Cold-side Engineering of a Thermophotovoltaic System

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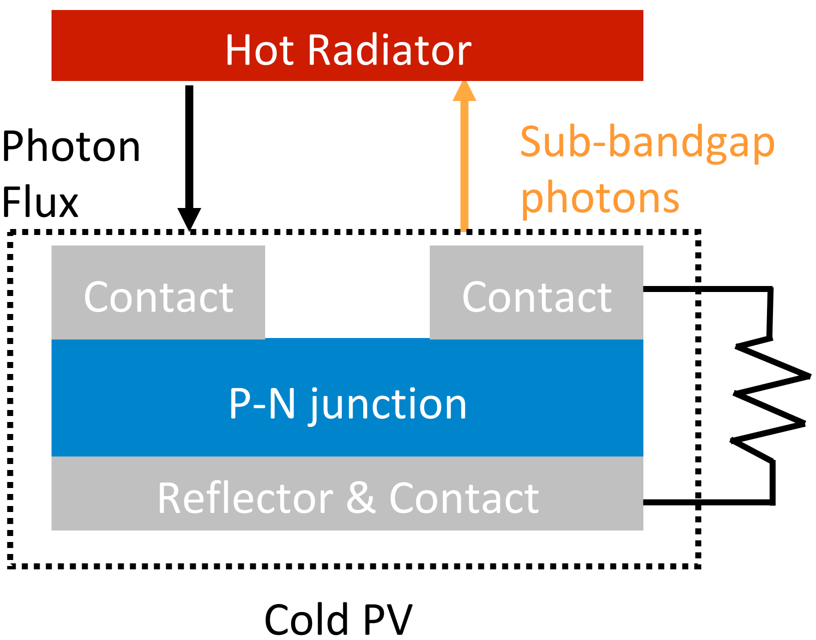
Cambridge, Massachusetts

Nov 30, 2017

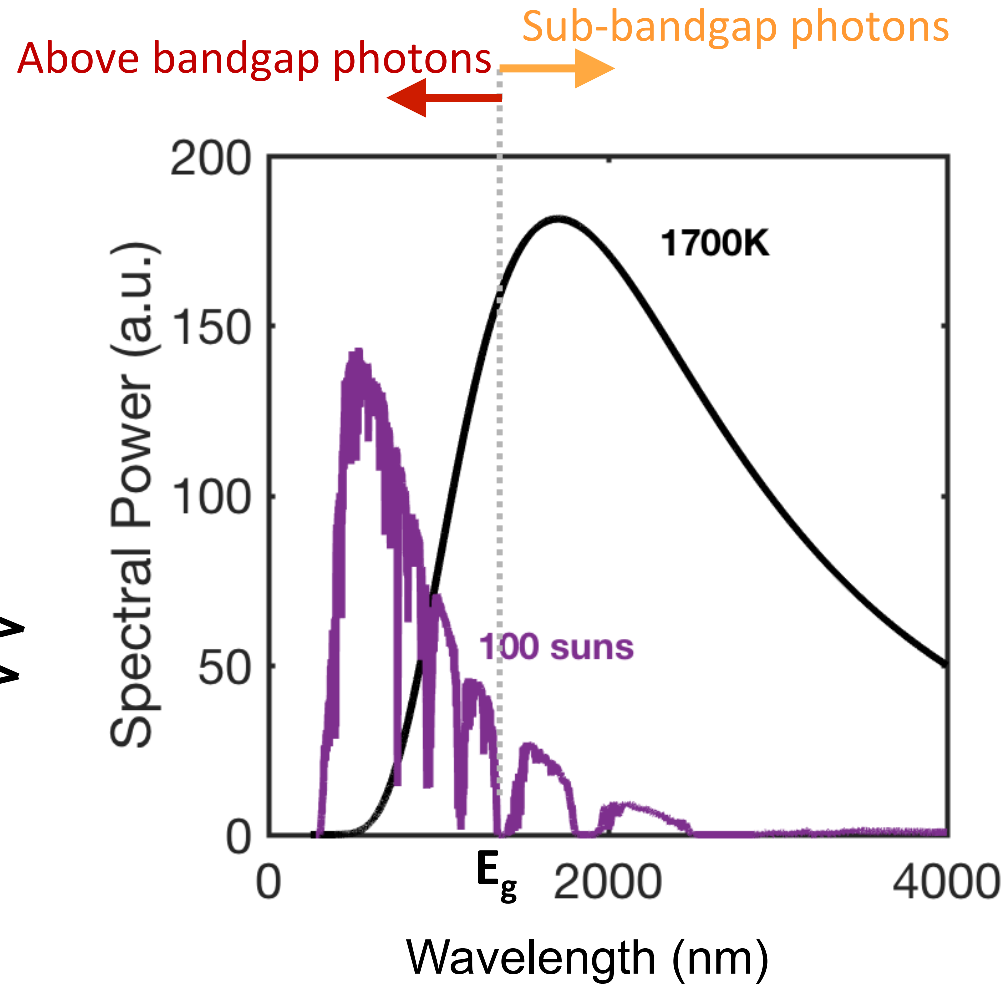
Descriptive title immediately introduces the story of the presentation.

