

Limit Performance of Silicon Solar Cells

Abstract

The energy demand, price, and environmental issues such as climate change have caused a shift in emphasis from fossil-fueled power generation to renewable sources such as solar energy conversion. The limiting efficiency of silicon has been investigated in which only the fundamental loss mechanism, radiative recombination and Auger recombination are operative.

Performance Limit of Solar Cell Technologies

The idealized limit of the performance of photovoltaics, for a given bandgap, is determined by the Shockley-Queisser (SQ) limit. However specific materials have a more fundamental limit, given by their own properties. In purple we show the best reported devices for a given technology and in red their fundamental limit.

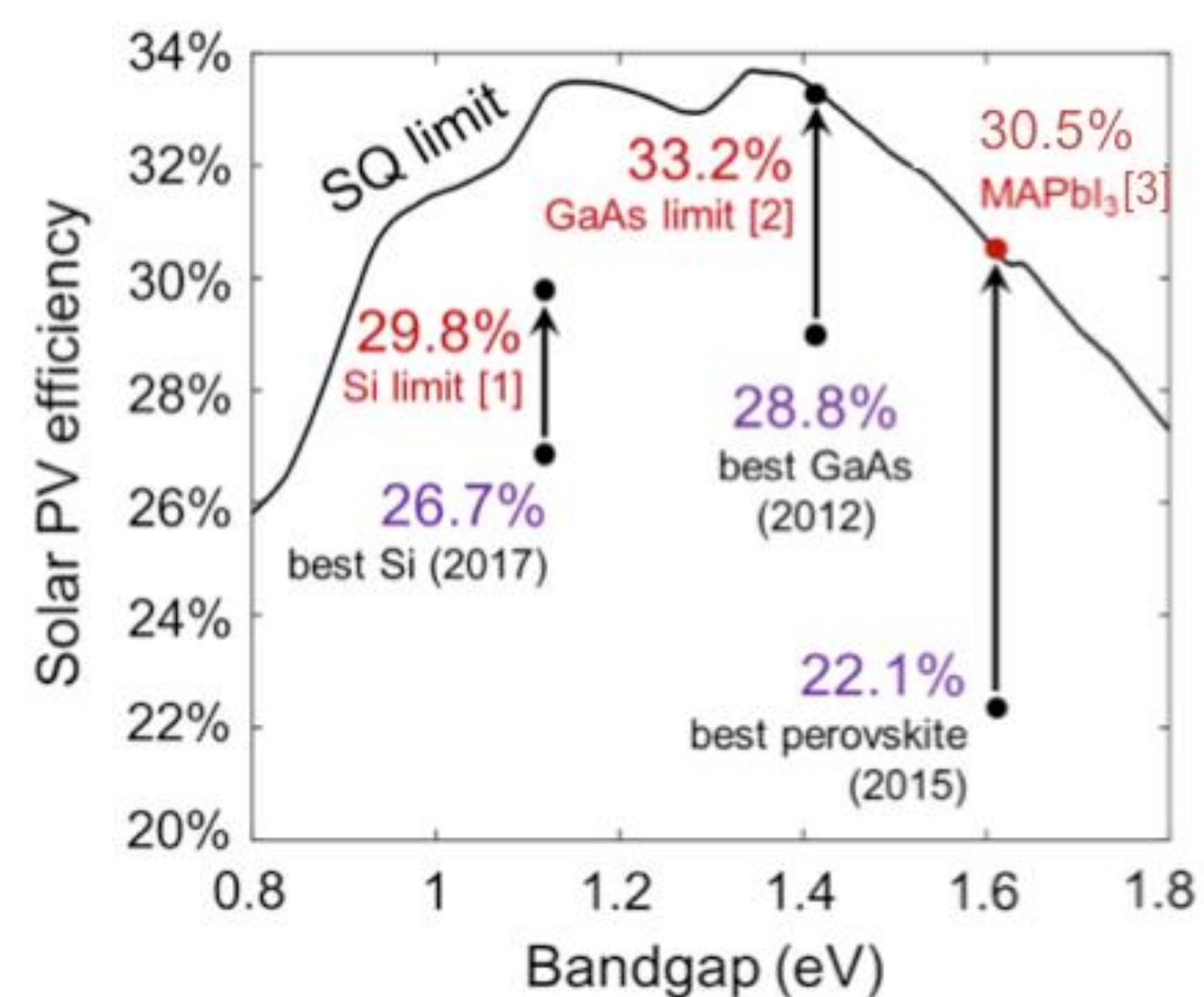
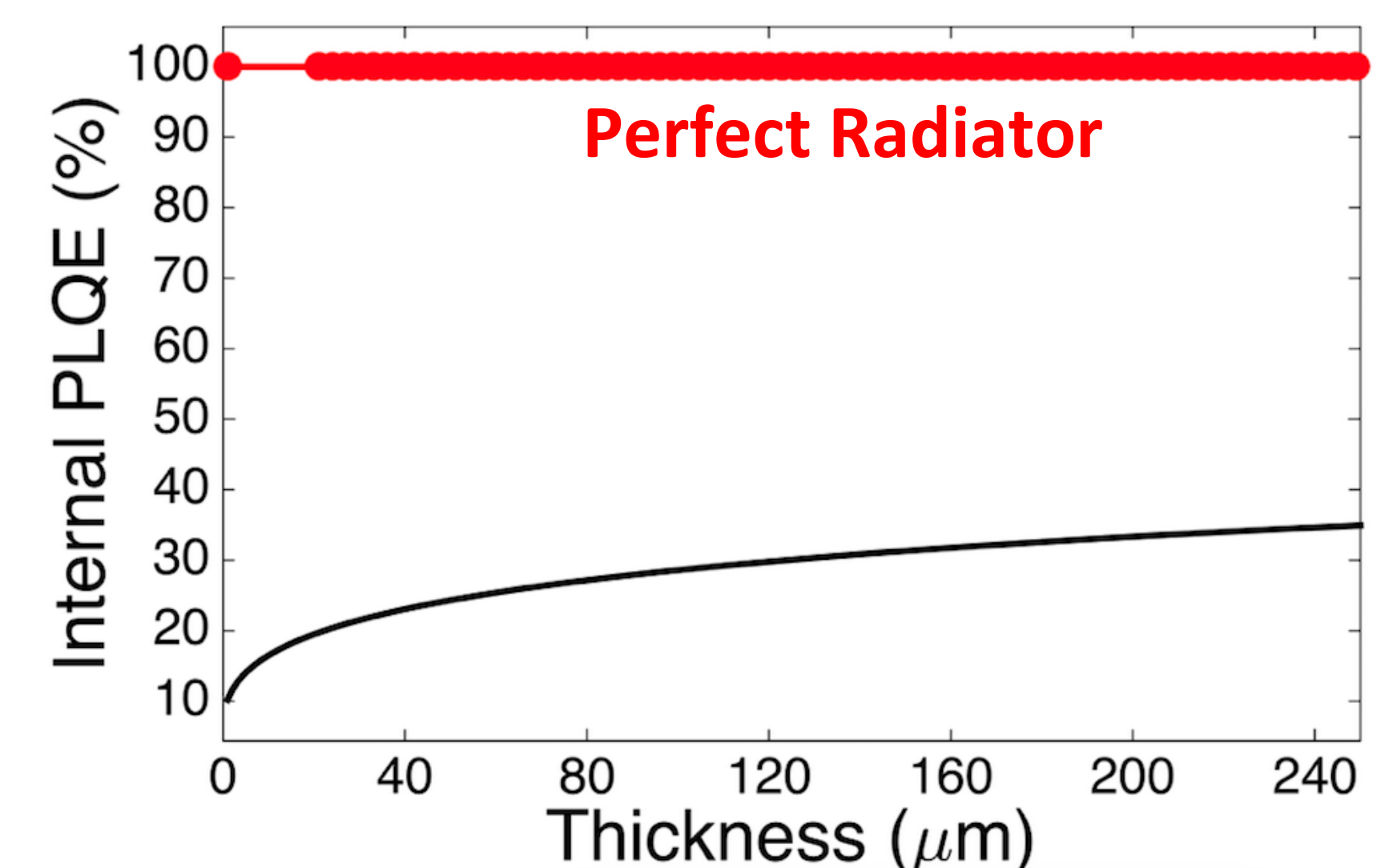


