Surface and composition bandgap engineered Si based nanocrystals in solar cells

V. Švrček¹, D. Mariotti², T. Nagai³, T. Yamanari³, K. Matsubara¹

¹Next Generation Device Team, AIST.
²Nanotechnology and Advanced Materials Research Institute, University of Ulster, UK
³Advanced Low Cost Processing Team, AIST.

Motivation
- Novel concepts: Innovative approaches to material synthesis are essential to enhance significantly solar cell performance.
- Silicon: Compatibility with cutting-edge photovoltaic technologies and natural environmental.
- Carrier multiplication in silicon nanocrystals (Si-ncs).
- Not yet demonstrated in solar cell.

Problems:
- Si energy band gap at quantum confinement probably too wide.
- Surface play significant role at quantum confinement.

Approaches:
- Nanocrystals surfactant free 3D surface engineering at quantum confinement effects.
- Si alloying with tin (Sn) might opens opportunity to decrease the band gap.

Nanocrystals 3D surface engineering
- Surface engineering without surfactant at quantum confinement size (< 5 nm).
- Microplasma induced chemistry:
  - ns/fs laser generated plasmas under colloid (Si-ncs in water/ethanol) surface.
  - DC microplasma generated between Ni tubing & colloid (He 250 SCCM).
  - Plasma generated between RF & ground electrode (He 250 SCCM).
  - 3D surface engineering of Si-ncs in aqueous is the most efficient in case of RF microplasma.

Energy band gap engineering
- RF microplasma compared to DC more efficient stabilization for the Si-ncs in water.
- Engineering of surface/interface with polymers enhanced efficiency of hybrid solar cells.
- Confined laser plasma in water allowed the growth of alloyed semiconducting silicon tin nanocrystals (SiSn-ncs).
- Both alloying and nano-structuring challenge the Si indirect nature.

Conclusions
- RF microplasma compared to DC more efficient stabilization for the Si-ncs in water.
- Engineering of surface/interface with polymers enhanced efficiency of hybrid solar cells.
- Confined laser plasma in water allowed the growth of alloyed semiconducting silicon tin nanocrystals (SiSn-ncs).
- Both alloying and nano-structuring challenge the Si indirect nature.

ACKNOWLEDGMENTS This work was also partially supported by a NEDO project and JSPS invitation and JSPS Bridge fellowships.

http://www.aist.go.jp/