Thermophotovoltaics

Color-coordination clearly relates the data to a cartoon of what's happening with the physics.

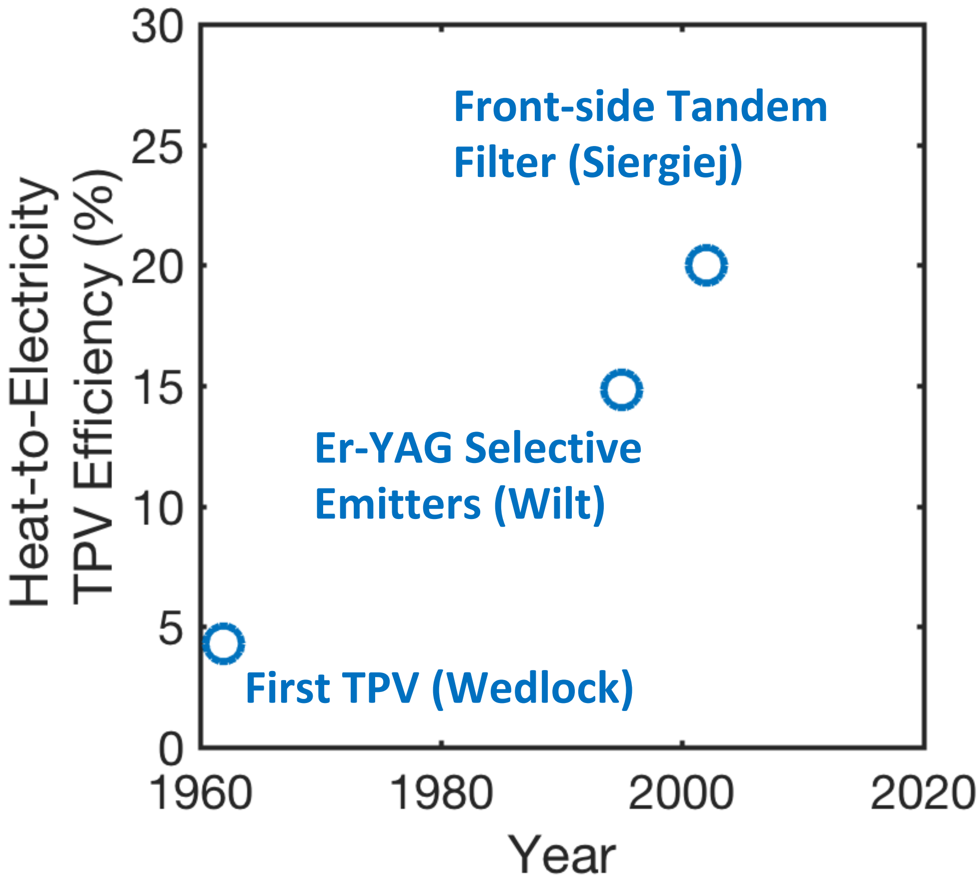


Graphic is simplified to give only the critical details.

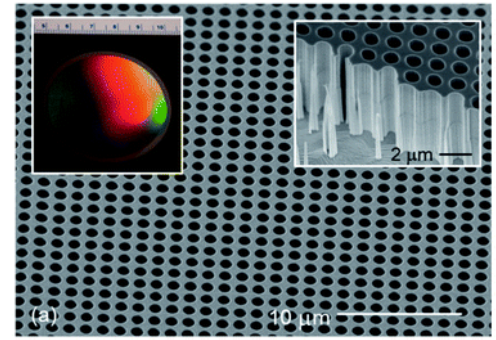


Spectral control towards higher TPV efficiency

Title compactly introduces the message of the slide, with graphics to support, allowing the speaker to effectively discuss the details.

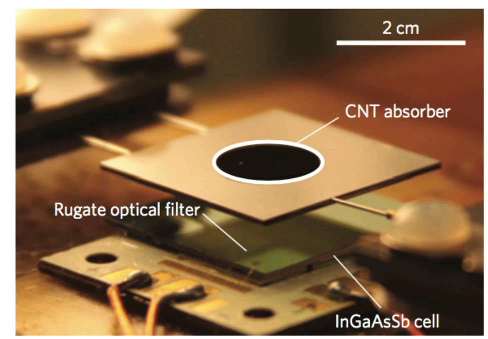


Simplified figure, large axes and label font. Graphically introduces a timeline to illustrate the rate of progress.