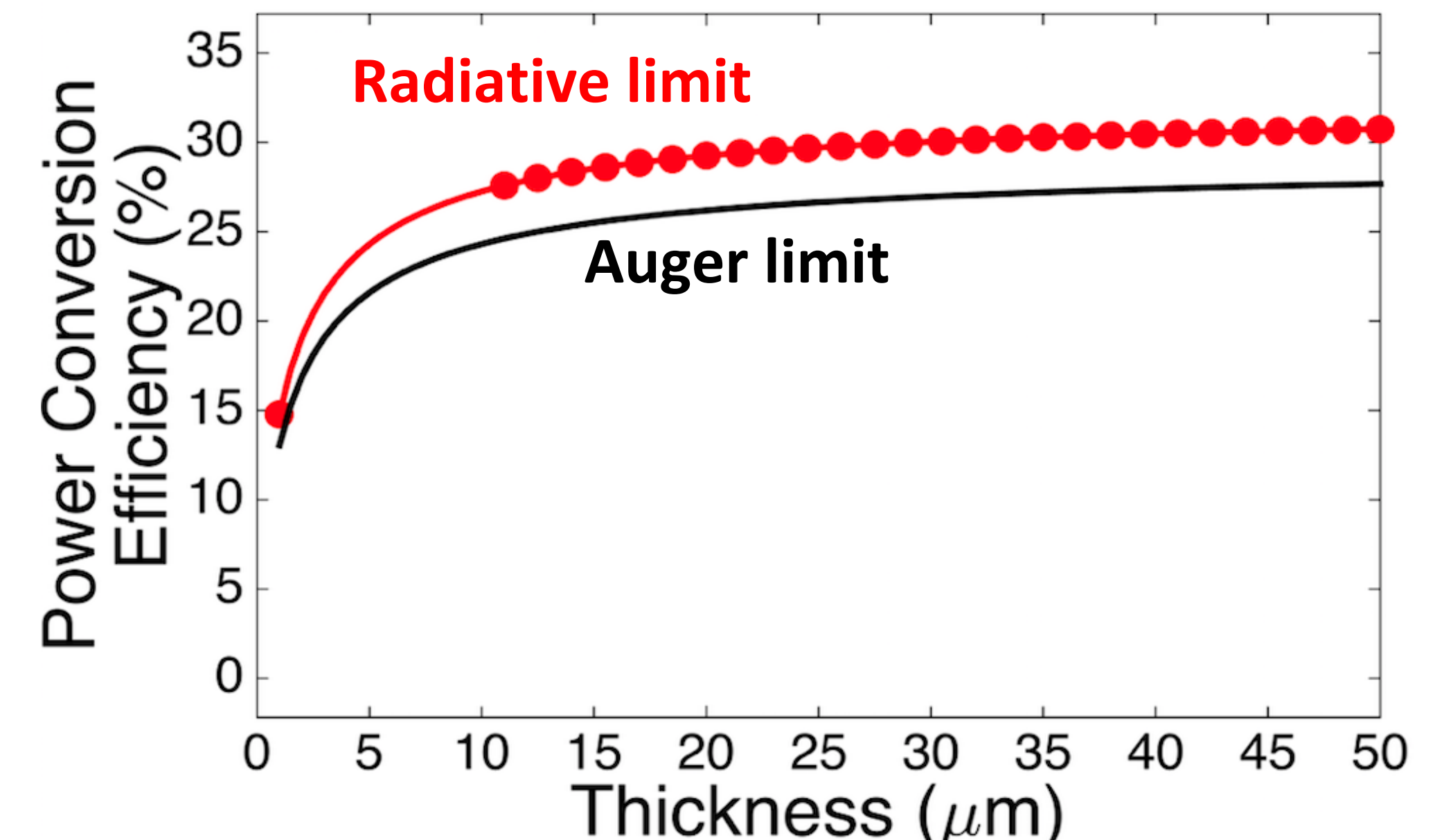
Image courtesy of Dr. Luis M. Pazos-Outón

Luminescence Efficiency and Power Conversion in Silicon

Increase in silicon thickness leads to a carrier concentration drop, reducing the effect of Auger, and increasing the internal luminescence efficiency.



