# *Hybrid solar cells based on nanocarbon materials and doped silicon nanocrystals with quantum confinement effects*

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Supported by NEDO, collaborations: Ulster University, Nanocarbon Center
Organic solar cells team

## Motivation

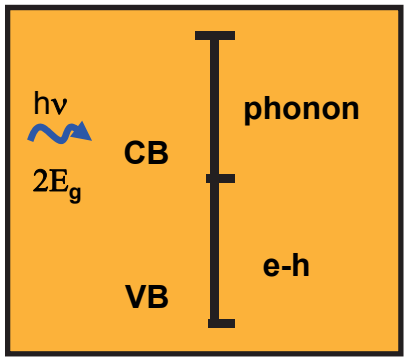
Silicon,, Carbon ⇨ compatibility with cutting-edge PV technologies and natural environmental

Colloidal silicon nanocrystals (Si-ncs) ⇨ surface engineering of Si-ncs quantum confinement effects (QC)

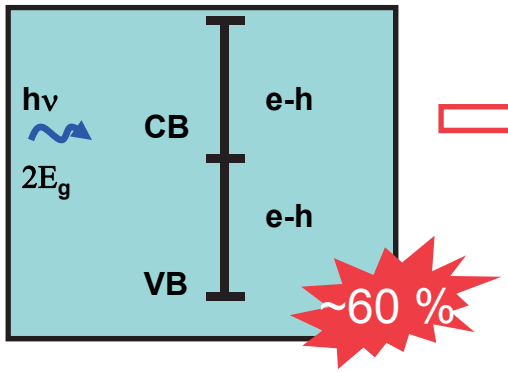
Hybrid materials ⇨ novel phenomenon (i.e., multiple excitons generations) Si-ncs with nanocarbon materials (e. g. nanotubes, $C_{60}$)

## mutliple excitonsgeneration (MEG)

Standard SC (~40 %)

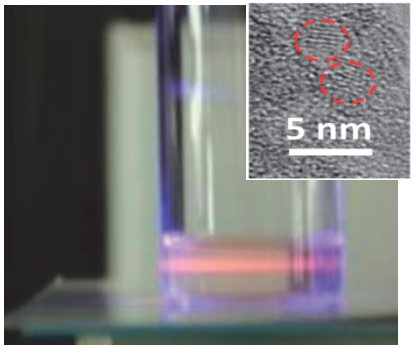



Nanocrystal-SC with MEG




## Si-ncs fabrication

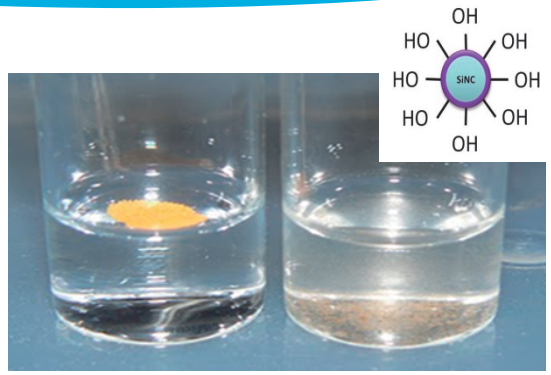
laser ablation
electrochemical
etching



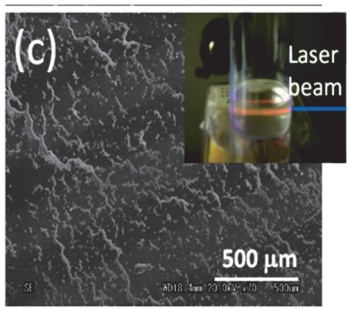

Svrcek et al. *Appl. Phys. Lett.* (2008) **92**, 143301
Svrcek et al. *Optics Express* (2009), **17** 520