2D Photonic Crystal (Rinnerbauer)

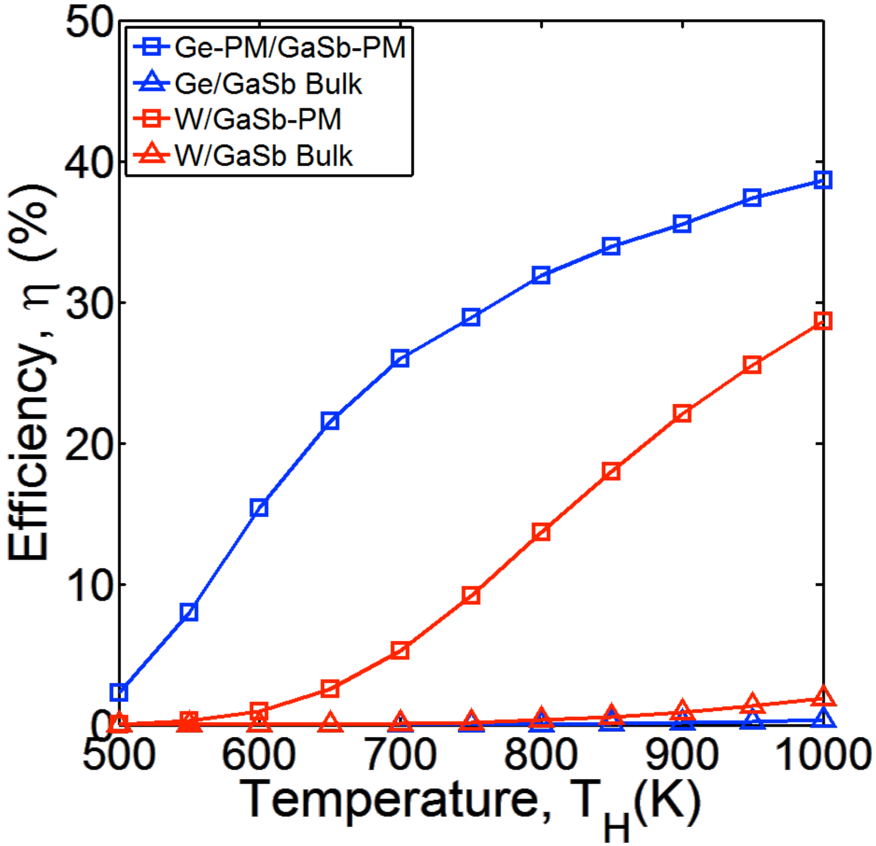
Critical components of this image are labeled

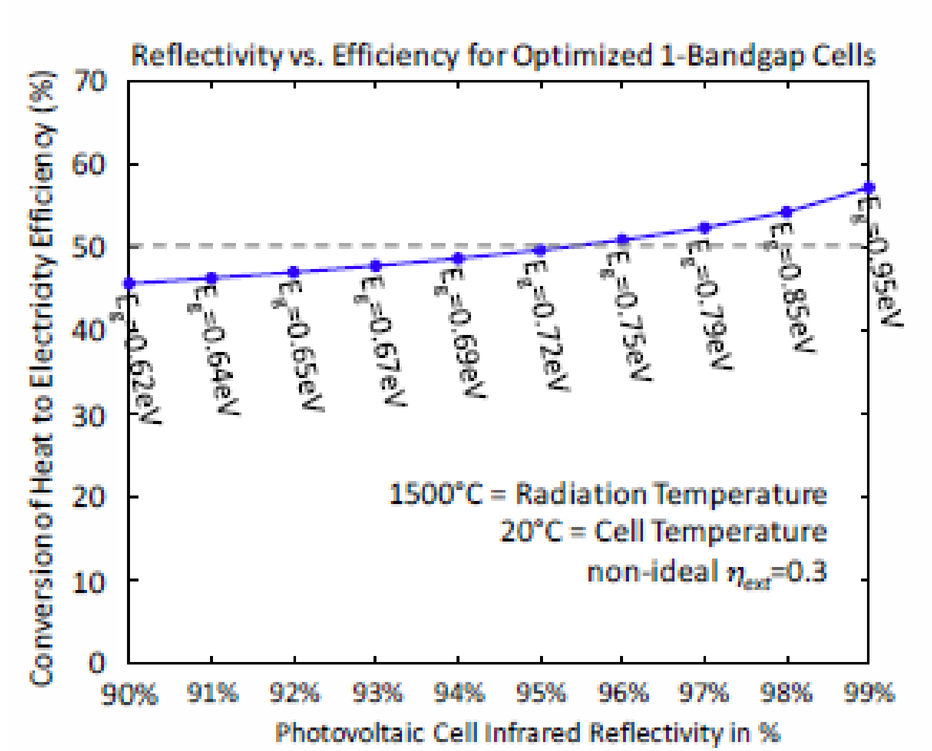


Solar-TPVs (Bierman)

Wedlock B. D., Electron Devices Meeting, 8 (48), 1962
Wilt, D. M., et al., *AIP Conference Proceedings, 1995*
Brown E. J. et al., Lockheed Martin Report (2004)
Rinnerbauer et al., Energy Environ. Sci., 5, 8815-8823, (2012)
Bierman et al., Nature Energy, 1 (6), 16068 (2016)

