FABRICATION OF SI QUANTUM-DOT SOLAR CELL AND ITS CURRENT-VOLTAGE CHARACTERISTICS

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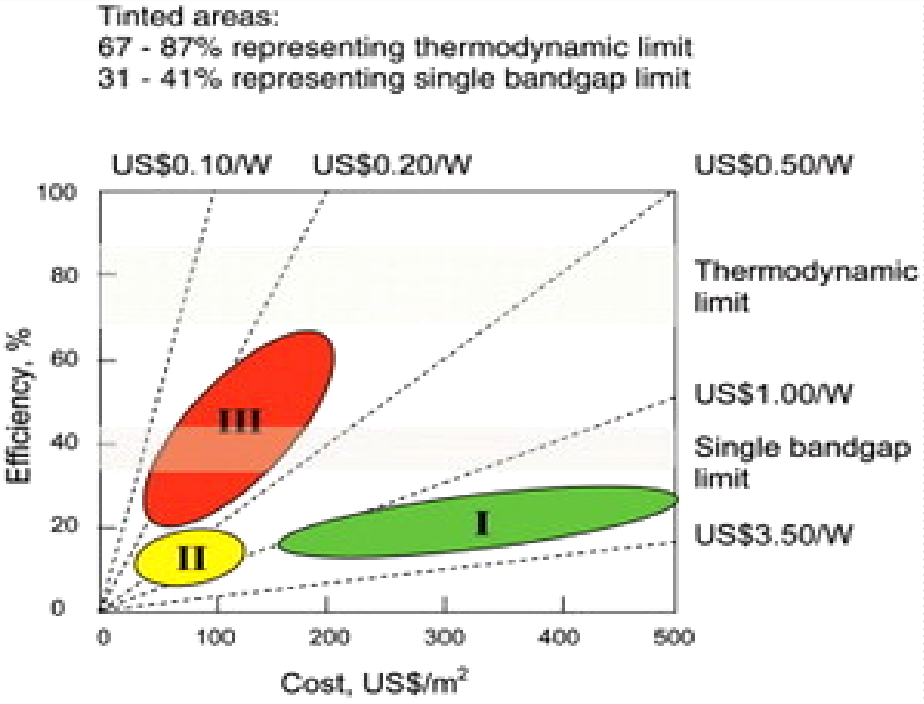
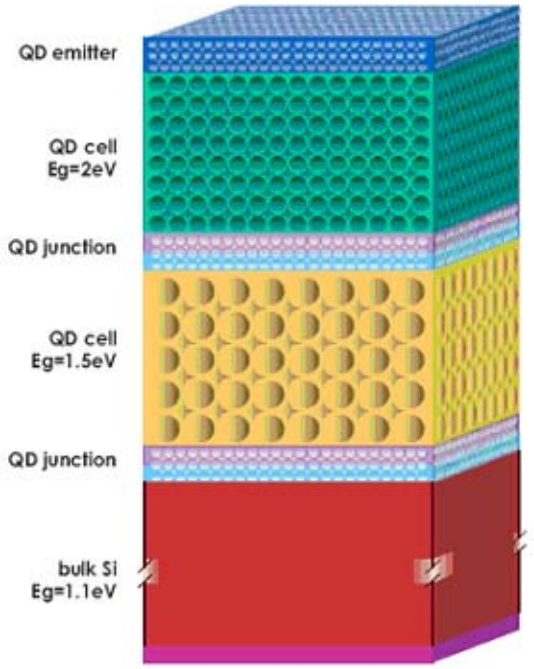
Introduction

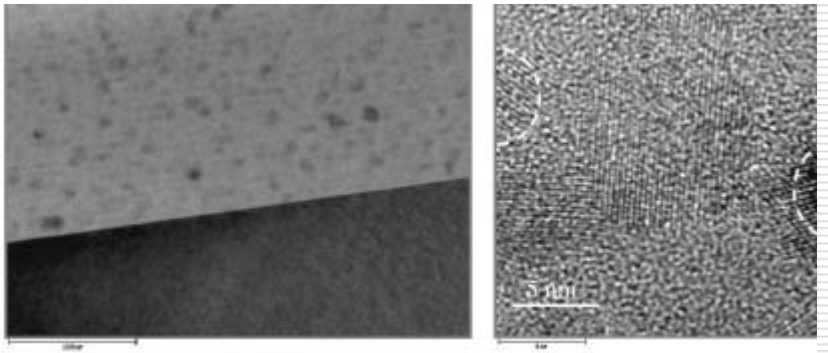
- All-Si tandem solar cell
  - Inexpensive Si thin-film technology in combination with high efficiency multi-bandgap approach.
  - Si QD superlattices are used as the higher bandgap cells in a tandem stack



