

# Surface engineered elemental and tin alloyed silicon nanocrystals in hybrid solar cells.

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## Motivation

- ◆ Silicon based nanocrystals Si-ncs (PV compatible, non-toxic)
- ◆ Quantum confinement and carrier multiplication
- ◆ Carrier multiplication (CM) not yet demonstration in PV device

## Challenges

surface at nanoscale  
without surfactant

direct energy band gap

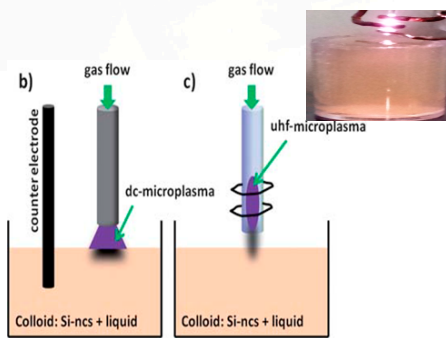
SiSn alloys undergo a real transition  
from indirect to direct bandgap



## Surfactant free surface engineering at nanoscale

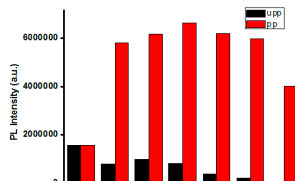
### Microplasma surface engineering of Si-ncs

- ◆ DC Microplasma
- ◆ Plasma generated between RF & ground electrode (60W@450MHz)

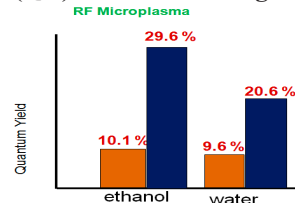


Svrcek et al. J. of Phys. Chem. C 115, 5084 (2011); Appl. Phys. Lett. 97 161502 (2010)  
Adv Function Mat, 22 954 (2012); Nanoscale 5 (4), 1385 (2013)

- ◆ Enhanced stability in water

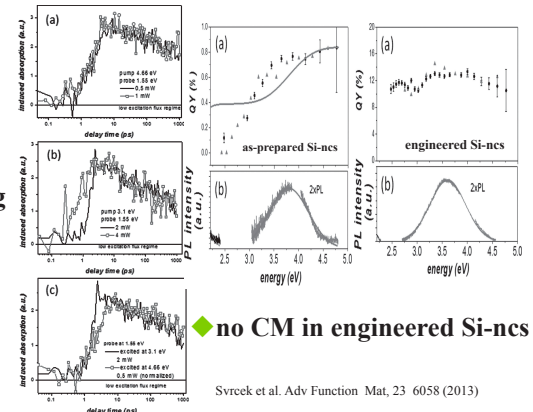


- ◆ Enhanced absolute PL quantum yield (QY) after surface engineering



### Carrier multiplication

- ◆ fs spectroscopy sensitive to multiple excitons in single Si-ncs
- ◆ QY excitons are excited (separated)



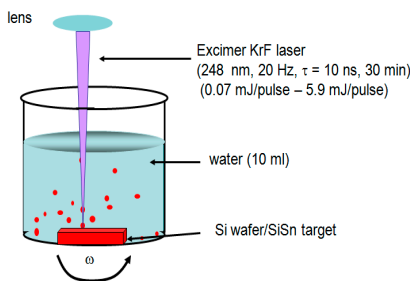
Svrcek et al. Adv Function Mat, 23 6058 (2013)

- ◆ no CM in engineered Si-ncs

## Energy band gap engineering

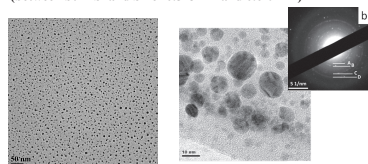
### Silicon tin nanocrystals (SiSn-ncs)

- ◆ Confined plasma in liquid medium (7GPa)
- ◆ Cloud of Si/Sn atoms and embryotic particles in liquid

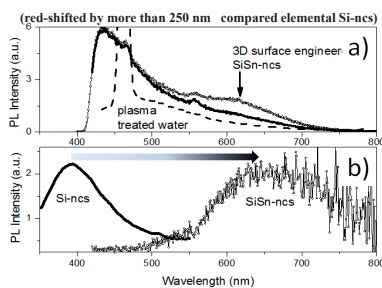


Svrcek et al. APL, 89, 213113 (2006) & Optics Express 17 520 (2009)  
Svrcek et al. Nanoscale 5 6725 (2013)

- ◆ Lattice constant is 0.593 nm. (between bulk Si and Sn of 0.343 nm and 0.649 nm)

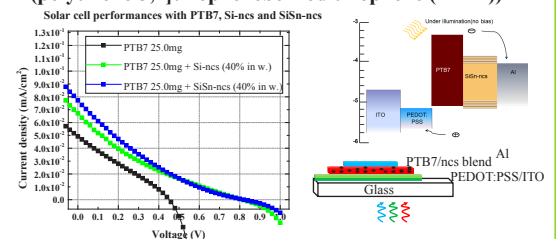


- ◆ PL after 3D surface engineering

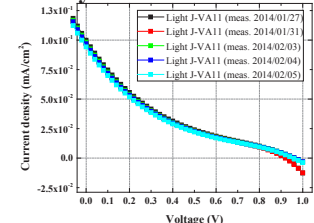


### Hybrid solar cells based on SiSn-ncs

- ◆ Si-ncs and electronic interactions (polythieno 3,4]thiophenebenzodithiophene (PTB7))



- ◆ Enhanced stability PTB7/SiSn-ncs A11



## Conclusions

- ◆ Microplasma surface engineered Si-ncs/SiSn-ncs- enhanced quantum yield and stability - however no carrier multiplication (CM)
- ◆ Confined laser plasma in water - energy band gap engineering alloyed semiconducting silicon tin nanocrystals (SiSn-ncs)

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