Cold-side Engineering of PV cells





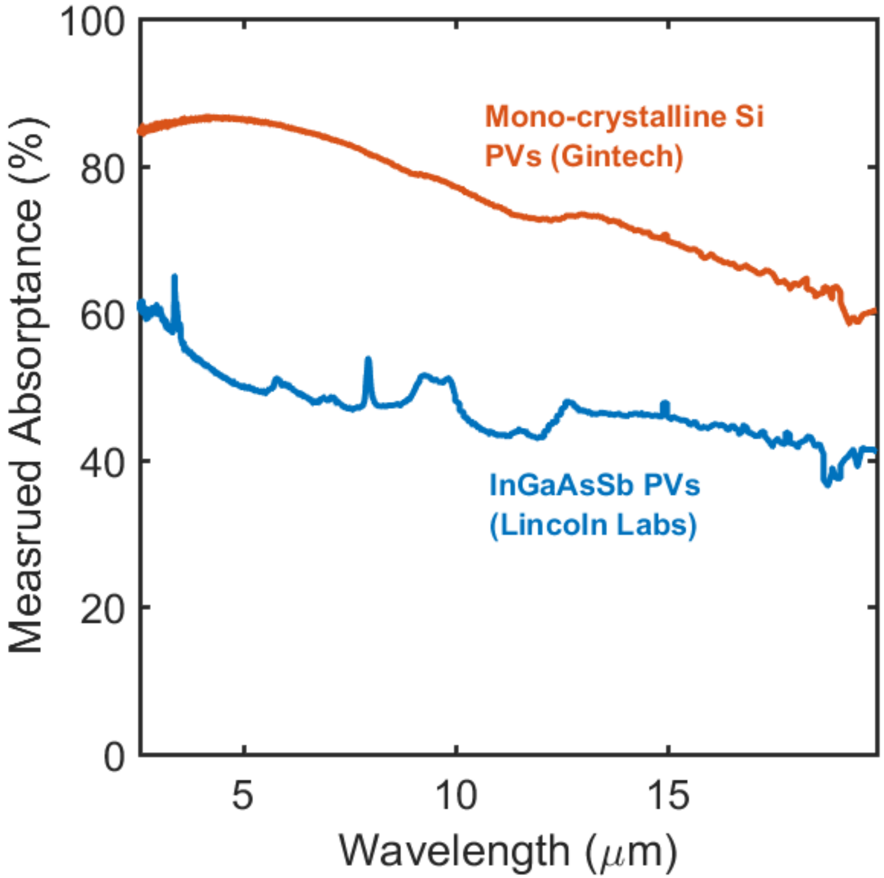
Use high resolution figures. If taken from another source, do the best you can.

Tong J., Hsu W.C., Huang Y., Boriskina S.V., Chen G., Scientific Reports 5 (2015)

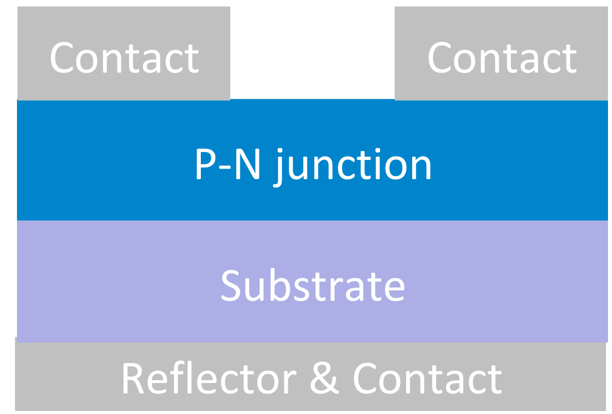
Ganapati V., Xiao, P., Yablonovitch, E., arxiv 1611.03544 (2016)

Standard PV cells not optimized for TPVs

A longer title clearly introduces a problem to be solved.



Introducing a roadmap diagram of the system, which will help locate the audience to where we are in the presentation and what part of the system is being discussed.



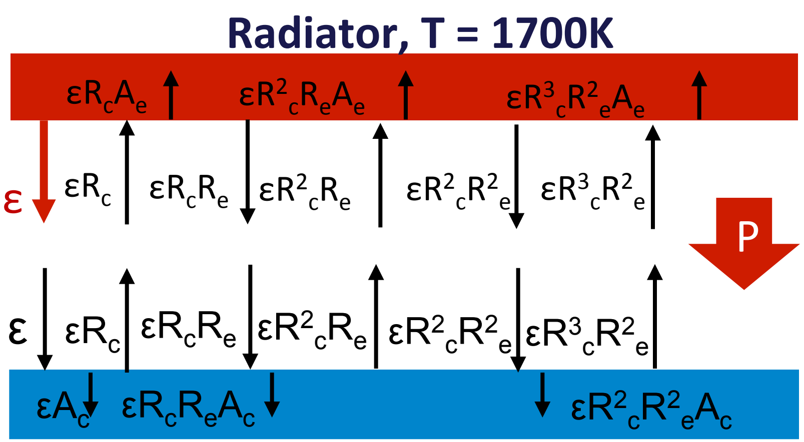
What causes high infrared absorptance?

Boxing an important question or takeaway focuses the audience's attention.