Limiting efficiency of silicon solar cells as a function of silicon thickness:



Auger Recombination is a Fundamental Material Property

While the performance of photovoltaics can be limited by having a poor mirror or large trap-mediated Shockley-Read-Hall recombination, to calculate the fundamental limit, we only consider Auger recombination.

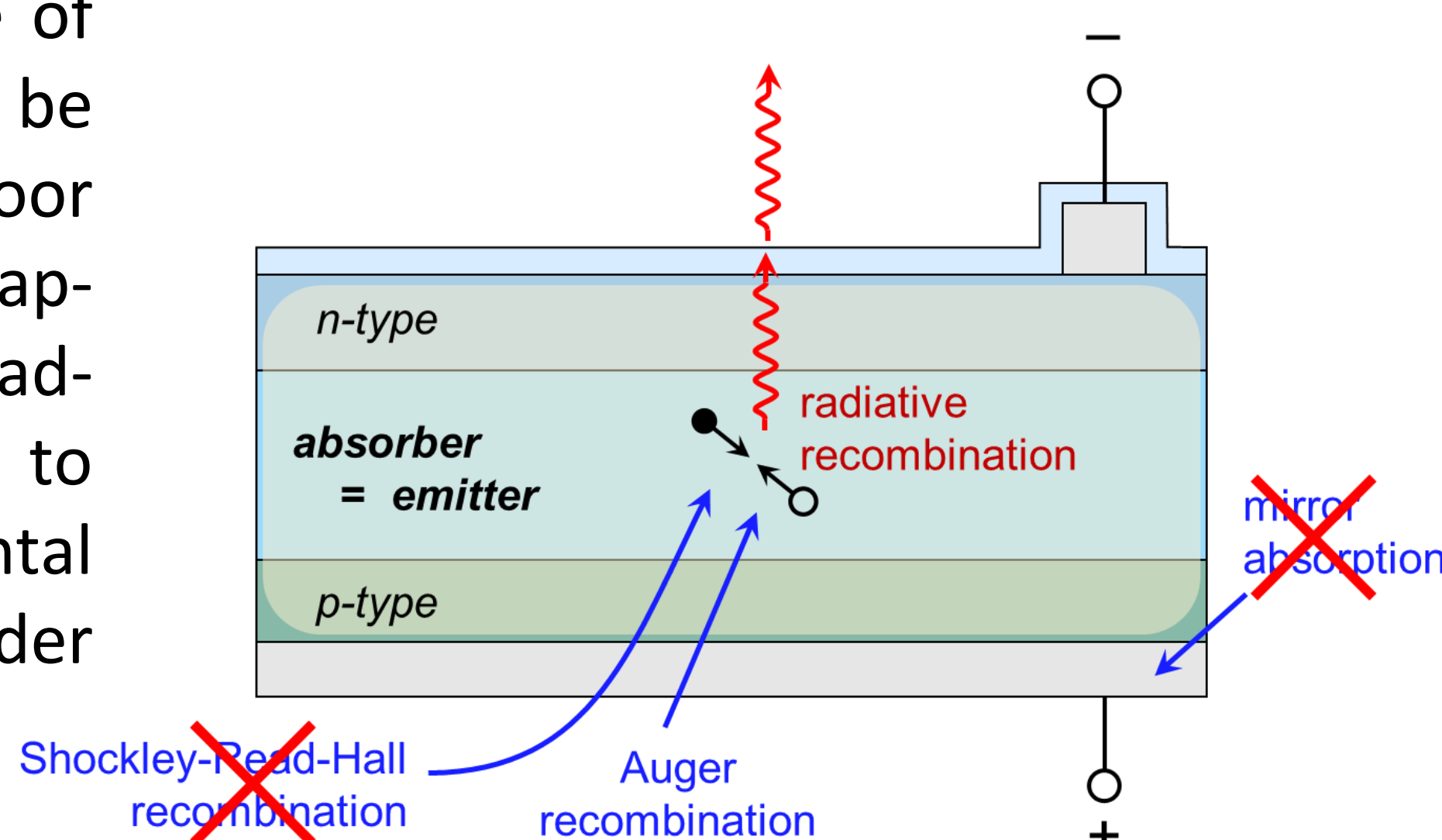
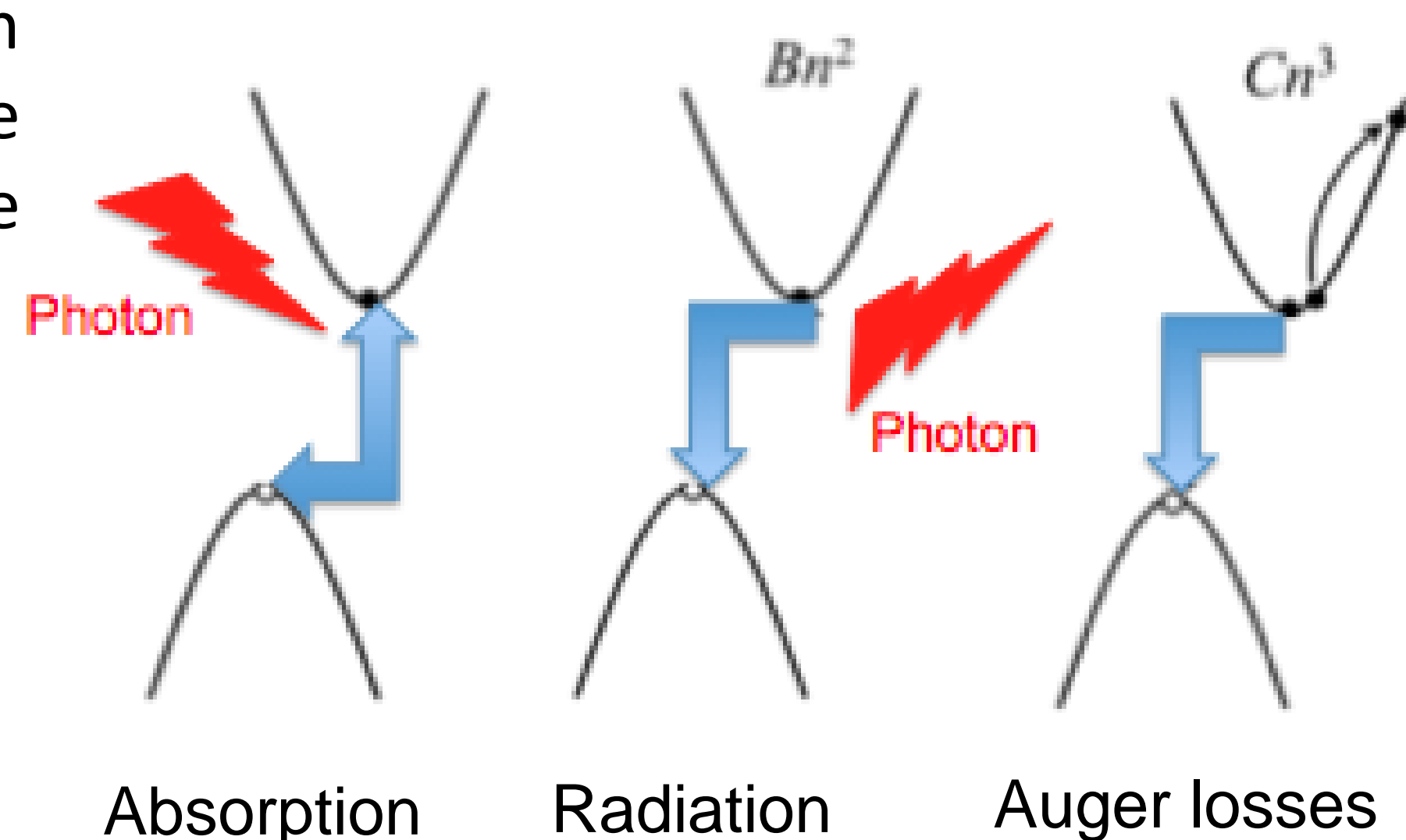


