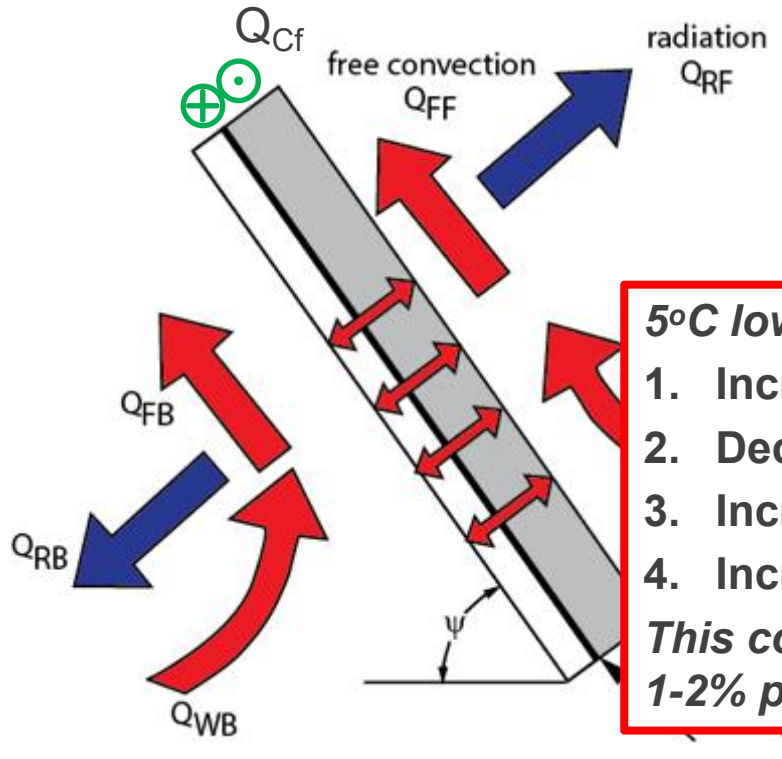


L_{th} = 3.2cm (Si areas)

Heat to frame = $L_{th}^2 H (t_{cell} - t_{frame})/\min(S, L_{th})$

Summary



5°C lower NMOT (NOCT) seems possible by:

1. **Increasing *R* (*1.2- 2.5um*)**
2. **Decreasing *R* (*>4um*)**
3. **Increasing rear convective loss**
4. **Increasing heat to frame**

This could measurably increase output by 1-2% plus life & energy production by >50%.