"The Future of Thin-film Solar Cells"

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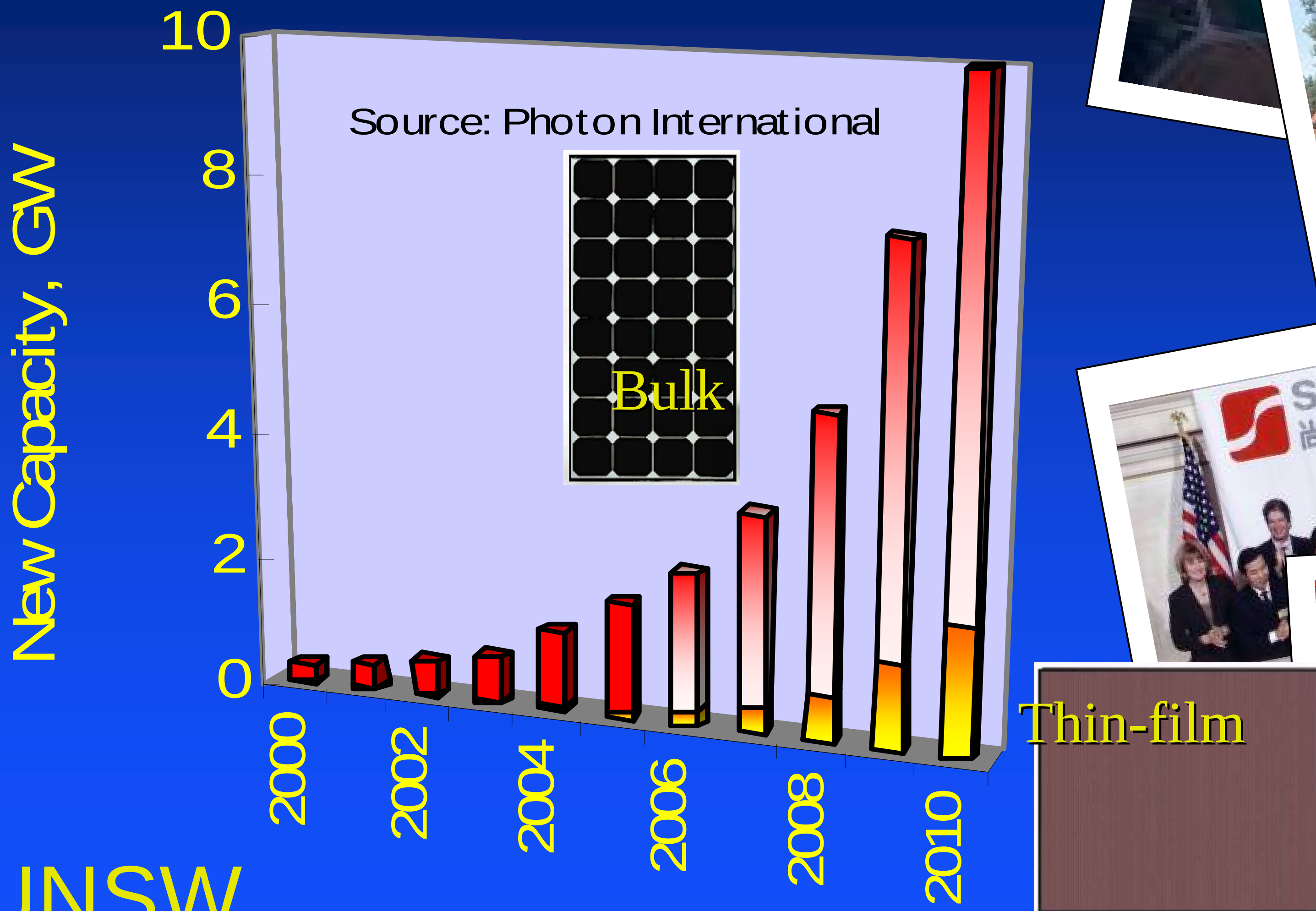
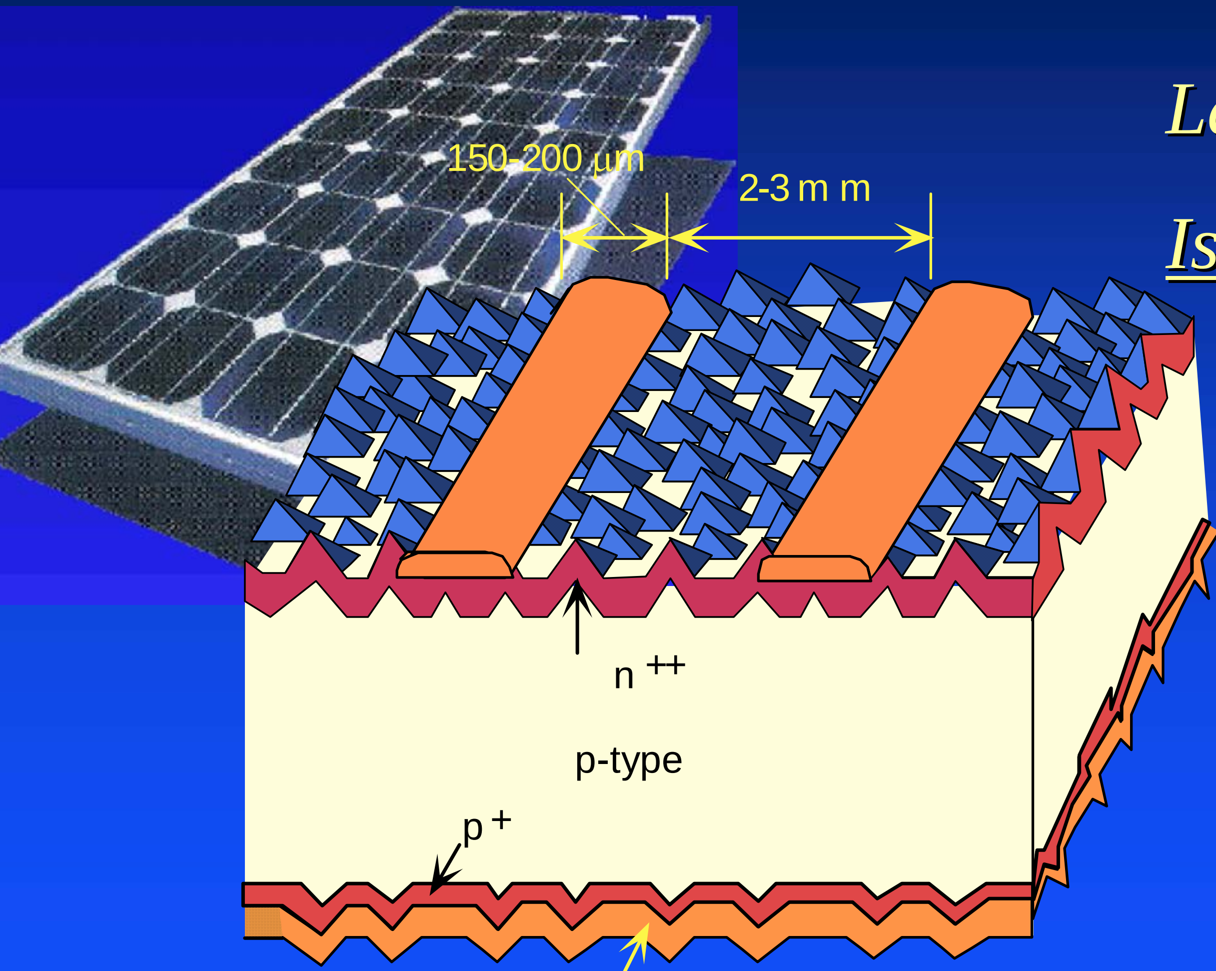
Photovoltaics booming