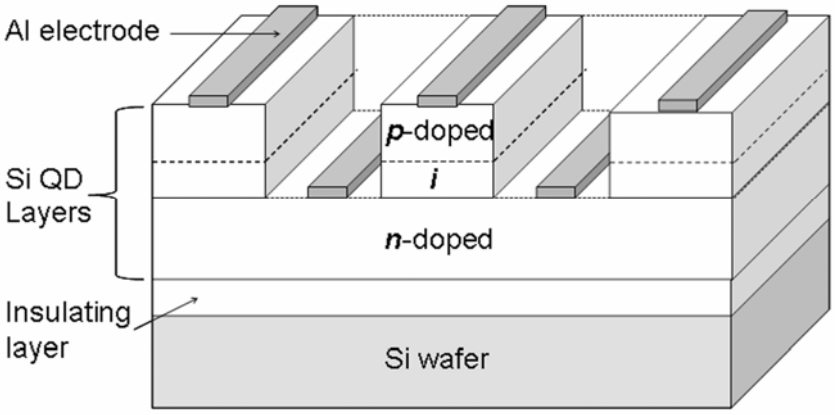


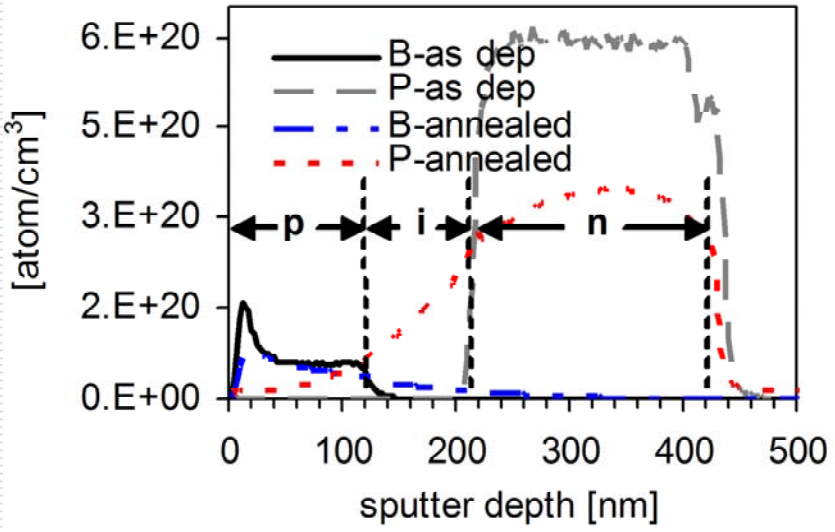
Device fabrications

- Si QD layers
  - SRO(4nm)/SiO_2(2nm)
  - High T annealing
- Interdigitated structure
  - Photolitho and RIE
  - Al electrodes

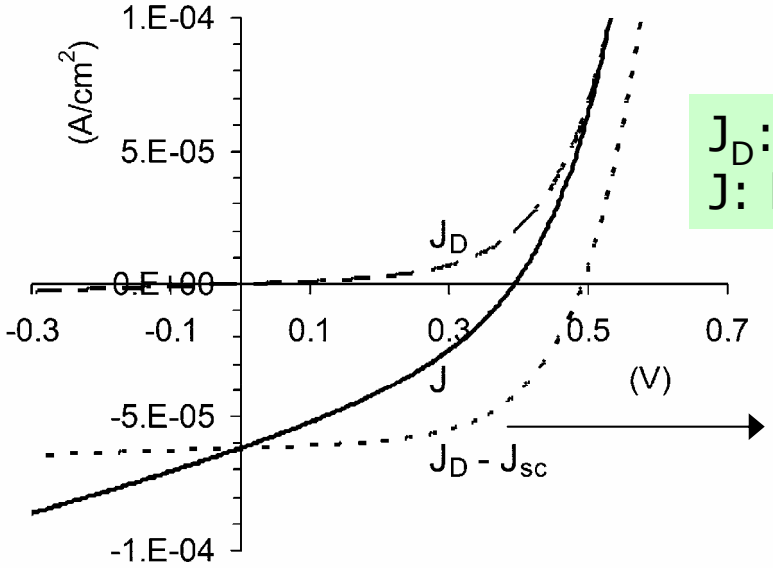


E.-C. Cho, et.al, Nanotechnology **19**, 245201 (2008).





Photovoltaic behaviors



J_D: dark IV
J: light IV (AM1.5G spectrum, 25°C)

superposition approximation ($J(V) = J_D(V) - Jsc$) does not hold

- PV characteristic properties of a prototype cell
  - Effective area : 4.7 mm^2
  - Voc = 394 mV, Jsc = 62 $\mu A/cm^2$
- Voltage–dependent photocurrent collection
  - Our Si QD layers in dielectric matrix have lots of defects
  - diffusion length would be very, very short