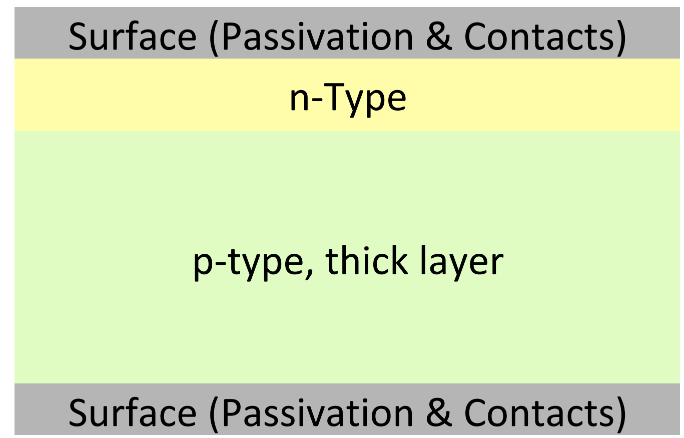
TPV Optical and Electrical Efficiency

Boxing the diagrams visually shows the distinction in two methods of modeling.

Cavity Efficiency



Electrical Efficiency



Good use of intrinsic meaning of colors, red = hot, blue = cold

Photon Recycling

$$P = P_0 \frac{A_{cell} A_{radiator}}{1 - R_{cell} R_{radiator}}$$

Carrier Transport, Generation and Recombination

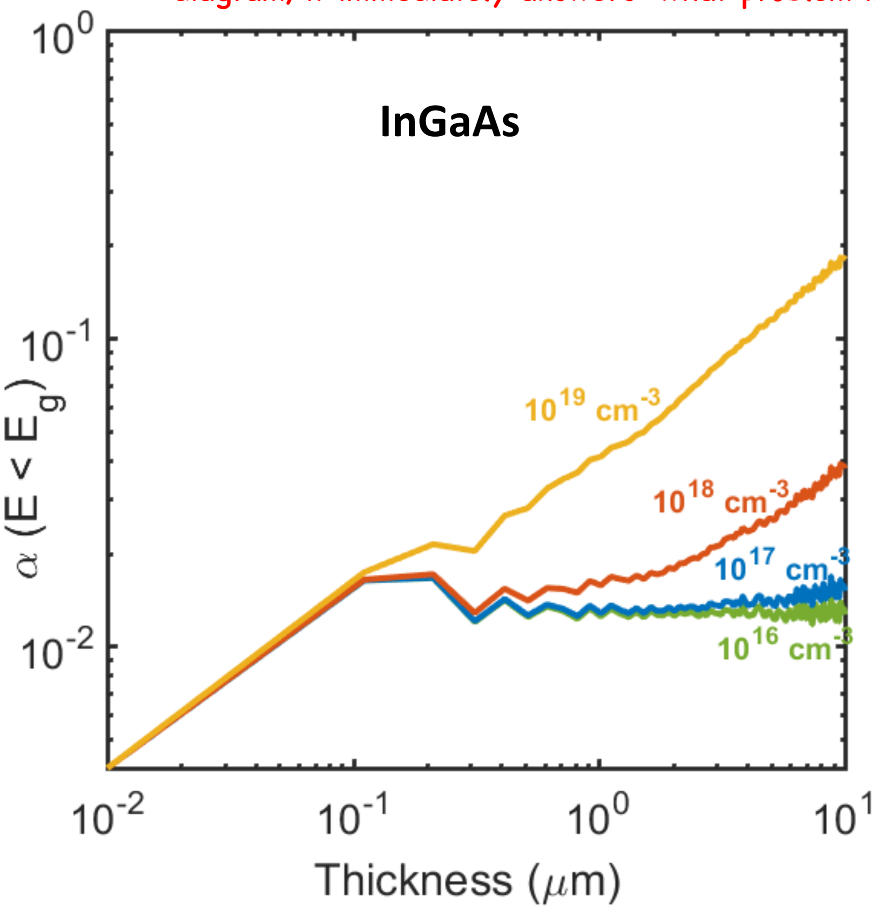
$$\frac{d^2 p_n'}{dx^2} - \frac{p_n'}{L_p^2} = -\frac{G_{external}}{D_p}$$

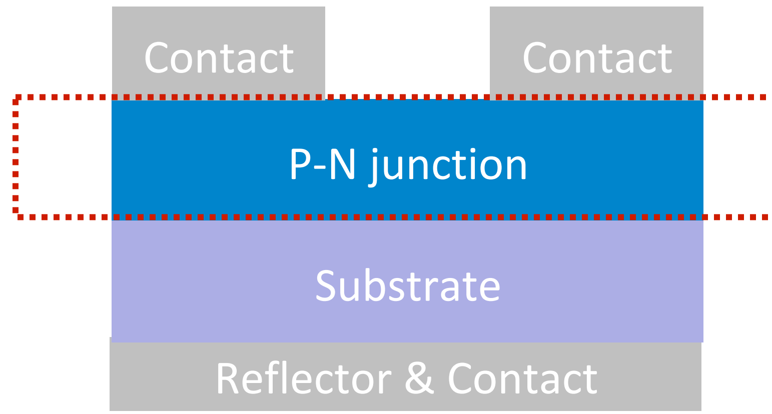
$$\frac{d^2 n_p'}{dx^2} - \frac{n_p'}{L_n^2} = -\frac{G_{external}}{D_n}$$

Critical equations that are not too busy to illustrate the effect. Keep in mind, some audiences may be familiar with a standard notation, others may not.