UNSW

First generation cells



Larger Si wafer area than ICs

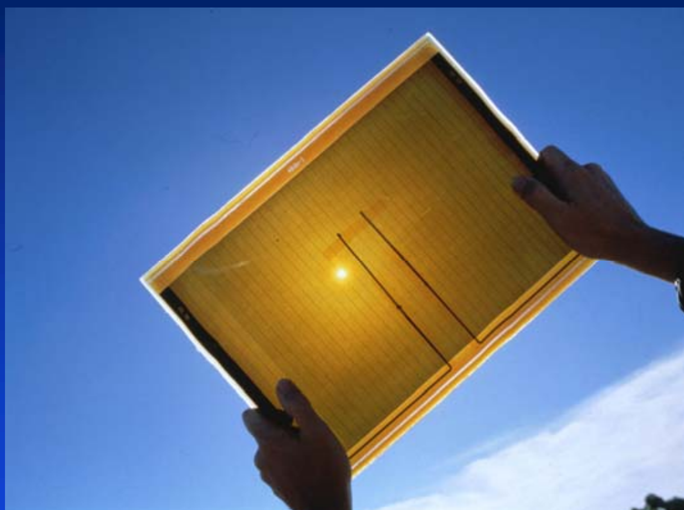
<u>Issues</u>

. thinner cells

. simpler Si purification

. higher conversion efficiency

Second Generation: thin-film



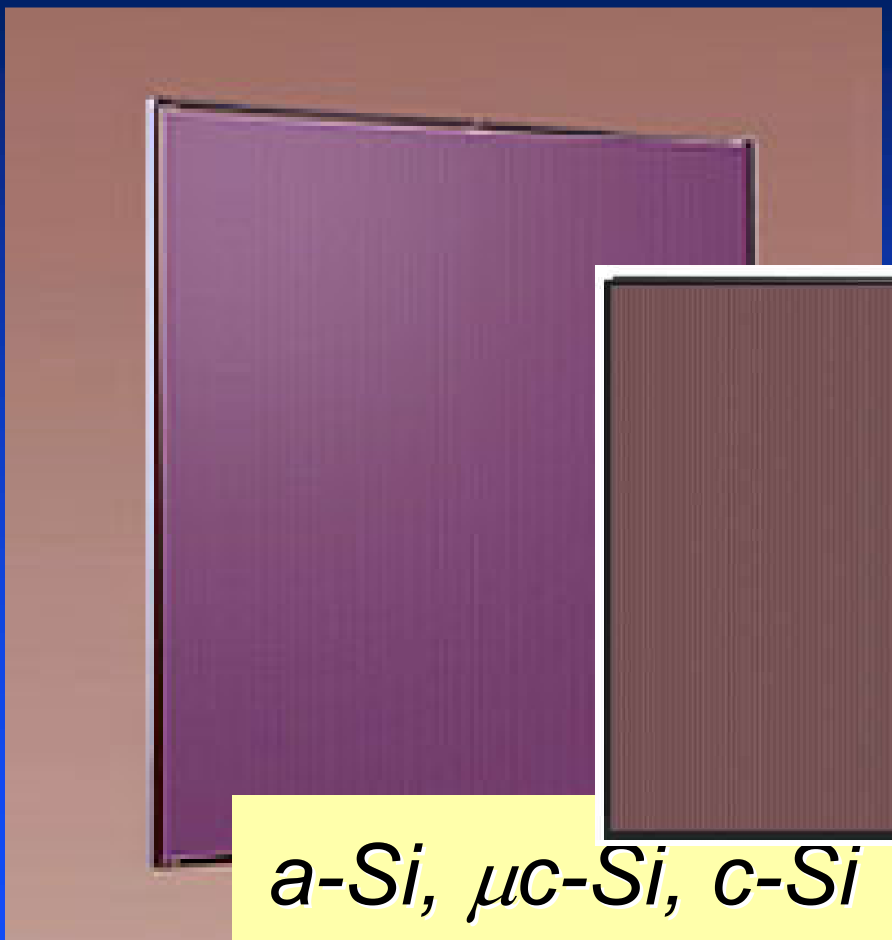
Advantages

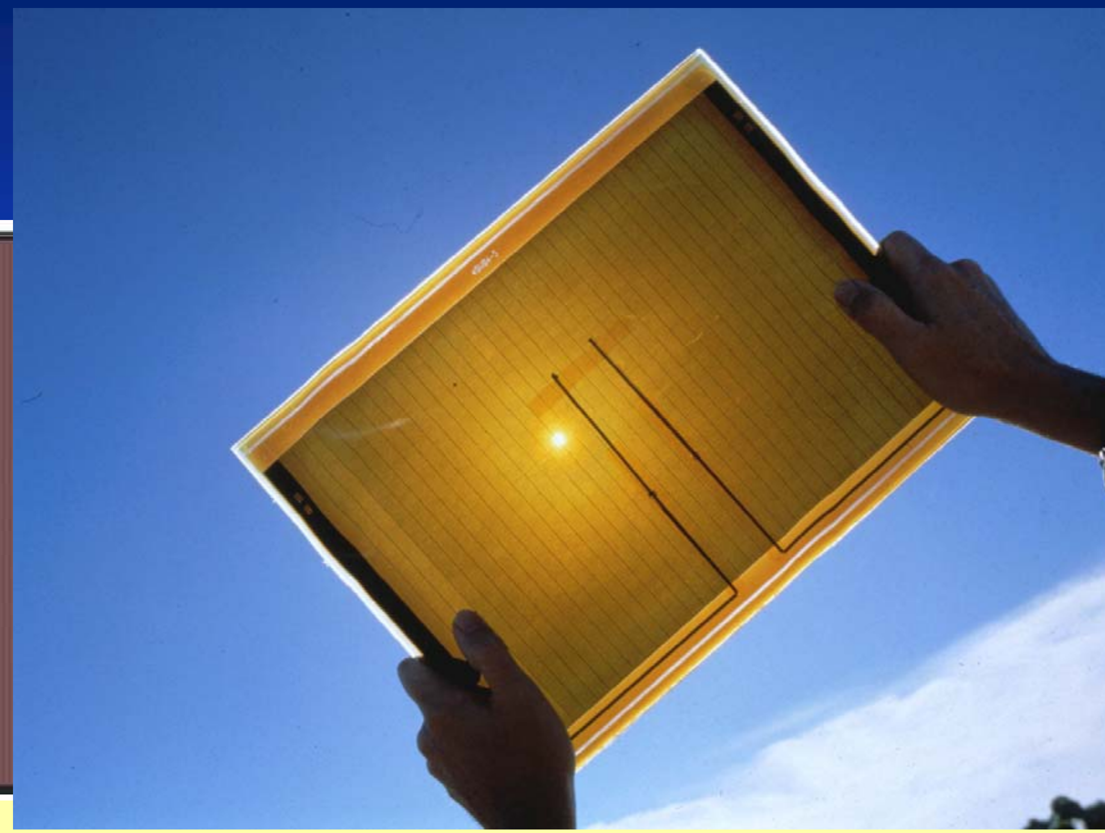
- low materials cost
- large manufacturing unit
- fully integrated modules
- aesthetics, ruggedness?

Thin-film Technologies

- **Silicon**
  - amorphous
  - microcrystalline
  - polycrystalline
- **Chalcogenide** (polycrystalline)
  - CIS, CIGS [Cu (In,Ga) $(Se,S)_2$]
  - CdTe
- **Dye sensitised**, **Organics**

