

Nanostructured Silicon-Based Tandem Solar Cells

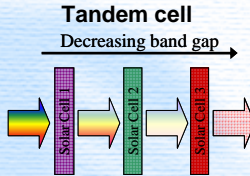
Martin Green, Gavin Conibeer, Eun-Chel Cho, Dirk König, Tom Puzzer, Shujuan Huang, Dengyuan Song, Young Cho, Ivan Perez-Wurfl, Thipwan Fangsuwannarak, Giuseppe Scardera, Edwin Pink, Yidan Huang, Chris Flynn, Xiaojing Hao, Thorsten Trupke, Sang Wook Park, Lara Treiber

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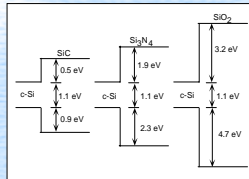
Concept

- To boost photovoltaic (PV) efficiencies
- Multiple energy level cell



- Thin film processes
- Abundant, non-toxic materials

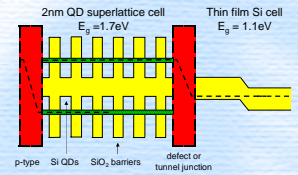
Engineer a wide band gap in a nanostructure



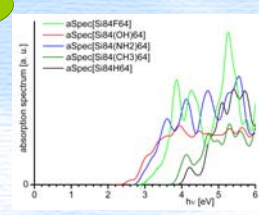
Tunneling probability:
Carbide > Nitride > Oxide

$$T_e = 16 \exp\left\{-d \sqrt{\frac{8m^*}{\hbar^2} \Delta E}\right\}$$

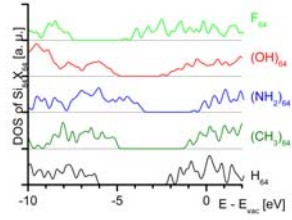
Si based tandem cell



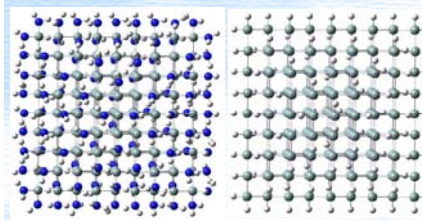
S



Absorption spectrum with different termination



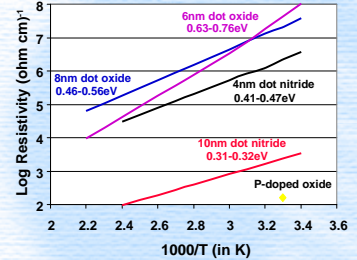
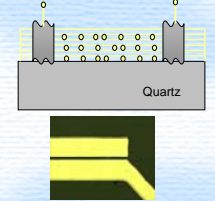
Density of State



Si165NH₂100

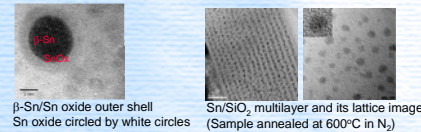
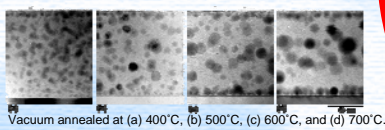
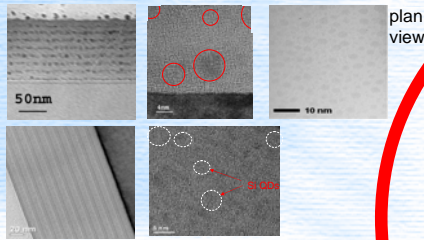
Si165H100

E



P

TEM x-sections of Si QDs: medium and high resolution.

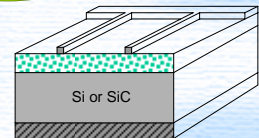


Current status of investigations

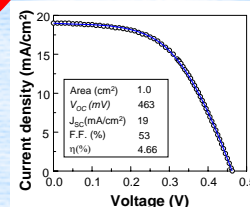
	SiO ₂	Si ₃ N ₄	SiC
Si	SPOED	SPOED	SPOED
Ge	S	-	-
Sn	SPO	P	-

- S = Simulation (Gaussian 03)
- P = Physical (HRTEM, XRD etc.)
- O = Optical (PL, Absorbance etc.)
- E = Electronic (Resistivity etc.)
- D = Devices (Diodes, Cells)

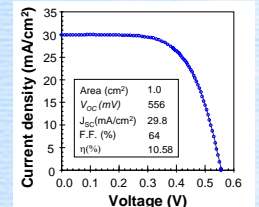
D



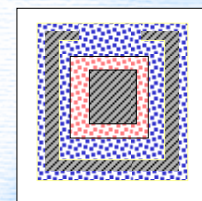
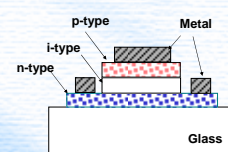
Heteroface cells



(p-type) Si NCs in SiC on (n-type) c-Si

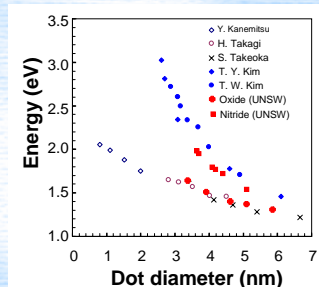
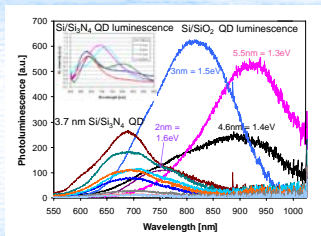


(n-type) Si NCs in SiO₂ on (p-type) c-Si



p-i-n cells

O



Conclusions and further work

- The concept is to produce a Si based tandem solar cell.
- Proof of concept has been achieved in demonstrating formation of Si QDs and that these have confined energy levels which vary with QD size.

- Further work is looking into effective doping of QD superlattice layers and formation of p-i-n structures to demonstrate a photovoltaic response.