Parasitic absorption in PV cells

Short-phrase title introduces the sub-problem being solved on this slide. Combined with the diagram, it immediately answers "what problem in what part of the system?"



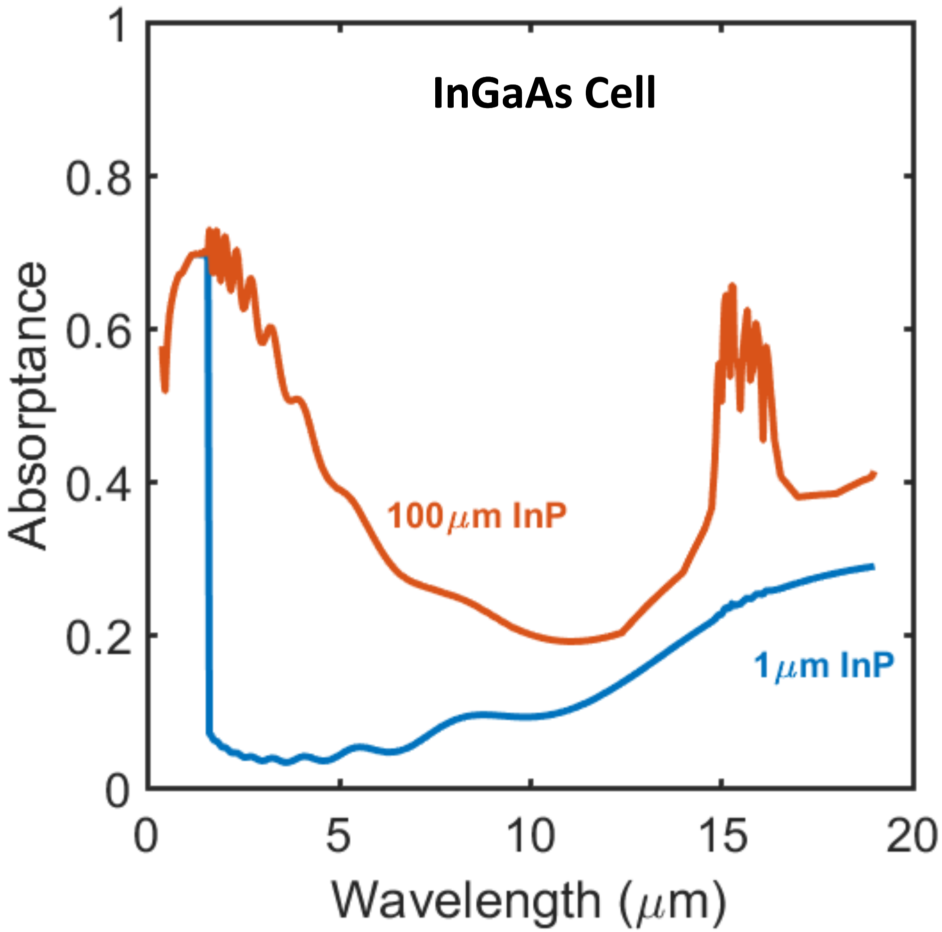


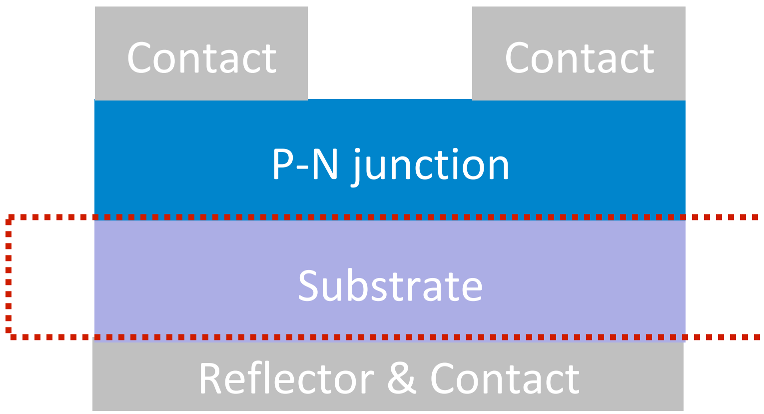
Recalling the roadmap diagram, highlighting exactly where we are.