Silicon Thin-Film



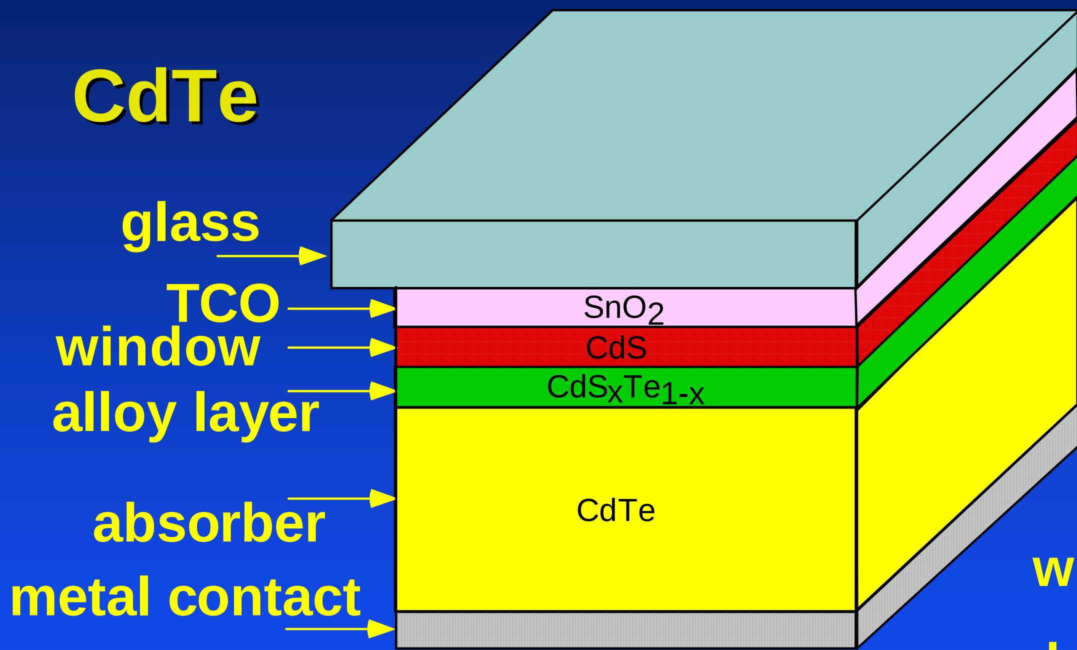


a-Si, μc-Si, c-Si

amorphous, microcrystalline, (poly-)crystalline

Chalcogenides: CdTe and CIGS

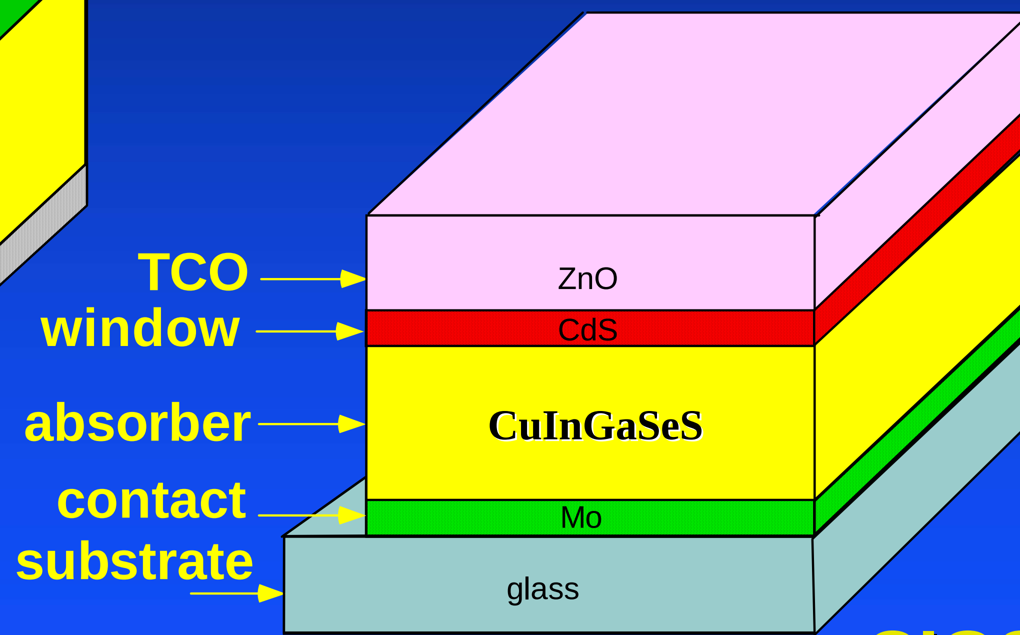
CdTe



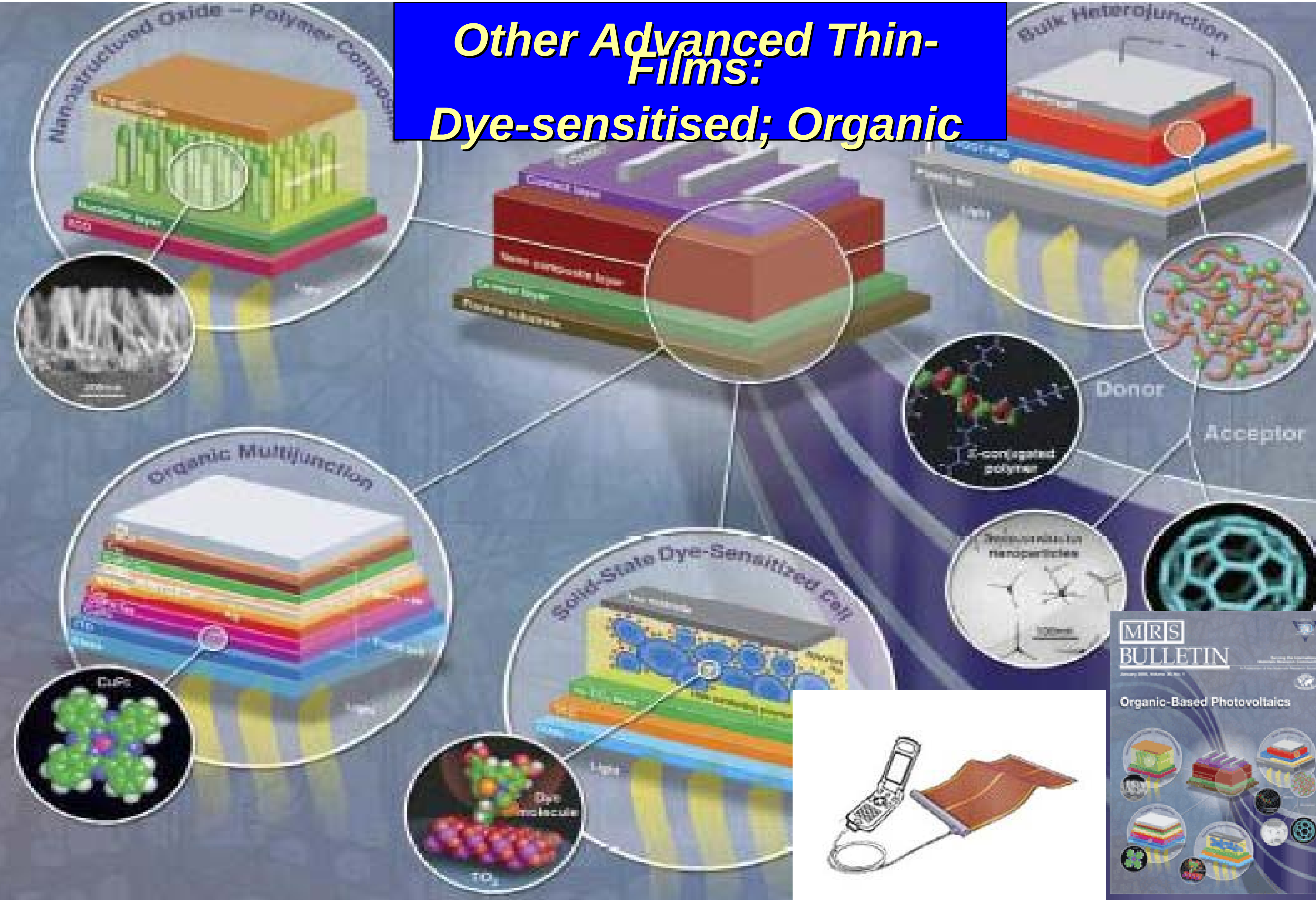
- easily deposited
- Cd toxic, Te scarce

CIGS

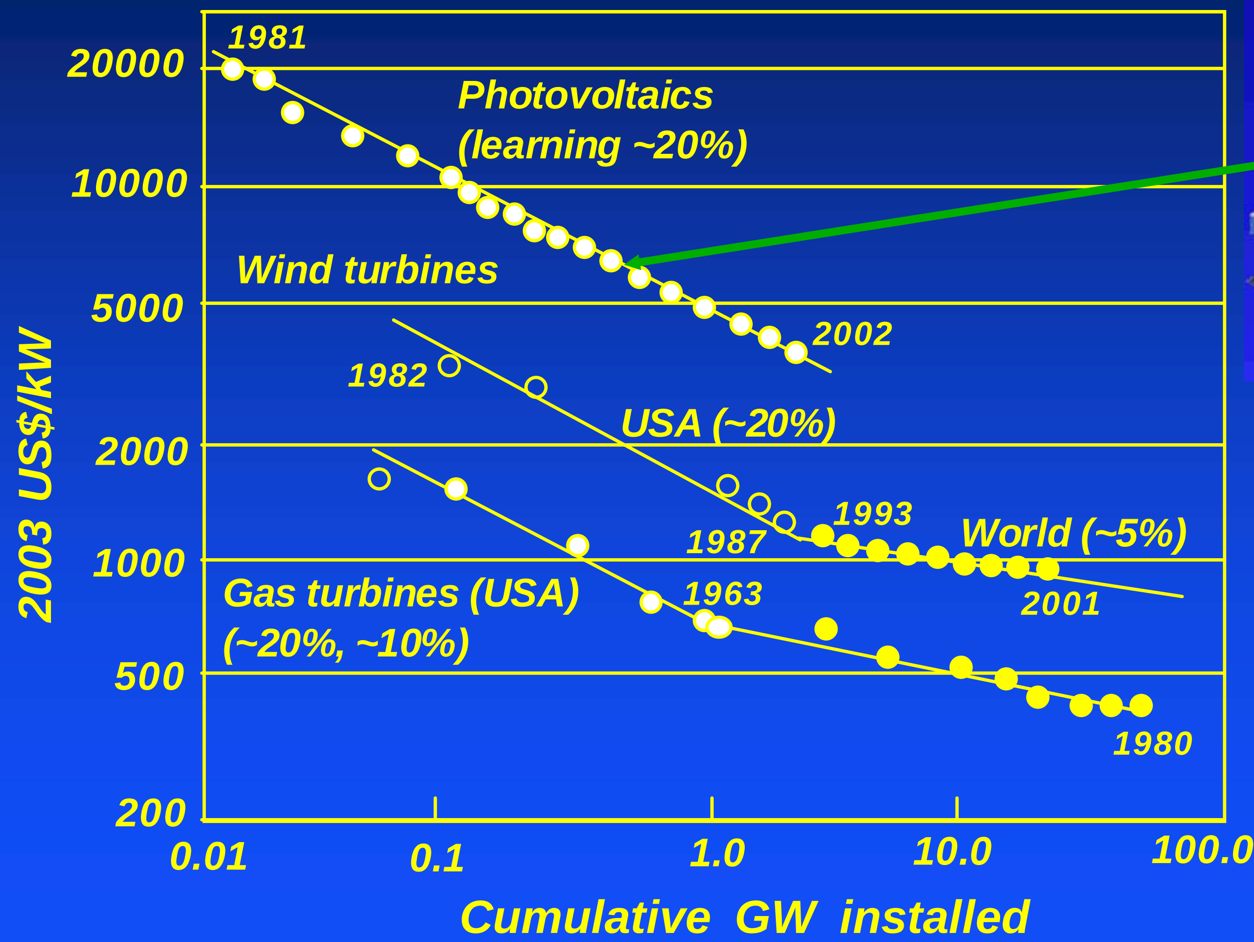
- highest efficiency
- tricky to deposit
- Cd toxic, In scarce



Other Advanced Thin-Films:
Dye-sensitised; Organic



Cost reduction



Adapted from
Grübler et al.,1999

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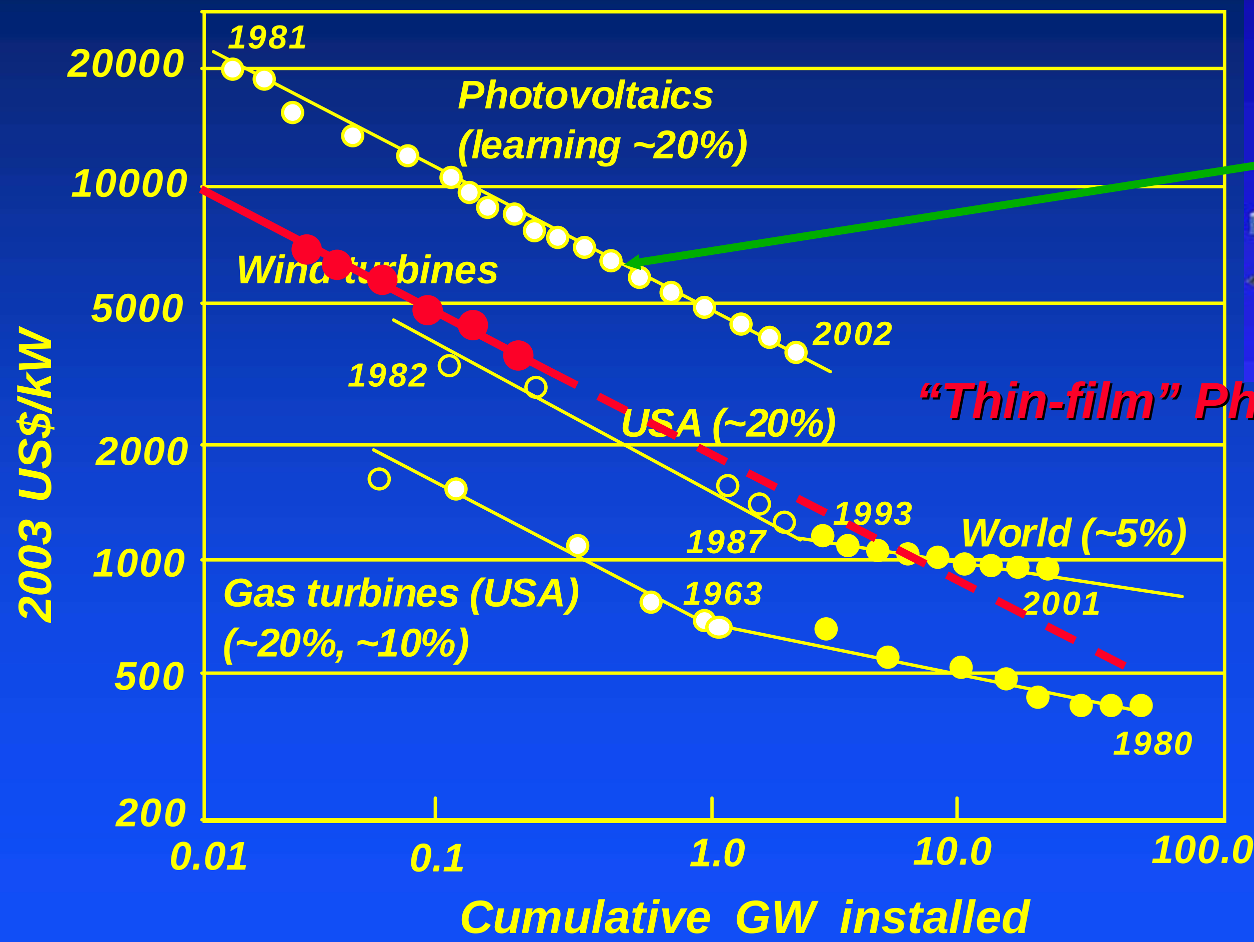
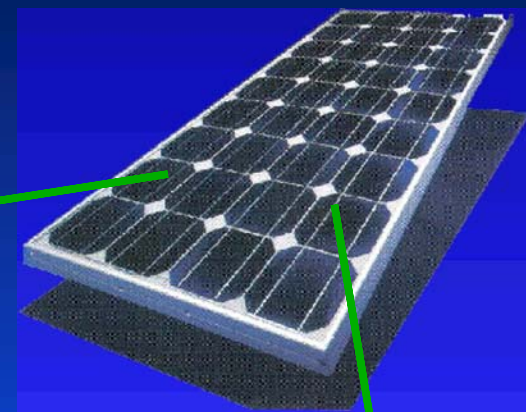
Cost reduction