Image courtesy of Dr. Luis M. Pazos-Outón

Carrier Generation and Recombination

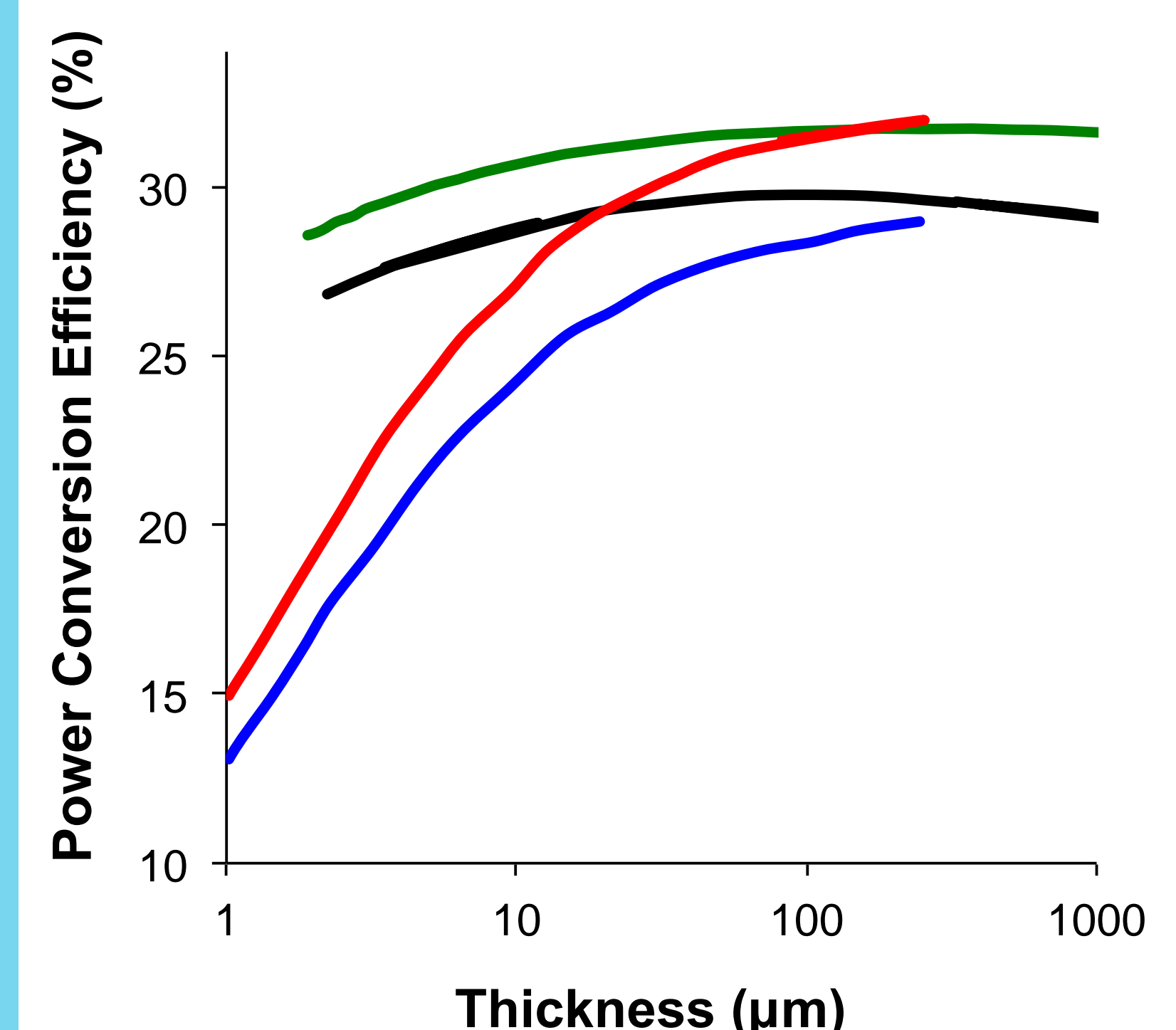
It is the competition between radiative and Auger recombination that can limit the performance of the materials.



Conclusion

- Radiative limit [1]
- Radiative limit (This work)
- Auger and free carrier absorption limit [1]
- Auger limit (This work)

Future work:
Investigate effect of free carrier absorption and surface texture in silicon



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Support Information

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[2] O. Miller, E. Yablonovitch, S. Kurtz, *IEEE J. Photovolt.* 2, 3 (2012)

[3] L. Pazos-Outón, T. P. Xiao, E. Yablonovitch, *J. Phys. Chem. Lett.* 9, 17 (2018)