International Seminar on Renewable Energy and Sustainable Development
Royal University of Bhutan, Thimphu, Bhutan
15-17th June, 2015 Bhutan

Prospects for high efficiency Intermediate Band Solar Cells using dilute nitride III-V semiconductors

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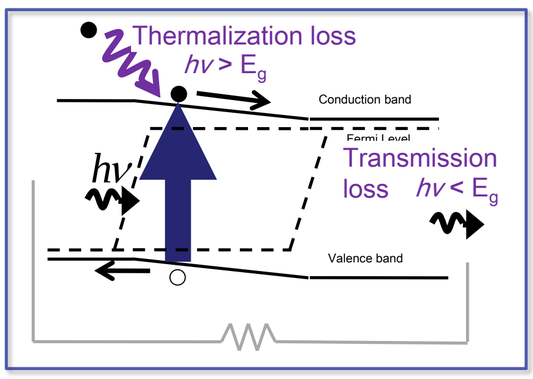
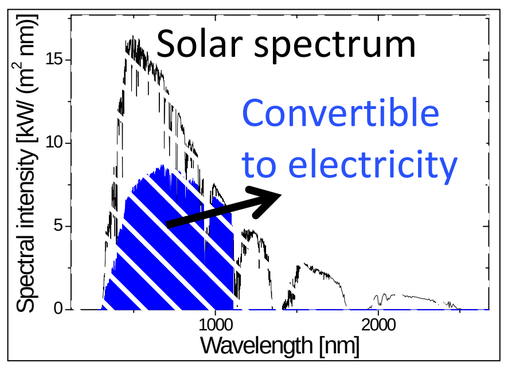
1. Introduction

Fundamental conversion losses

Sun light → *Electricity*

Maximum theoretical efficiency:
30% (one sun) → **Shockley-Queisser Limit**

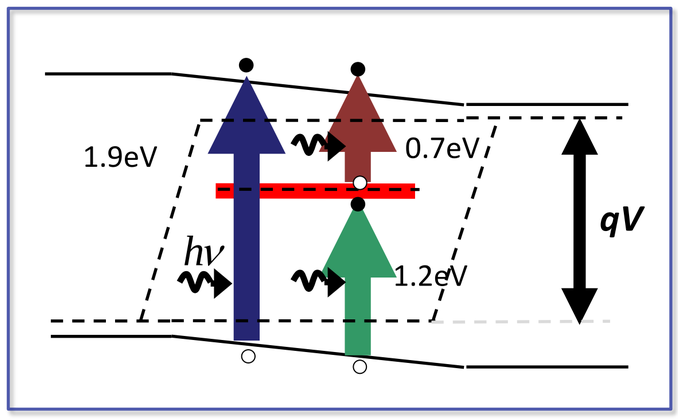


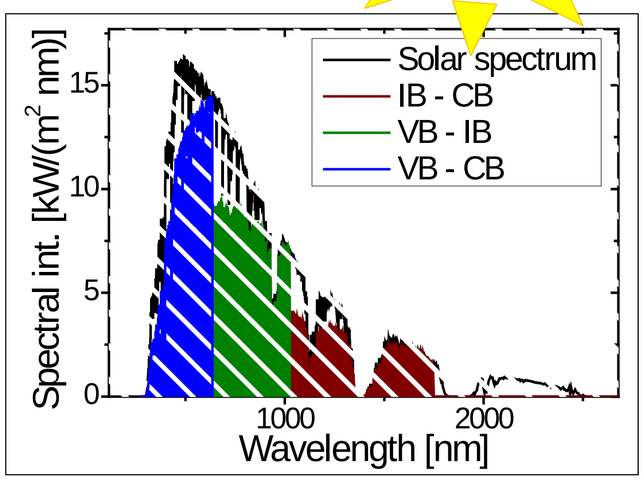


Intermediate Band Solar Cell

Additional photocurrent by **two-step photon absorption** while maintaining high open-circuit voltage of host material

Maximum theoretical efficiency [1]:
47% (one sun), 60% (concentration)