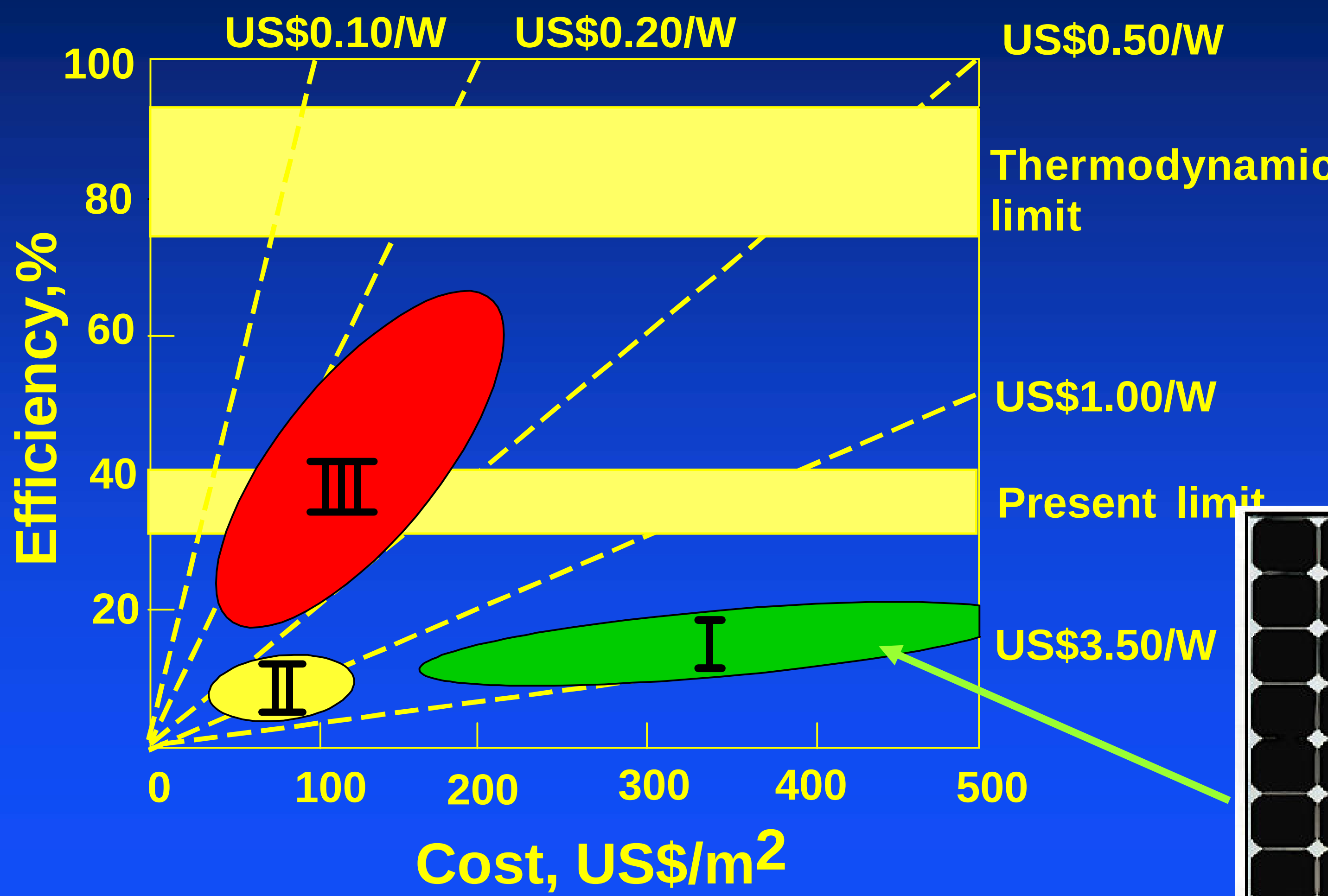




“Thin-film” Photovoltaics

Adapted from Grübler et al.,1999

The 3 generations



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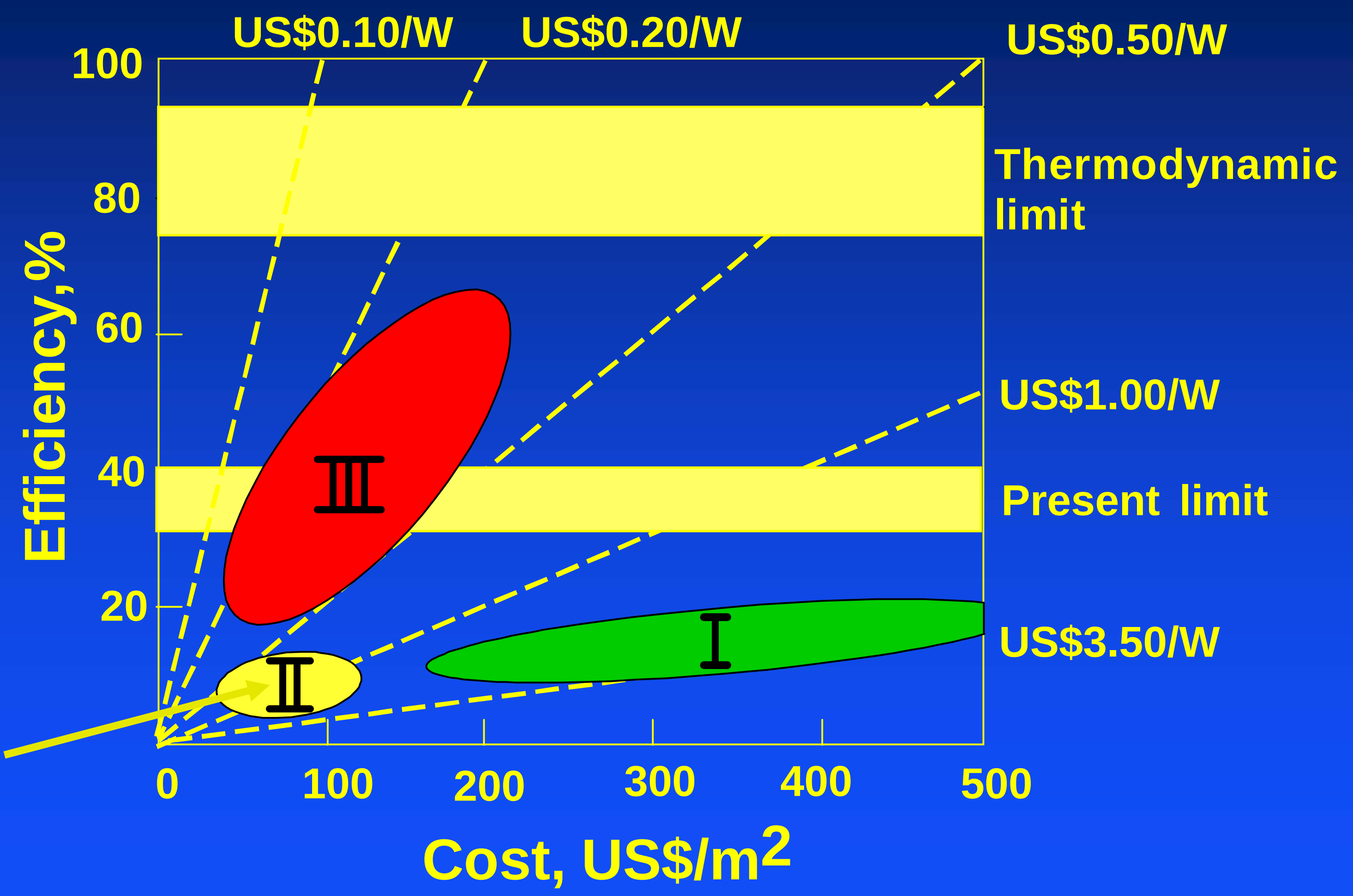
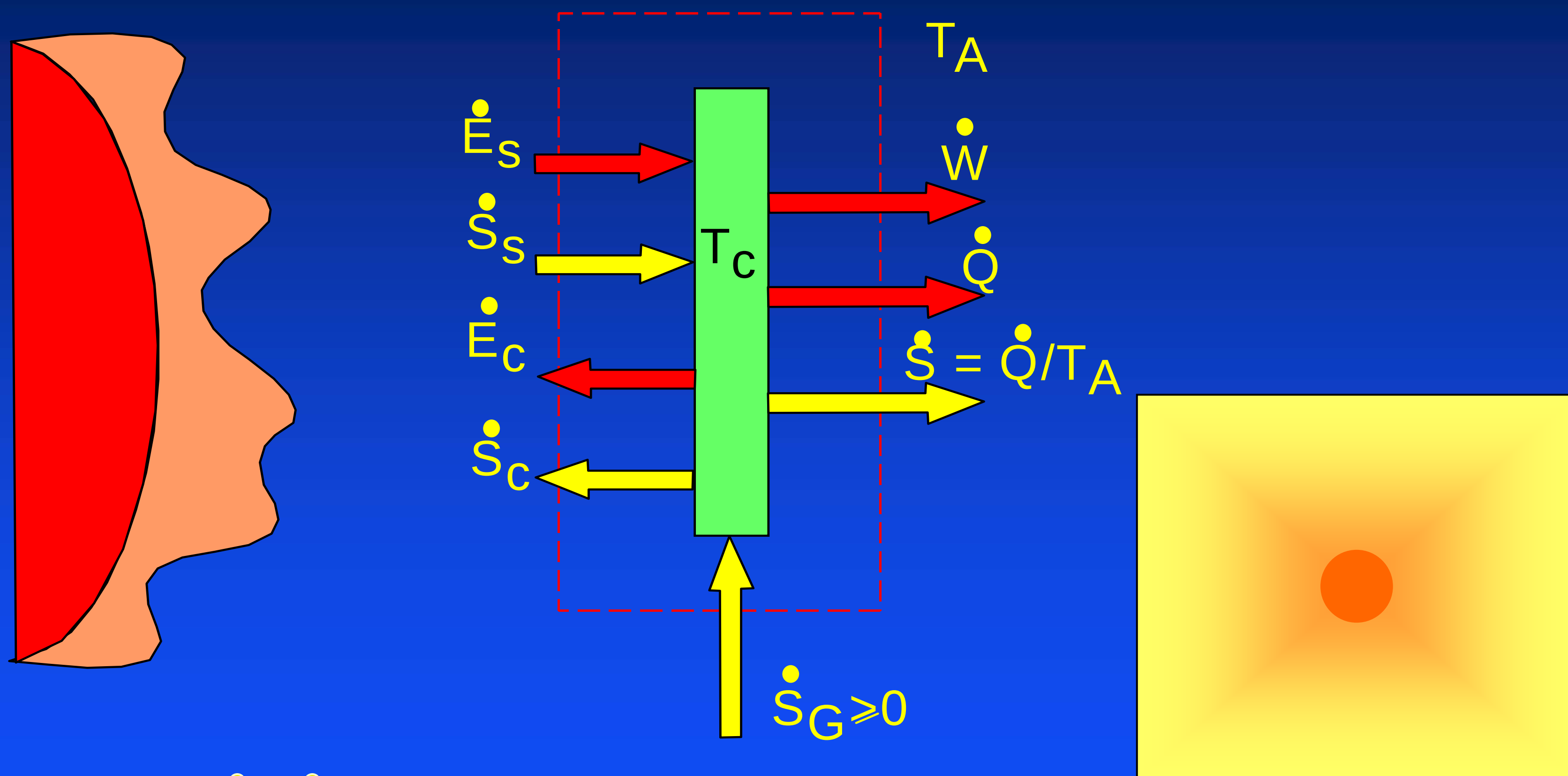
The 3 generations



