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III-V multi-junction solar cells on Silicon

Motivation

- Global Energy Crisis
- Single Cell Si solar cells dominate photovoltaics
- The ability to obtain high performance multi-junction III-V solar cells on Si substrates is of great interest for photovoltaics (PV)

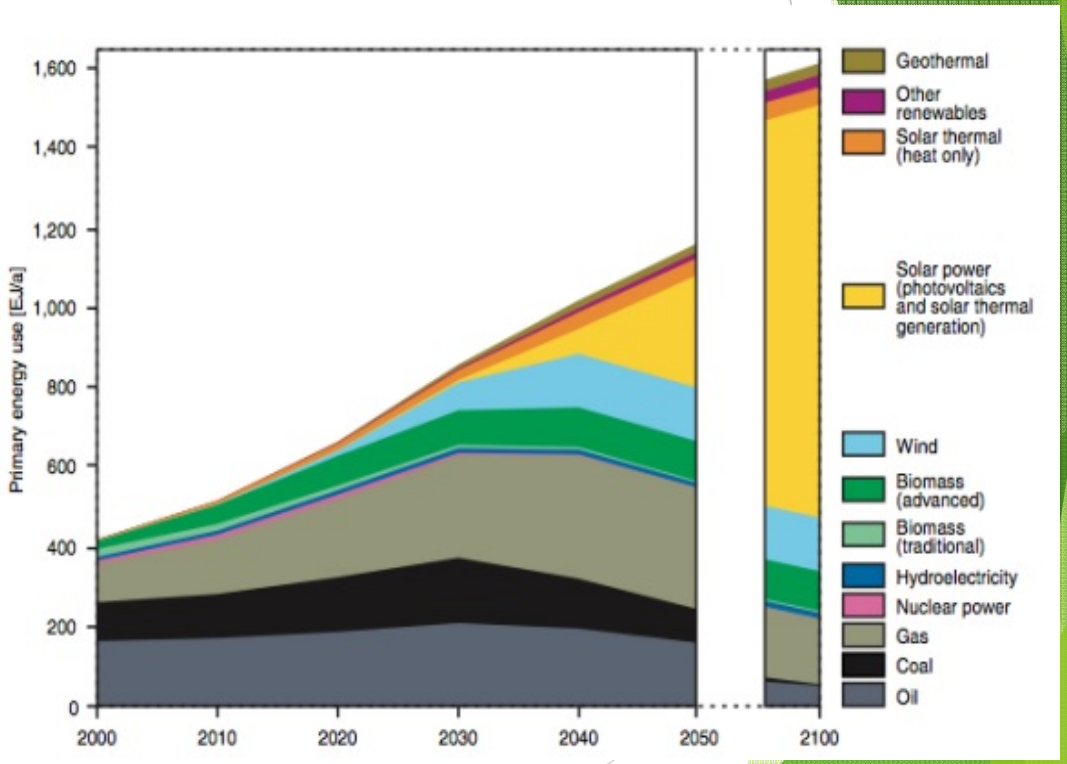

Figure 1. Global Energy Sources [1]

Why III-V on Si

- III–V materials families
- Si
- Very attractive pair [2]