## surface engineering @ nano-level

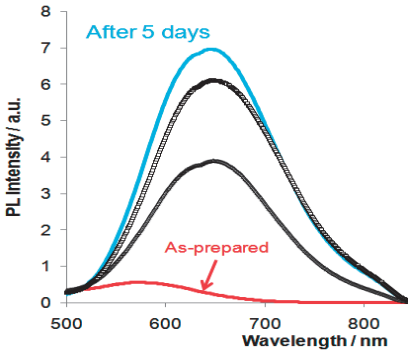
ns laser
microplasma
in liquid media




**surface termination(hydrophilic)**




**Si-ncs self assemblies spheres**

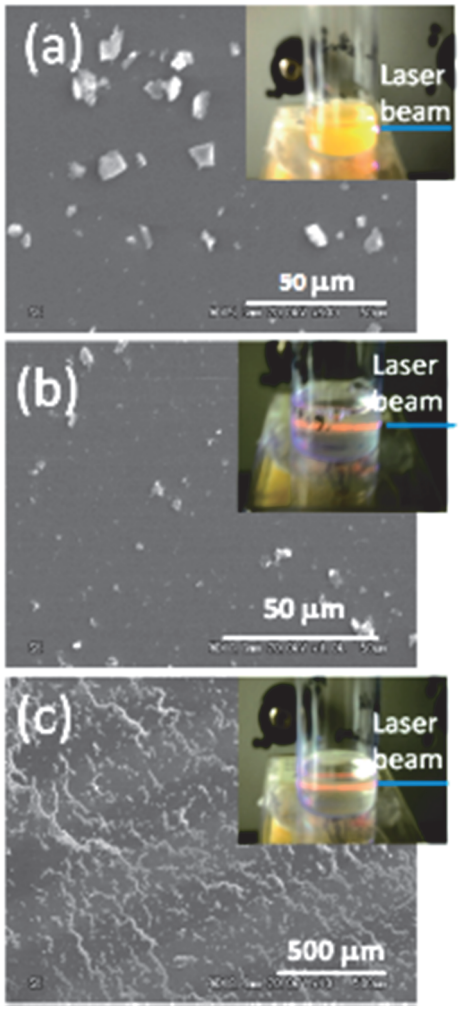


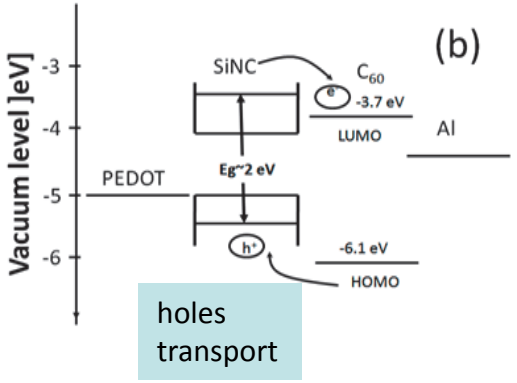

**Si-ncs stability**

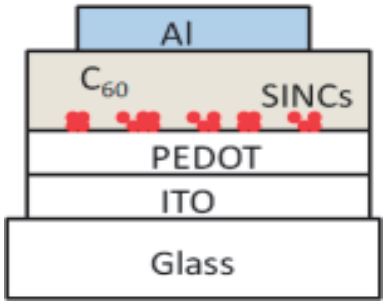
*Svrcek et al. Applied Physics Letters* **97**, (2010) 161502

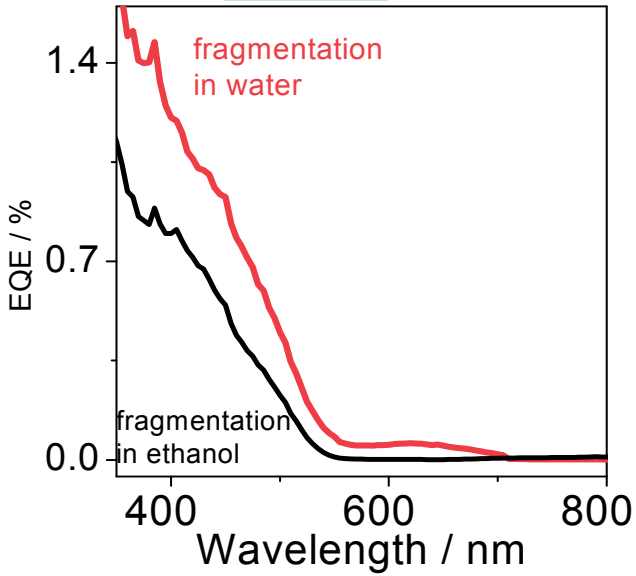
# Si-ncs assemblies/fullerenes

Surface engineering + QC ⇨ Si-ncs approaching, transport




Stable and conductive Si-ncs based self-assemblies by ns laser Si-ncs surface engineering in water