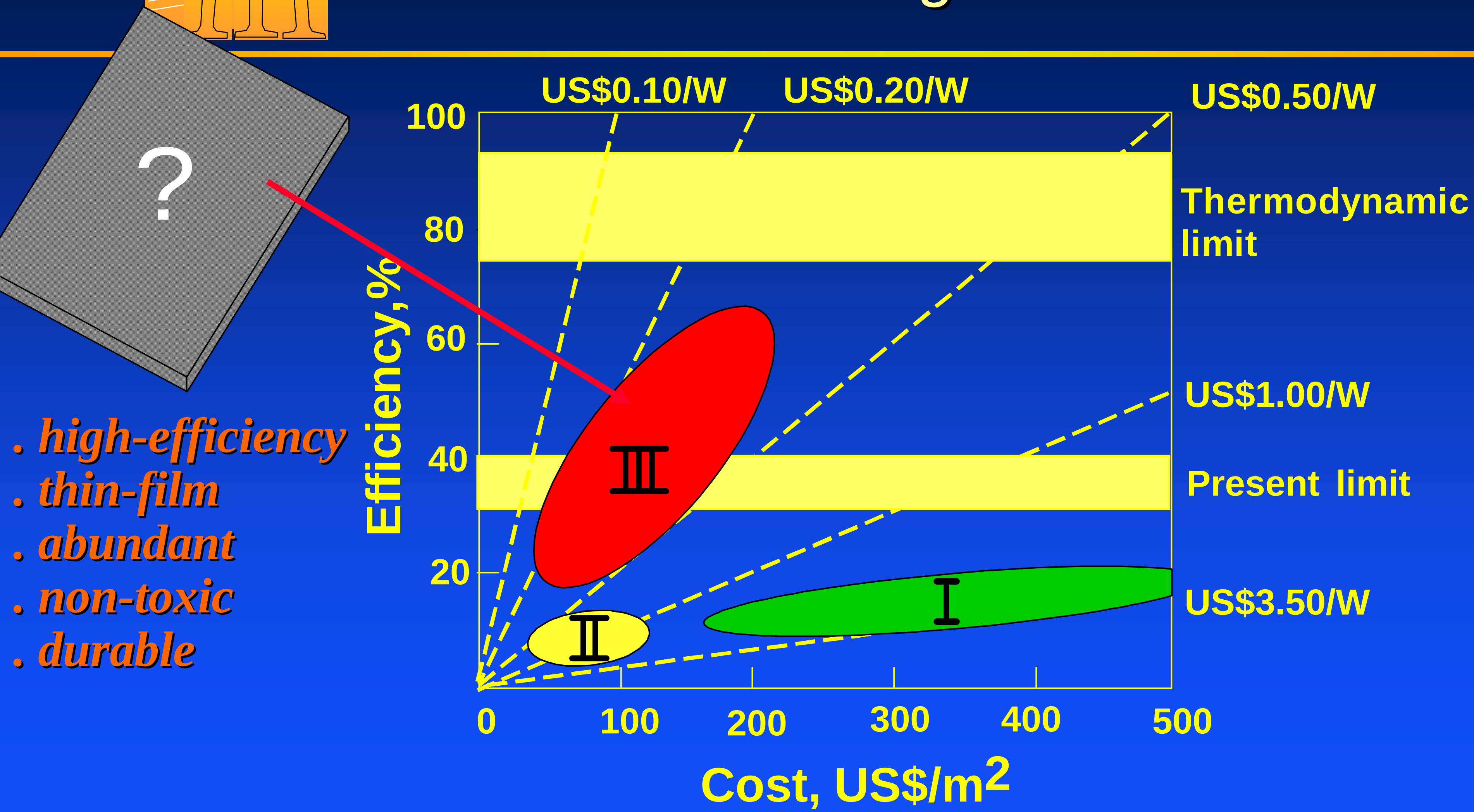
Includes dye, organic

Thermodynamic efficiency limits



$\eta \leq (1 - T_A\dot{S}_s/\dot{E}_s) =$ *93.3% (direct) = 73.7% (global)*

The 3 generations



. high-efficiency
. thin-film
. abundant
. non-toxic
. durable

UNSW approach

SUNTECH 尚德电力

bp

Evolutionary emphasis upon crystalline silicon

(robust, abundant, non-toxic)

UNSW approach

I

SUNTECH 尚德电力

bp

Evolutionary emphasis upon crystalline silicon

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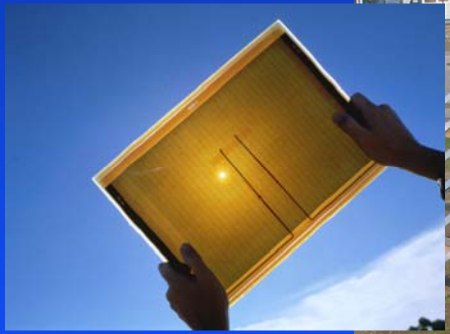

II

UNSW

UNSW approach

Evolutionary emphasis upon crystalline silicon

(robust, abundant, non-toxic)

I

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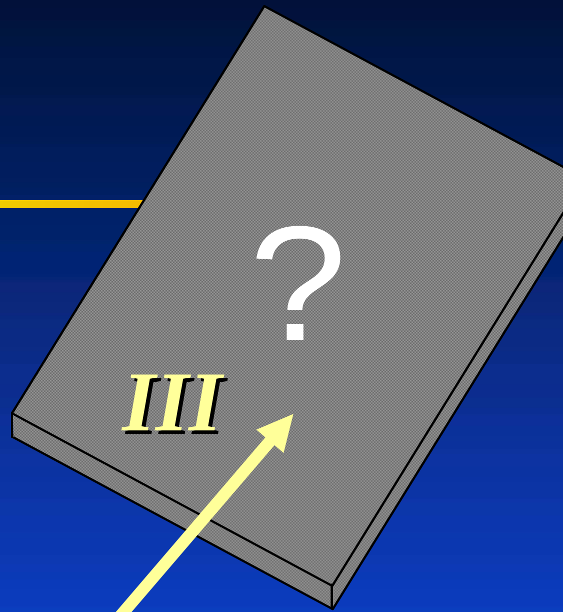
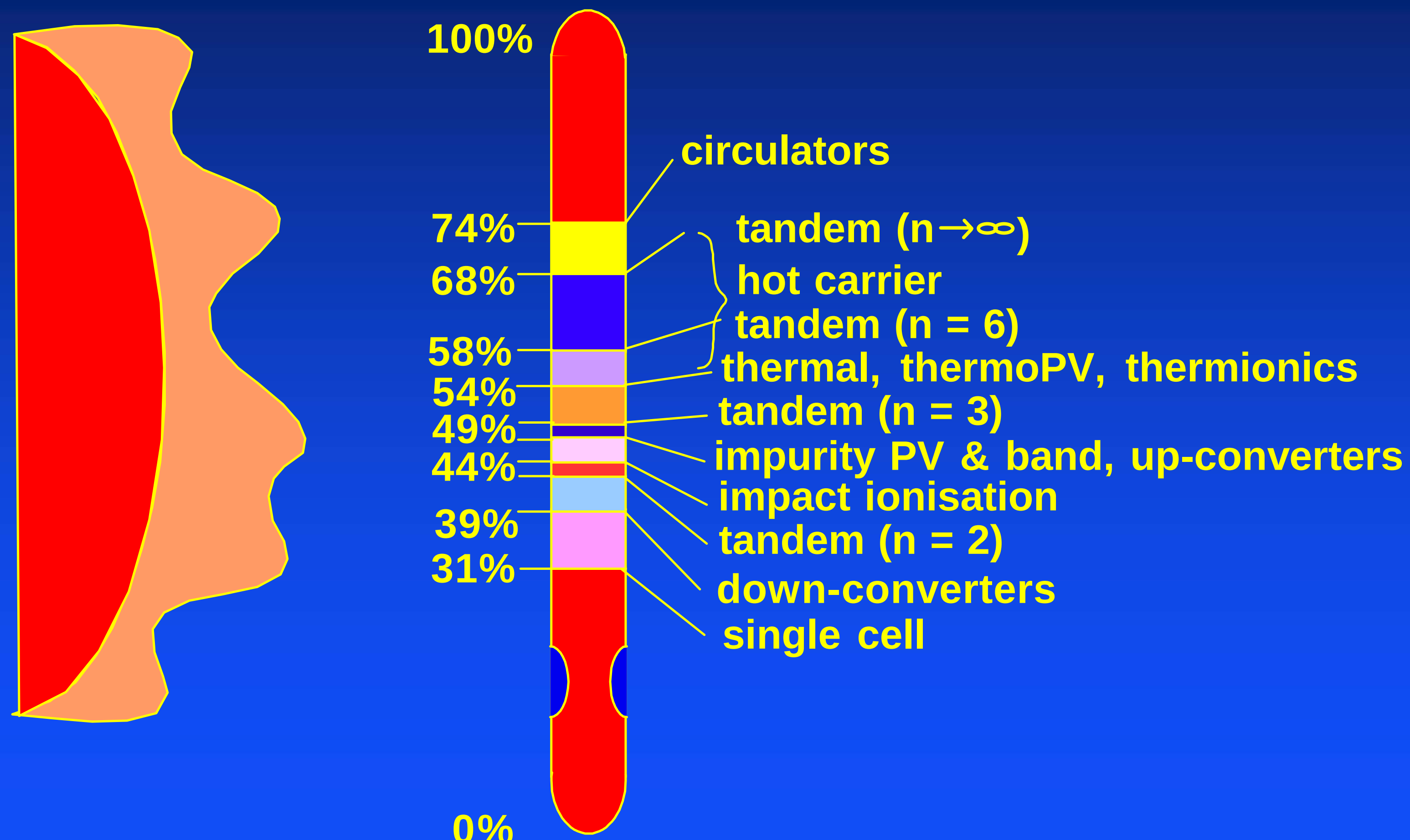
bp