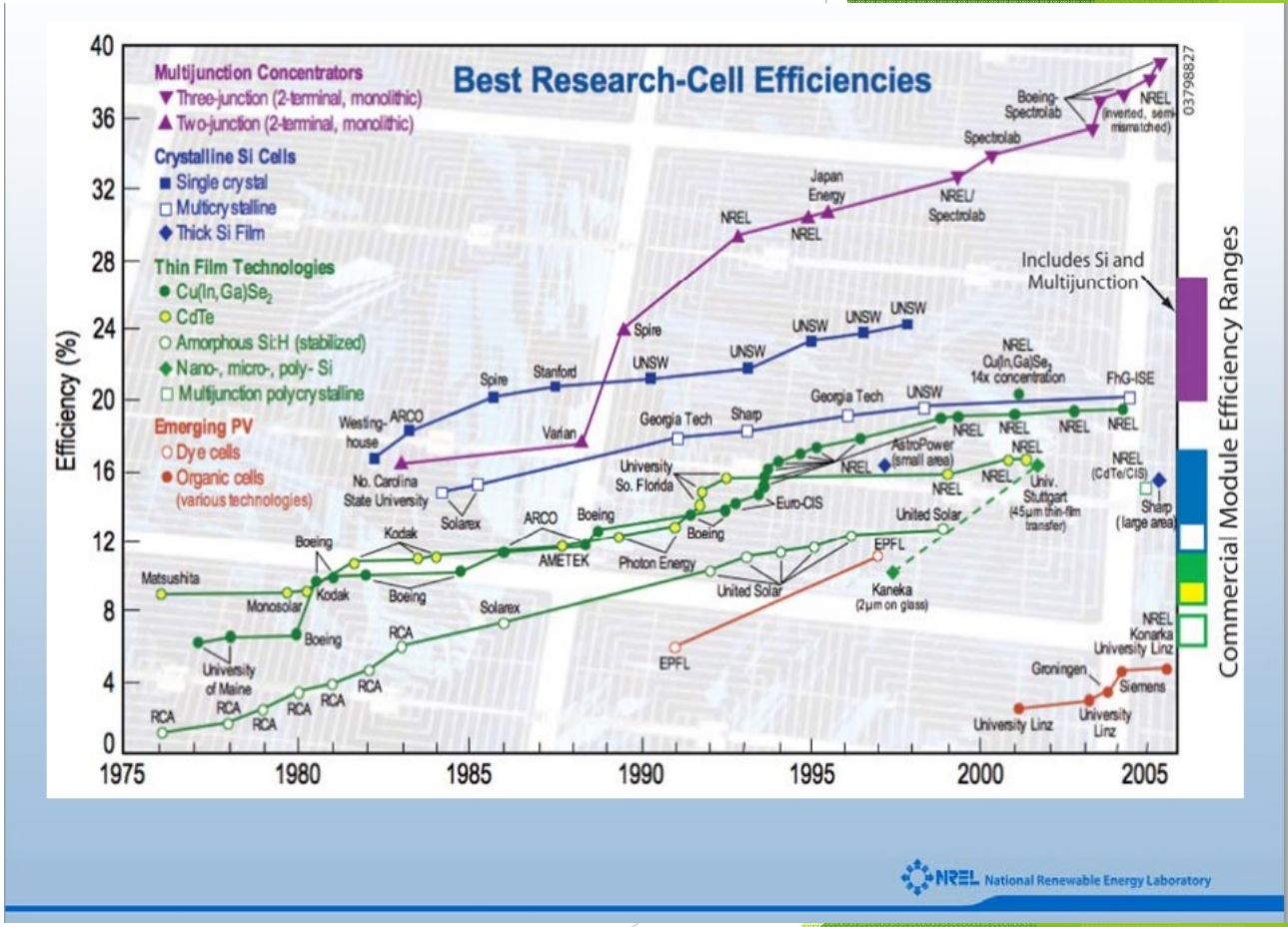

Figure 2. Solar Cell Efficiencies [3]

Designing a multi-junction solar cell

- III–V multi-junction solar cell begins with taking a raw wafer and forming individual layers of crystalline semiconductor on the substrate [1]
- Multiple forms of epitaxial techniques
- Most successful III-V growth on Si comes from a technique called epitaxial lateral overgrowth (ELO) of lattice mismatched polar semiconductors on Si via growth of nano-seeds in apertures opened in thin SiO 2 layers [1]

Design process continued…

- High efficiency multi-junction solar cells require true epitaxial growth [2]
- In designing multi-junction solar cells, two or more semiconducting layers are stacked as p–n junctions to collect light [2]
- A typical 3-junction solar cell structure comprises three n–p junctions stacked on top of each other—each layer with a band gap energy higher than the layer below it—and assembled with low resistive tunnel junctions [2]

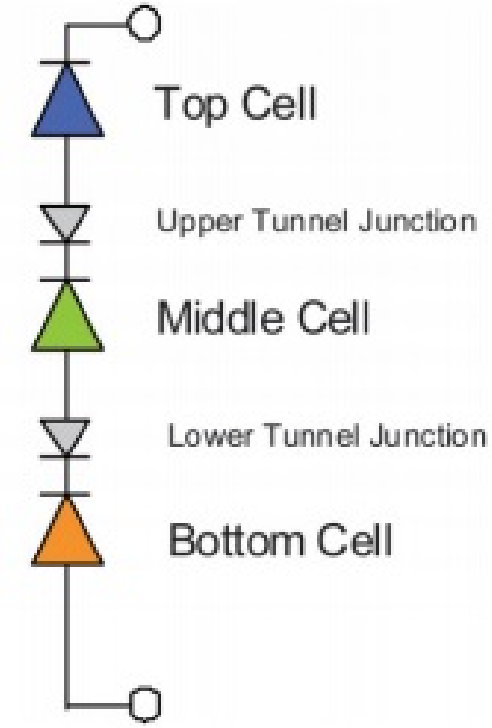

Figure 3. Electrical Model [3]

Challenges of Integration

- The polar on non-polar epitaxy, the thermal mismatch and the lattice-mismatch makes the growth of GaAs on Si very challenging [2]
- Dislocations generated due to mismatch between GaAs and Si can propagate into the photoactive cell region and significantly impede the minority carrier lifetime and hence the overall cell performance [2]
- Impact of threading dislocation density (TDD) [2]

Realization Criteria

- Two very important parameters in determining the efficiency of the a solar cell
- Minority Carrier Lifetime [4]
- Current matching [4]

Conclusion

- In summary I have discussed multi junction III-V solar cells on Si substrates
- While III-V tandem cells on Si are sensitive to dislocations, careful design and optimization of these solar cells on Si can enable a high theoretical energy conversion efficiency.

References

1. http://www.spectrolab.com/pv/support/Cotal_III_V_multijunction_photovoltaics.pdf
2. http://scholar.lib.vt.edu/theses/available/etd-05202013-153306/unrestricted/Jain_N_T_2013.pdf
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