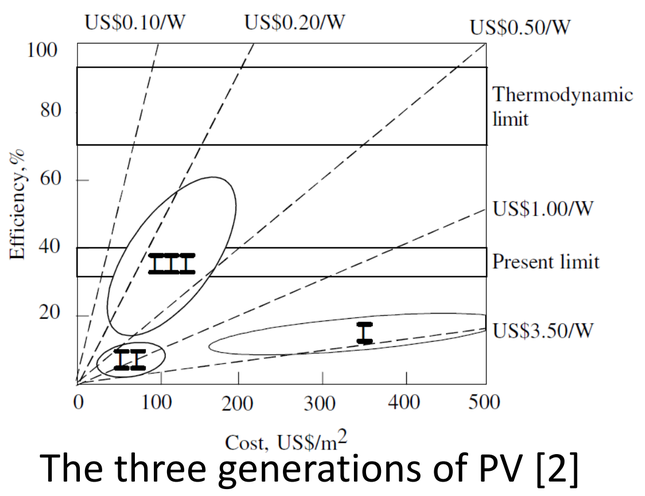


2. Promise of Third Generation PV

Goal: Reducing **Levelized Cost of Electricity**

Higher conversion efficiencies → more generted electricity per area

Sun light concentration ?
Not feasable in locations with lot of diffuse sunlight

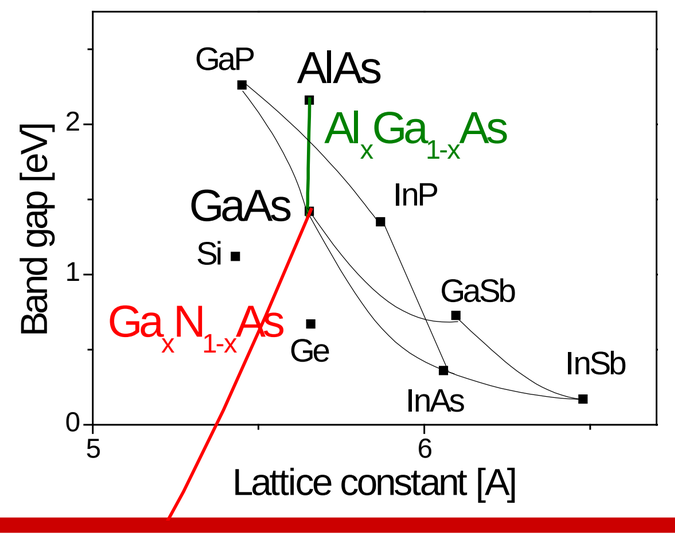


The three generations of PV [2]

3. Dilute-N GaAs - A unique material

Extremely large bowing factor: 17 – 18 eV

- Small amount of N lower the band gap energy of GaAs drastically
- Only small change in lattice constant allows the epitaxial growth on GaAs



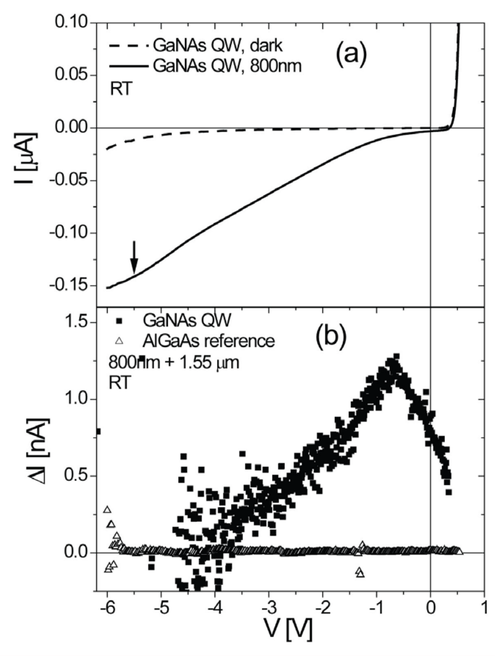
4. Achievements in IBSC research

Two-step photocurrent generation

Exciting carriers from valance band to conduction band in **a two-step absorption process via intermediate energy states** of the GaNAs quantum structure

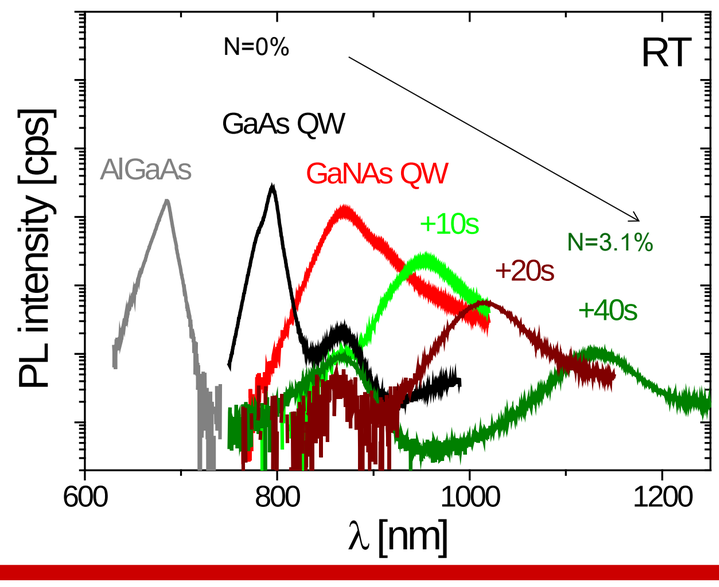
Clear two-step photocurrent generation realized in GaNAs QW embedded solar cell [3]

Localized states by N allow intra-band absorption

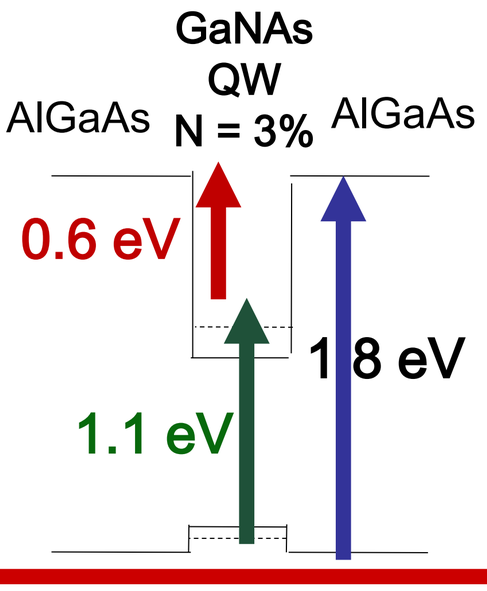


Close-to-ideal transition energies

Photoluminescence emission largely red-shift with N concentration →
Deeply confined QW structure achieved



Transition energies close to ideal match to solar spectrum



5.Conclusion

The Intermediate Band Solar Cell concept has been propose to overcome present efficiency limitations. Using the unique properties of dilute-N GaAs we have demonstrated some of the key processes of two-step photo-current generation, and close-to-ideal transition energies. Despite significant progress, the IBSC concept remains a fundamental research topic at present. Its future contribution to sustainability requires significantly simpler and cheaper fabrication techniques.

References

[1] A. Luque and A. Marti, PRL 78 (1997) 5014.
[2] M.A. Green, Third Generation Photovoltaics.
[3] M. Elborg et al., JJAP 51 (2012) 06FF15.

We gratefully acknowledge financial support from JSPS, Kakenhi Grant No. 26790007.