Free Carrier Absorption

$$\alpha(\omega) = \frac{Ngq^3}{\varepsilon_0 n m_c^2 c\mu\omega^2}$$

Parasitic absorption in PV cells



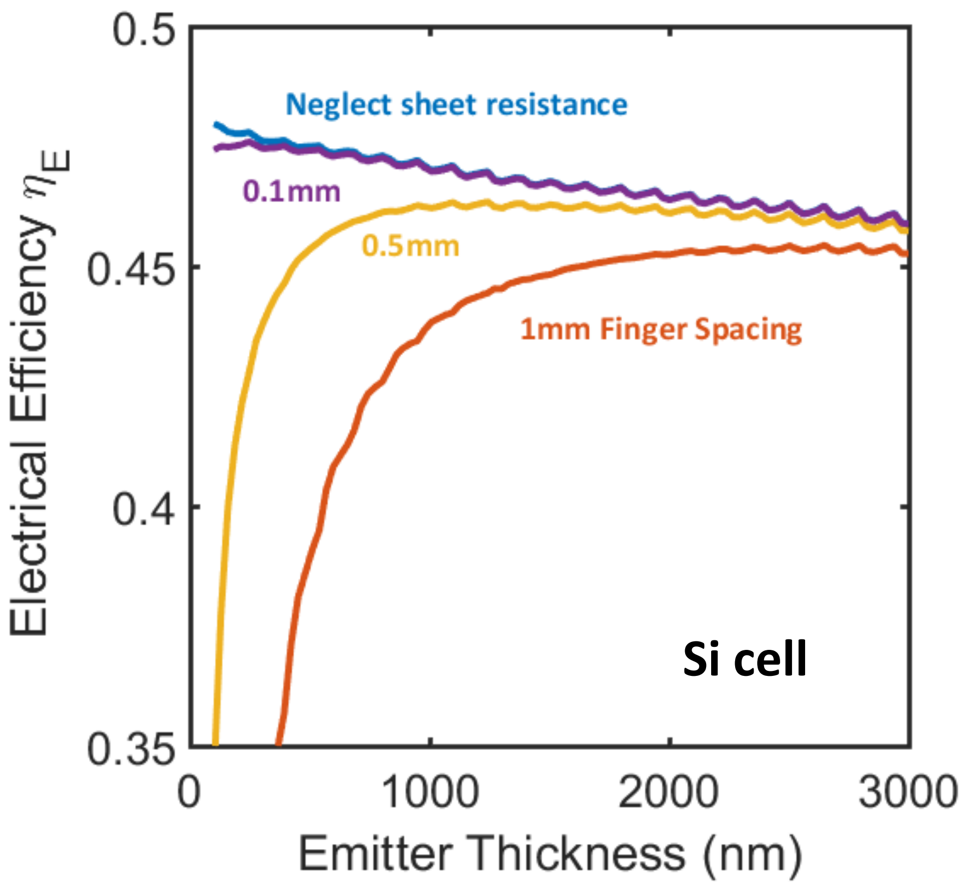


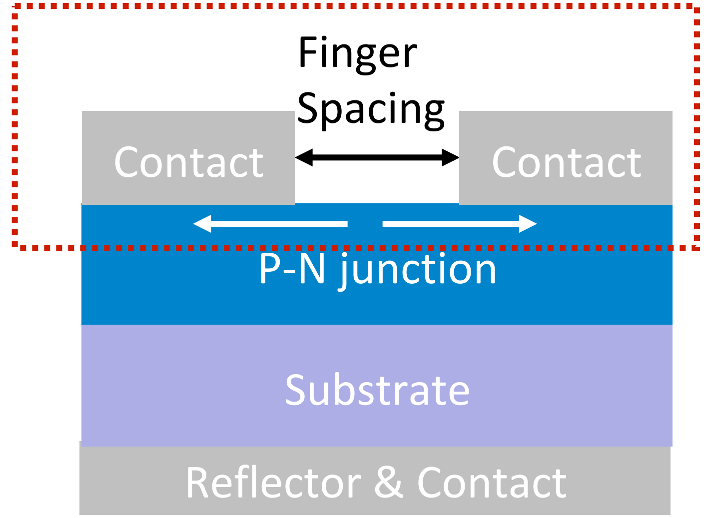
Free Carrier Absorption

$$\alpha(\omega) = \frac{Ngq^3}{\varepsilon_0 n m_c^2 c\mu\omega^2}$$

Consistency between graph color schemes. Ensure colors that are not supposed to be associated from figure to figure are not.