II

csgsolar taking the next step



Third generation options



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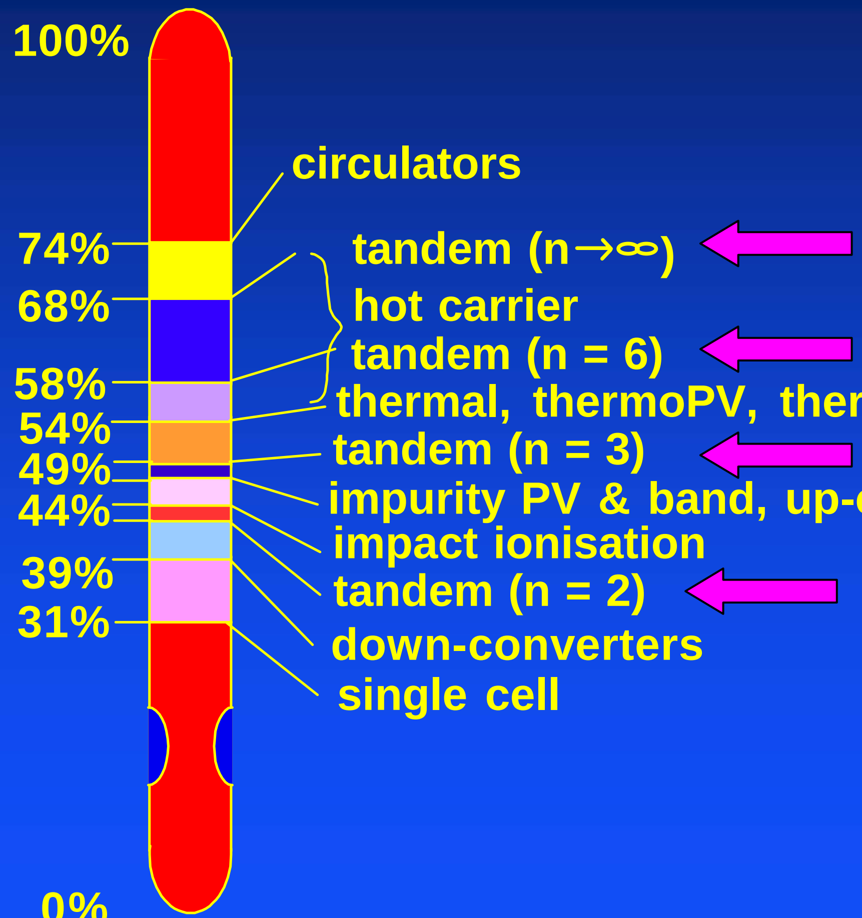
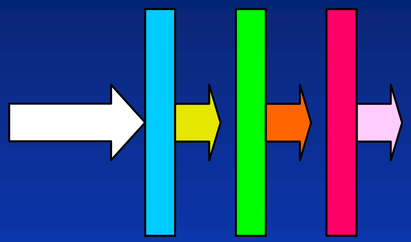
Third generation options





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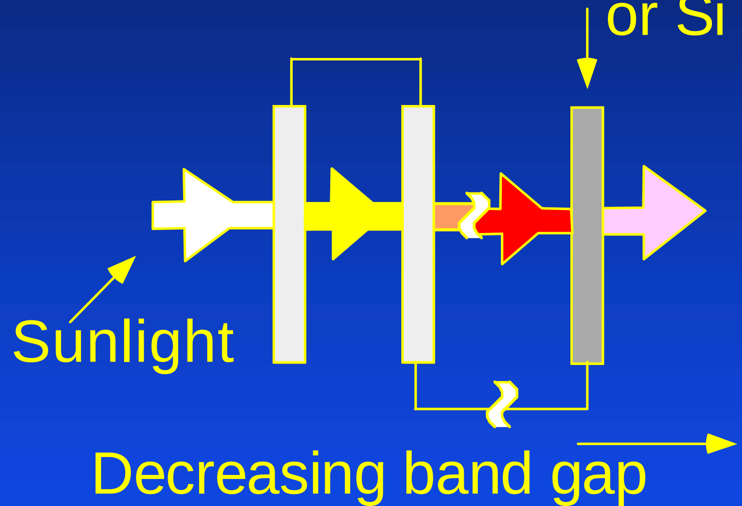
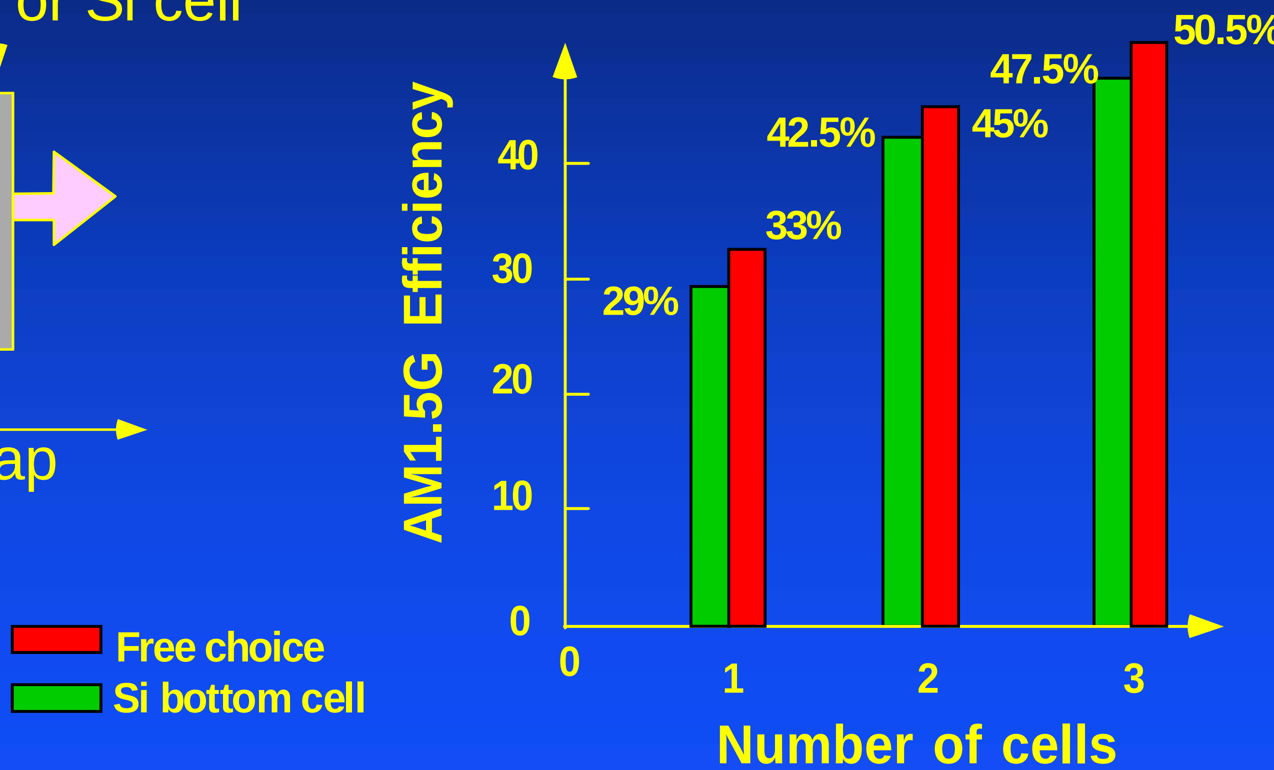
Si-based tandems