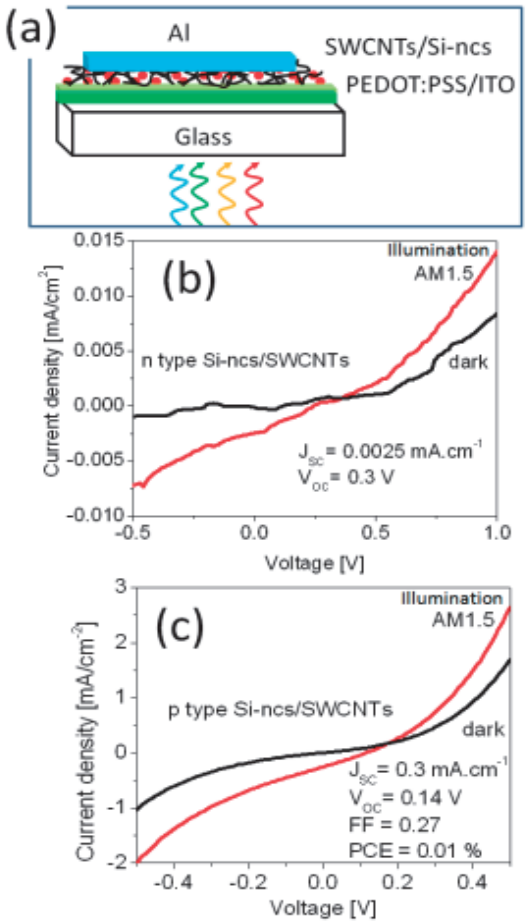
Quantum confinemnets in Si-ncs electronic coupling Si-ncs with fullerenes

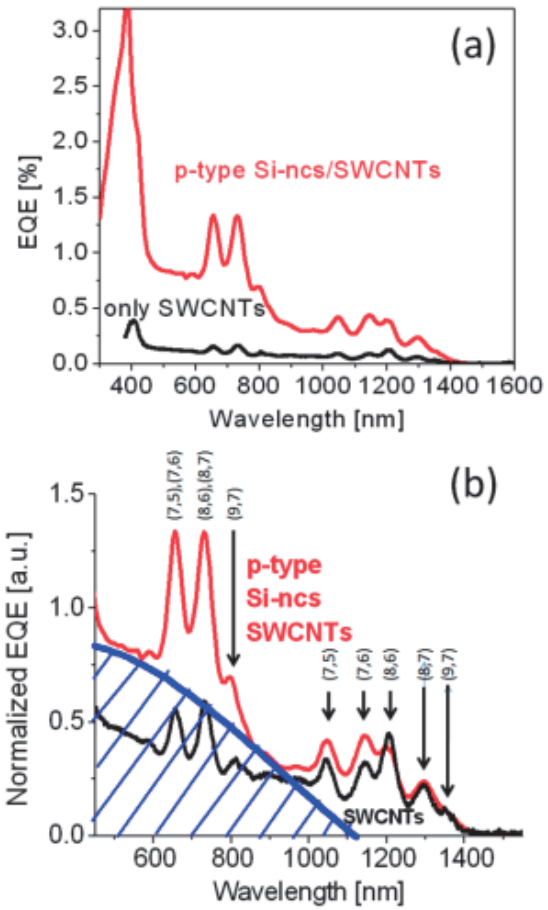
Excitons dissociates @ Si-ncs/ fullerene interface and photocurrent generation.

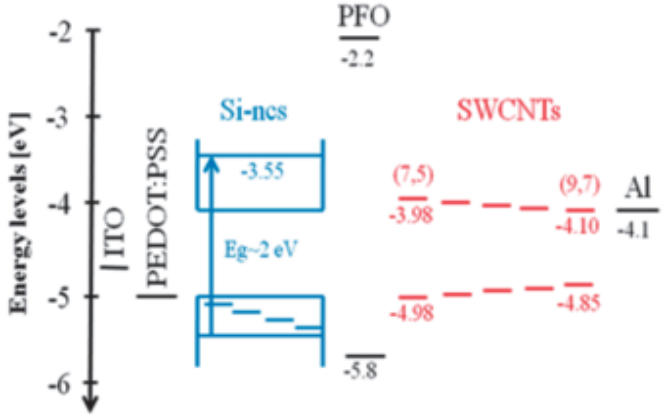
*Svrcek et al. J.of Physi.D: Appli.Phys.* **43** (2010) 415402, *Svrcek et al. J. of Phys. Chem. C* (2011) 115, 5084

# Si-ncs /single walled carbon nanotubes

p-type doped Si-ncs and SWCNTs ⇨ harvesting in broad spectral range 300-1400 nm




Bulk-heterojunction photovoltaic solar cells

Well-defined rectification behavior, short-circuit current and open-circuit voltage,

Energy levels between p-type Si-ncs and semiconducting SWCNTs such as (7,5) are adequate for exciton dissociation and carrier generation.

*Svrcek et al. J. of Phys. Chem.Lett.* (2011) 2, 1646