Current-Voltage characterization

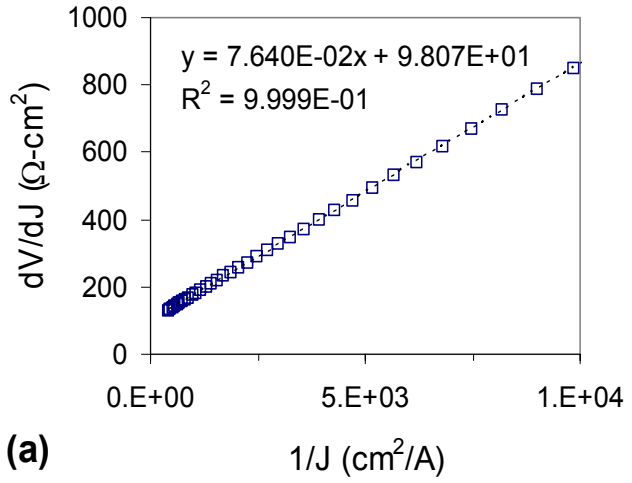
- Applying a diode model to dark IV data

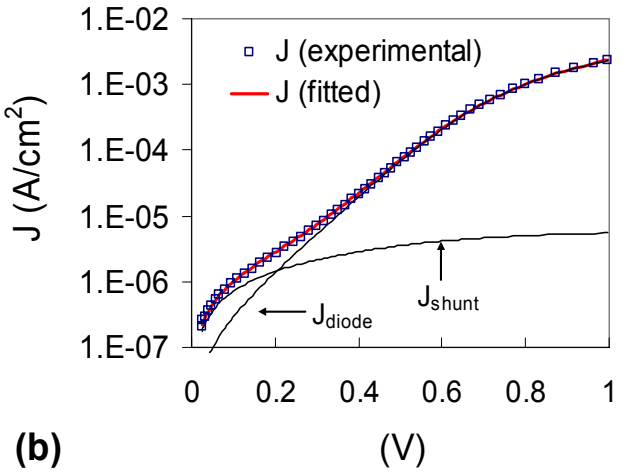
$$J_D(V) = J_0[\exp(q/nkT \times V_j) - 1] + V_j/R_{sh}$$

where, $V_j = V - J \times R_s$

  - Determination of parameters
    - n, J_0, R_s, R_{sh}

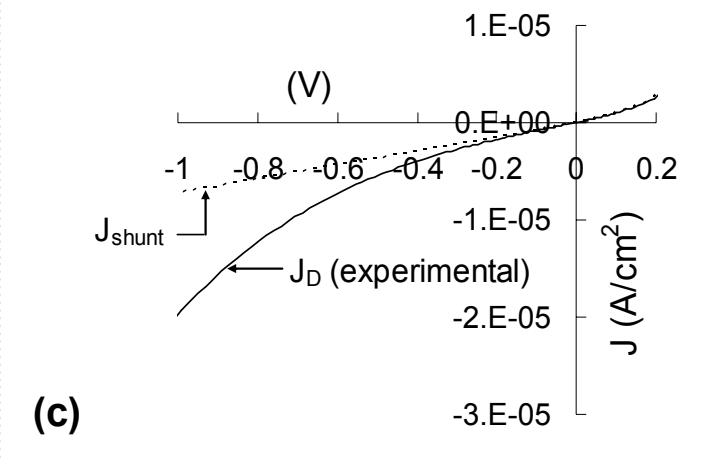
- Experimental and fitted dark I-V curves



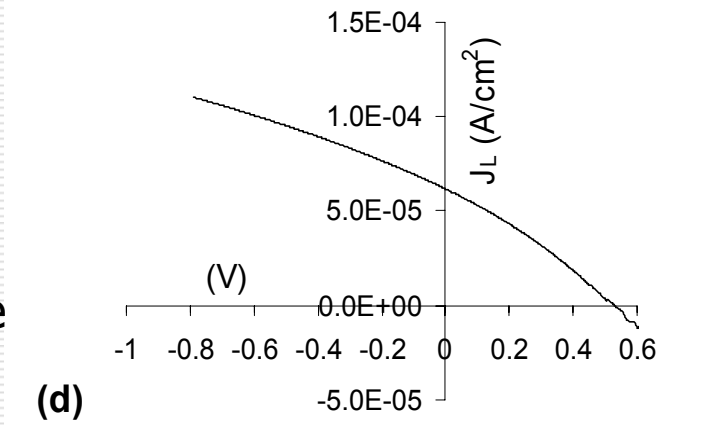


Current-Voltage characterization

- In reverse bias
  - This poor rectifying behaviour of Si QD pn-junction is due to the inter-diffusion of dopants



- Photocurrent $J_L(V)=J_D(V)-J(V)$
  - Tunneling probabilities of photogenerated carriers in QD increase with electric field
  - Conduction mechanism in QD materials is still complex issue



Concluding remarks

- A single junction Si QD solar cell was fabricated and its photovoltaic properties were examined.
- The prototype device is promising towards the realization of all-silicon tandem solar cells based on Si QD materials
- For practical usage as a top cell in tandem device,

  Voc should be increased above that of the standard cystalline Si solar cells (>700 mV) and the current be improved in orders of magnitude

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