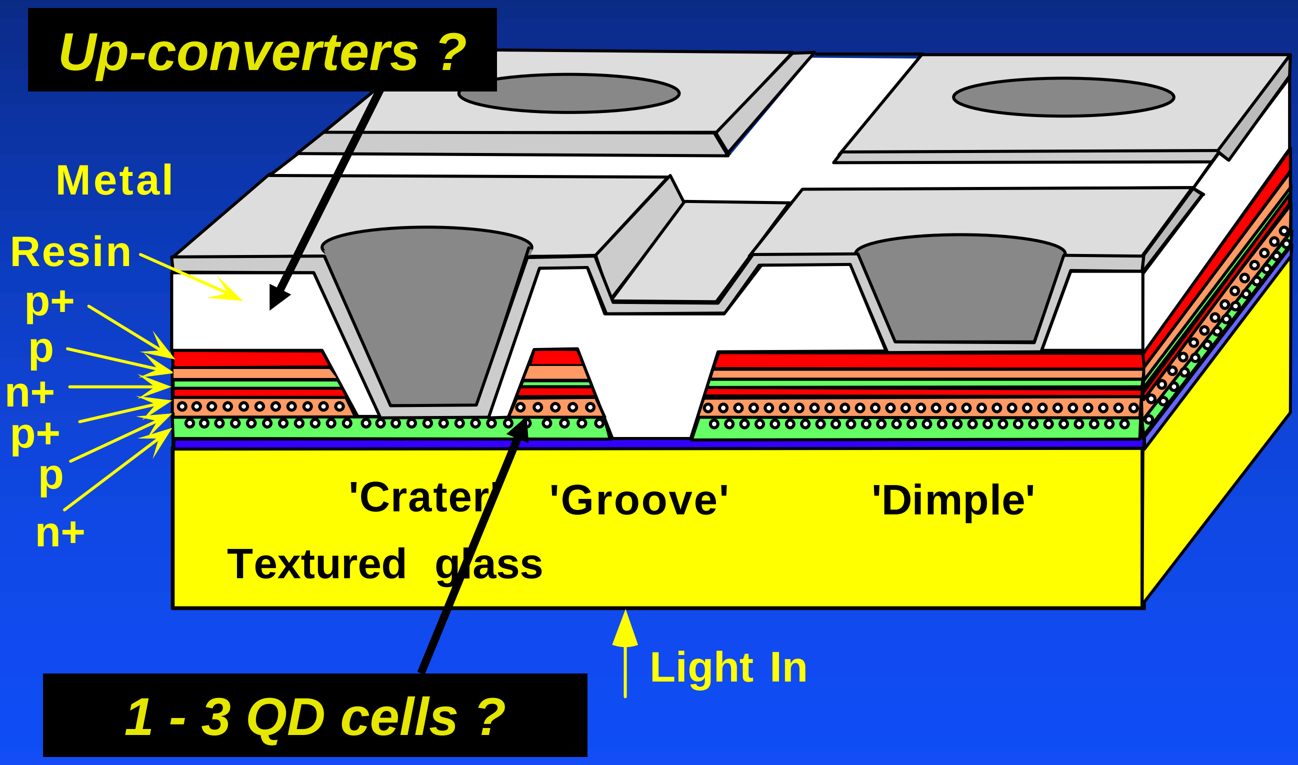


Intrinsic radiative and Auger losses included

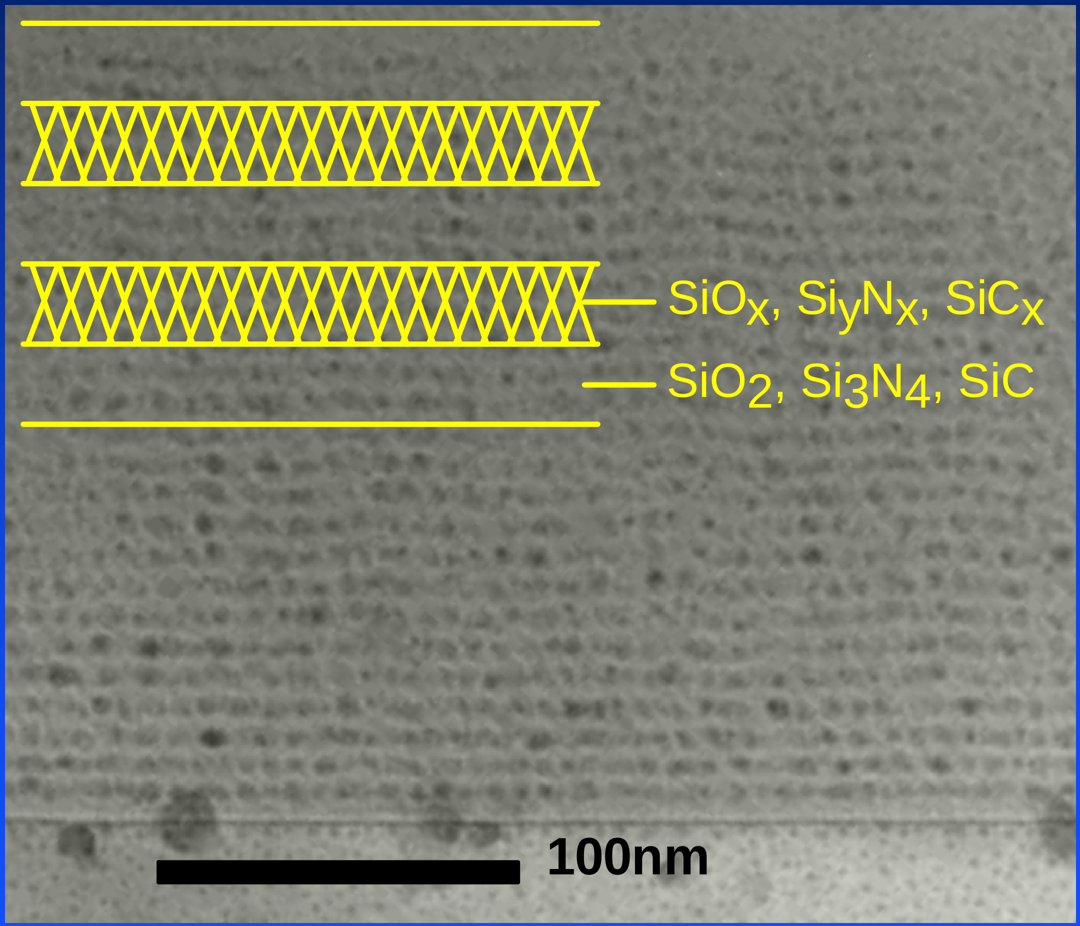
Si-tandem concept

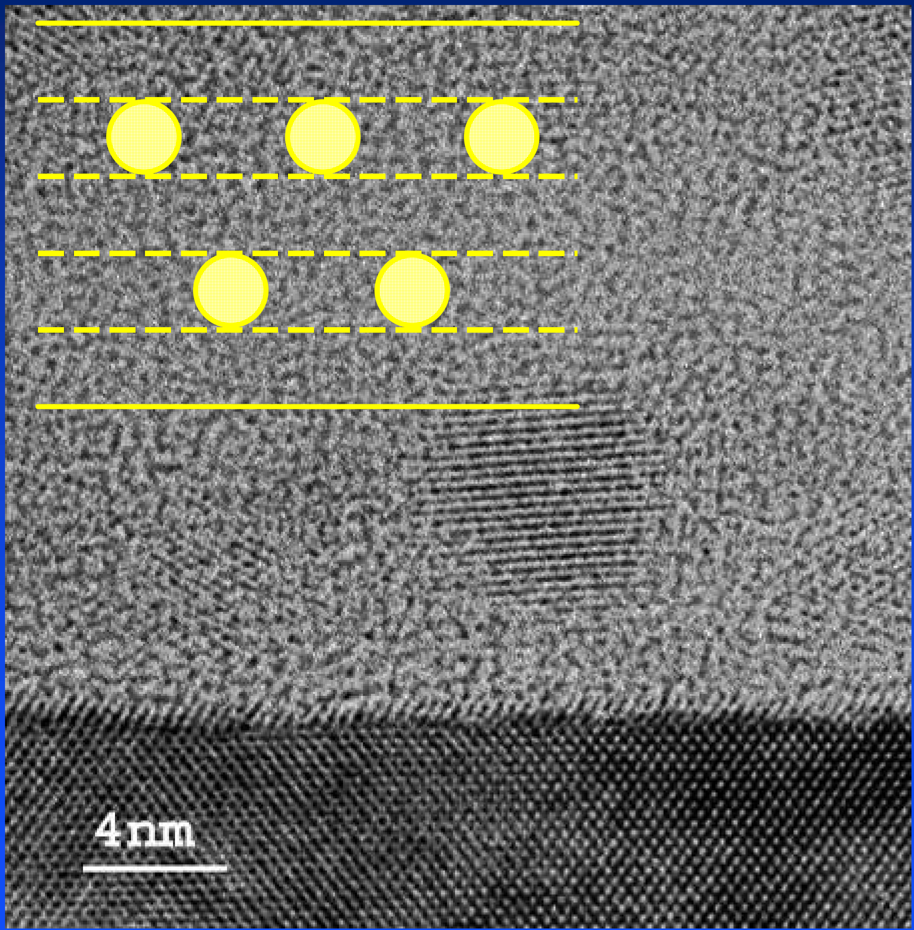
CSG Solar approach

- . high-T silicon
- . high-density contacts
- . good optics
- . deposit then process
- . also suits hot-carrier