Electrical Efficiency and Sheet resistance of PV cells



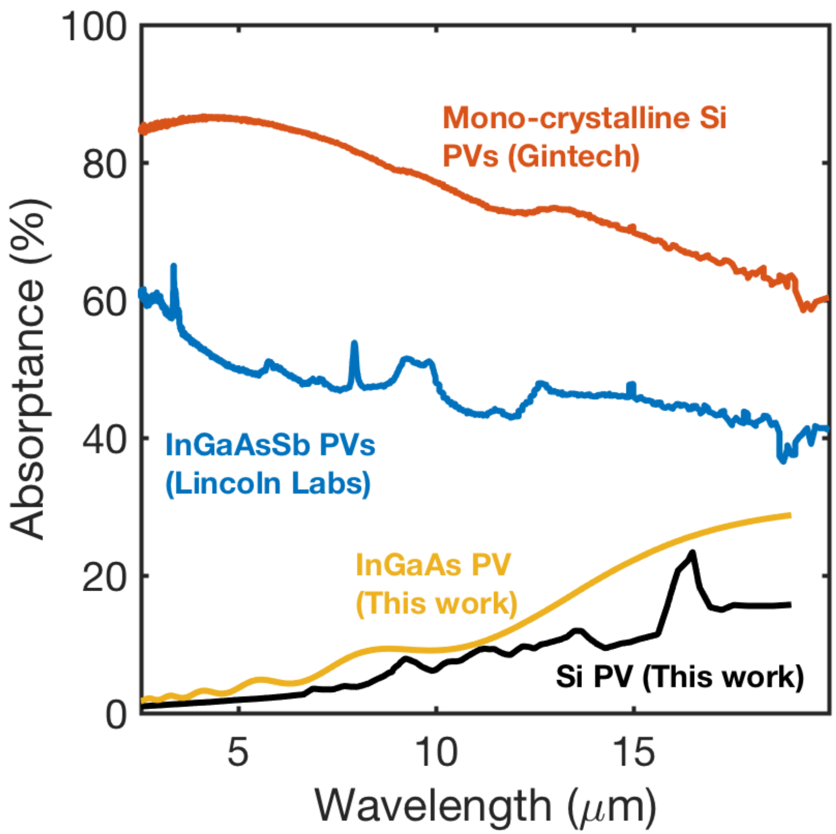


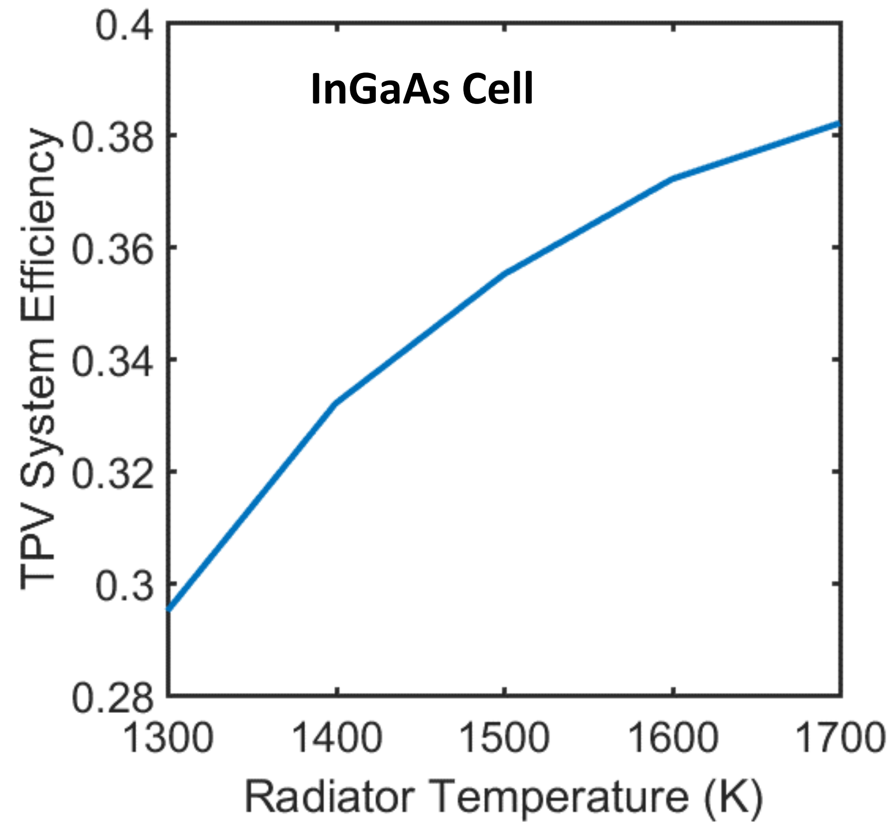
Power Loss to Sheet Resistance

$$\frac{P_{loss}}{P_{\max P}} = \frac{S^2 \rho_s J_{\max P}}{12 V_{\max P}}$$

Excellent consistency of: the roadmap system diagram, a single figure of data and a key takeaway per slide, effectivley focusing the audience's attention.

Cells Designed for high system efficiency





Great labeling identifies what has been done and what this presentation has added to the state of the art.

η (Si TPV system) = 25-29% with T_h = 1700K

η (InGaAs TPV system) = 37-38% with T_h = 1700K

Summary & Future Plans

Bolding and colored text highlights the audience to the key impacts that have been achieved or are desired to be achieved. Surrounding texts briefly reminds how this was achieved.

- Minimize doping and layer thickness of emitter and high doped region to **decrease sub-bandgap absorptance due to free carriers**
- Minimize thickness of substrate due to free carriers and phonon absorption modes

- Moderately doped thin n-type layer can **maintain good electrical efficiency** due to high short circuit current
- Finger spacing of front contacts needs be optimized to **reduce power loss due to sheet resistance without increasing parasitic absorption**

- We intend to fabricate designed cells and test its system efficiency

Acknowledgement

- Prof. Gang Chen, Prof. del Alamo, Prof. Evelyn Wang
- Dr. S.V. Boriskina, Y. Tsurimaki, Dr. A. Vardi, W. Lu, L. Manoush, T. Cooper, C. Kelsall, A. Leroy, Dr. B. Bhatia
- NanoEngineering group

- DOE, EFRC S3TEC center
- DOE BES

Acknowledgements is a great concluding slide. If appropriate, any support slides can go after.