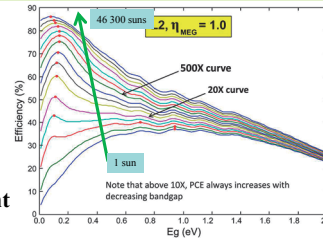


Surfactant free surface engineering of P and N doped Si-ncs and their integration in solar cell structures

V. Švrček¹, C. McDonald^{1,2}, M. Lozac'h¹, T. Tayagaki¹, D. Mariotti², K. Matsubara¹
¹Research Center for Photovoltaics, Advanced Processing Team
²University of Ulster, U.K.

Motivation

- ◆ Silicon based nanocrystals Si-ncs (PV compatible, non-toxic)
- ◆ Doping and surface control of Si-ncs at quantum confinement
- ◆ Carrier multiplication (CM) in nanocrystals enhanced under concentration light

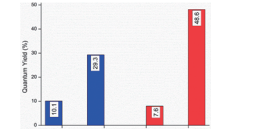
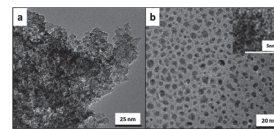
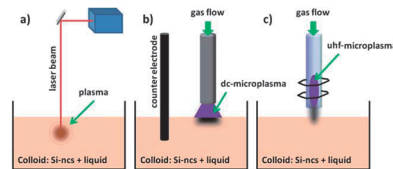


Optimum bandgaps (red dots) for maximum MEG PCEs for various solar concentrations of: 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000 up to 46300 for the L2 MEG characteristic.

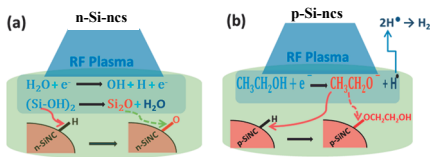
J. Phys. Chem. Lett. 2012, 3, 2857

Surfactant free surface engineering of doped Si-ncs

- ◆ Phosphorus & Boron doped Si-ncs suspended in ethanol



- ◆ RF microplasma



- ◆ e- reacts with ethanol remove the H and produce the CH₃CH₂O⁻ ions.
- ◆ p-Si-ncs are e- deficient surface radicals can easily react and replace the Si-H termination with Si-O-CH₂-CH₃ passivation
- ◆ CH₃CH₂O⁻ may not be reacting with surface of n type Si-ncs
- ◆ n type Si-ncs preferentially react with H₂O₂ produced during the processing.

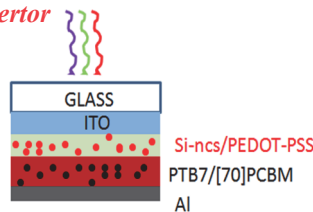
ACS Appl Mater Interfaces (2015) 7(51):28207-14.

- ◆ Well dispersed and stable after surface engineering

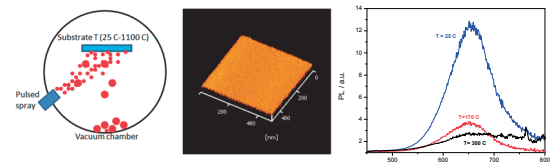
Surface engineered Si-ncs in solar cells structures

- ◆ Surface engineered Si-ncs used as PL convertor

- *Reduction of thermalization losses
- *Increase the collection probability
- *Avoid degradation of polymers



- ◆ Ultrathin films < 30 nm with smooth surface
- ◆ < 2 nm roughness made from engineered Si-ncs
- ◆ PL films deposited at low angle and different substrate T

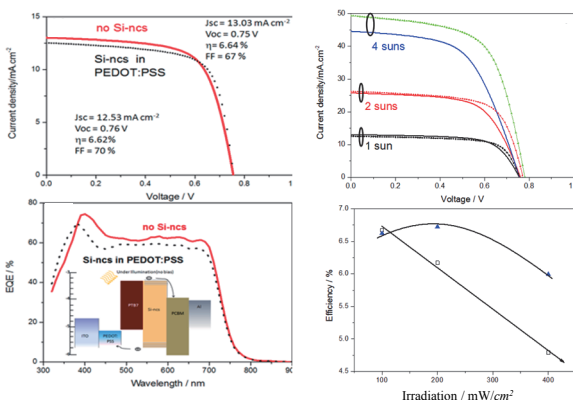


- ◆ Surface engineered Si-ncs

- ◆ high PL efficiency (QY around 30%)

- ◆ Stable Si-ncs in water

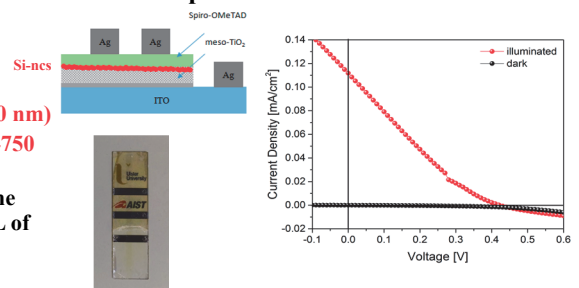
- ◆ Introduction of Si-ncs into water soluble poly(4-styrenesulfonate) (PEDOT-PSS)



- ◆ Conversion of high energy photons (< 400 nm)
- ◆ Red-emission (~500-750 nm) via PL
- ◆ Enhanced EQE in the blue region where PL of Si-ncs occurs.

Nanoscale, 7, 11566, 2015.

- ◆ Transparent solar cells deposition at room temperature



Conclusions

- ◆ Surfactant free microplasma surface engineering of doped Si-ncs and enhanced PL quantum yield and stability in water for n doped Si-ncs
- ◆ Surface engineered Si-ncs in solar cells → PL down shift convertor → enhancement of the photocurrent up to 30 % under concentrated light
- ◆ Photoluminescent ultra thin films (< 30 nm) and solar cells successfully made from surfactant free surface engineered Si-ncs