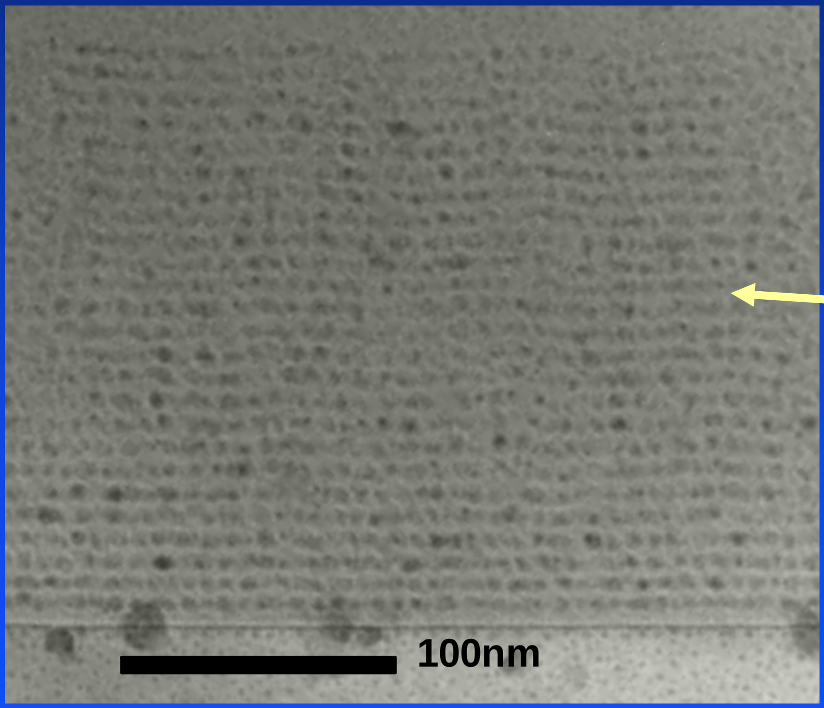
Fabrication of Si quantum dots

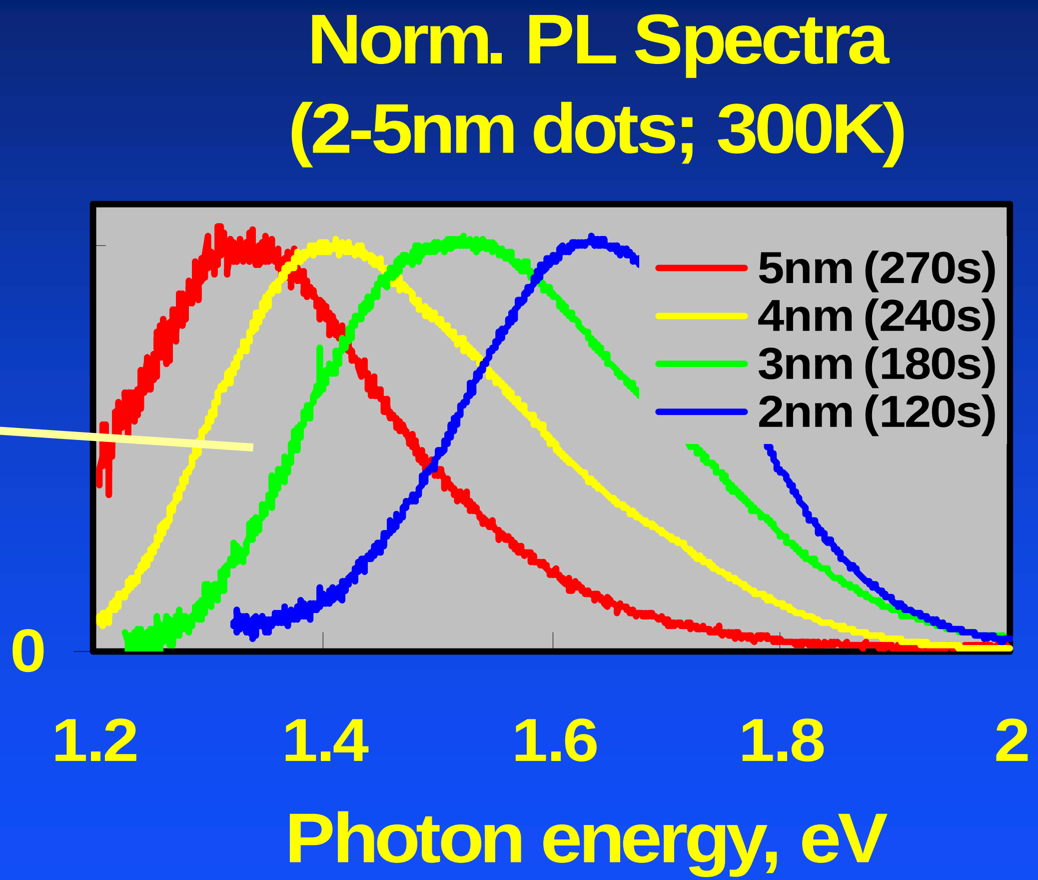




Zacharias et al., APL 80, 661, 2002

Si quantum dot photoluminescence





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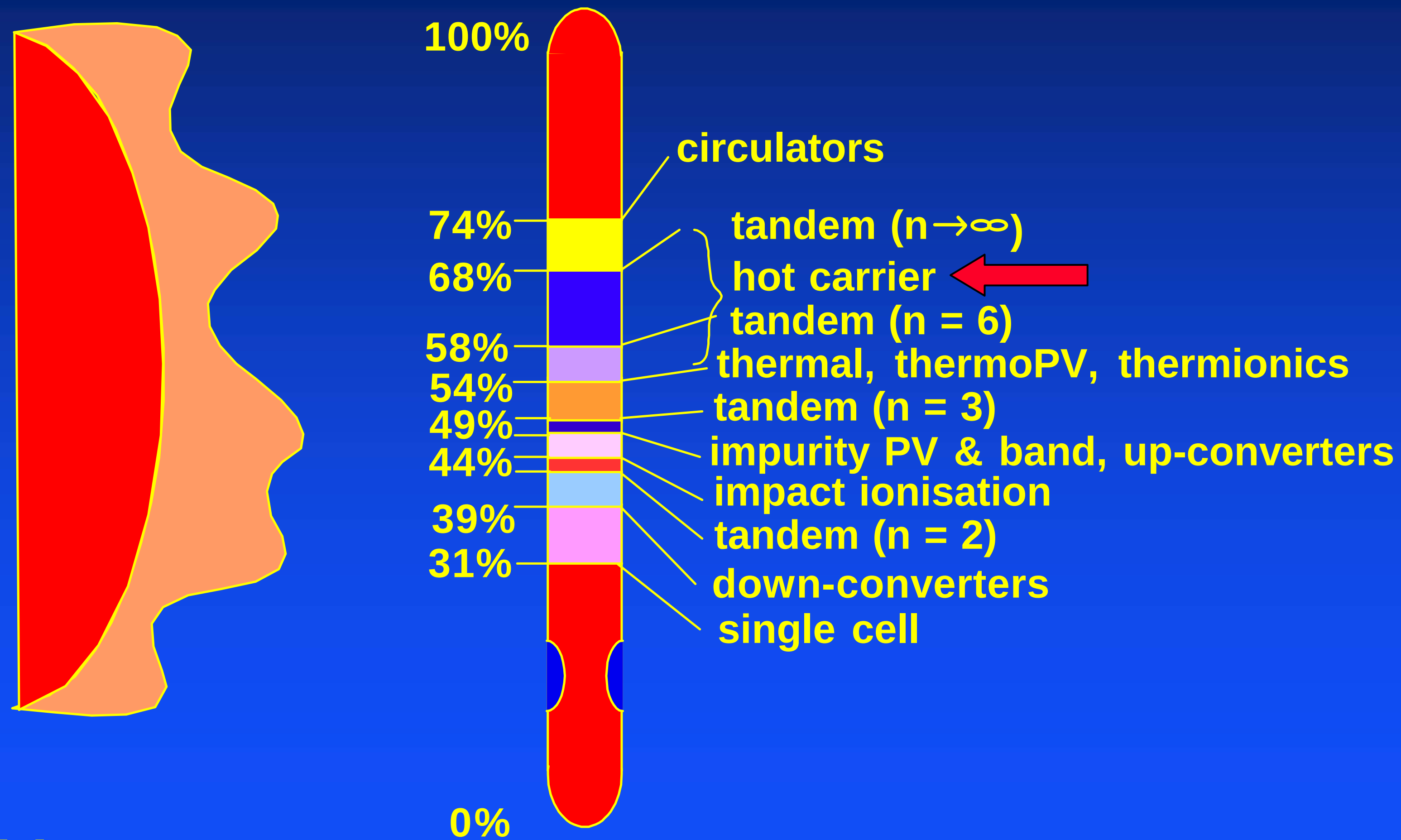

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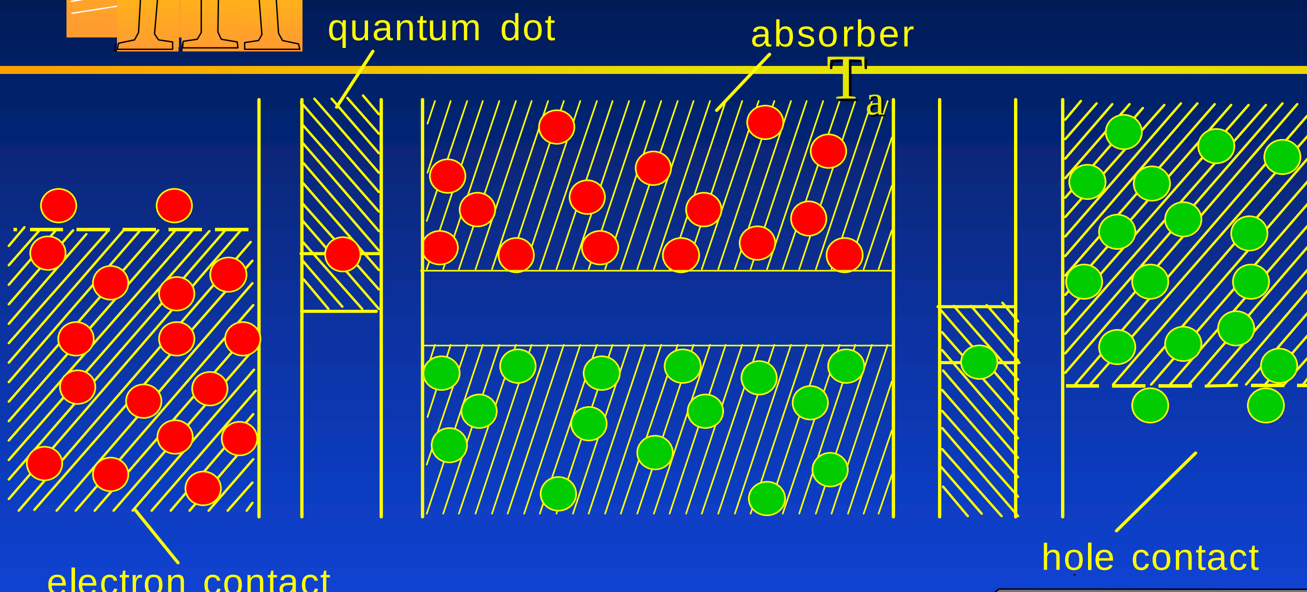
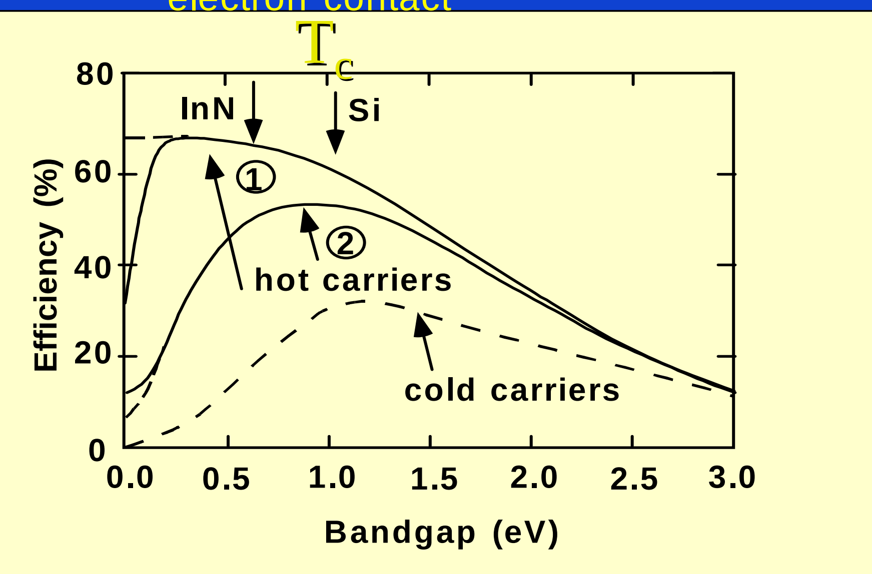
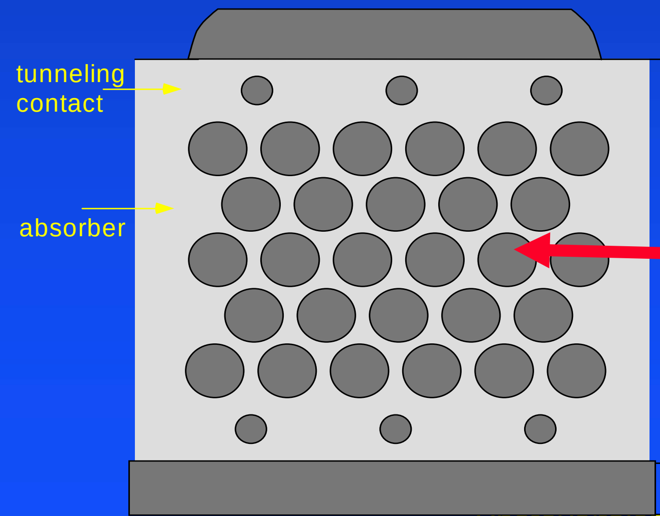
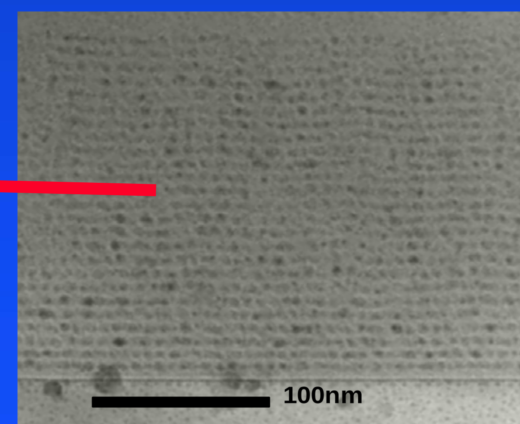
Hot-carrier cell concept



Efficiency > 4 cell tandem







Summary

- *need to fix carbon problem at source*
  - *– provide clean, more cost-effective electricity options*
- *photovoltaics provides a solution provided*
  - *– volumes increased and costs reduced dramatically*
- *high energy conversion efficiency is the key to lowest possible long-term costs*
- *high efficiency thin-film technologies described for post-2020 era*