

# Plasma induced surface engineering of SiNCs: single QDs and submicron particles

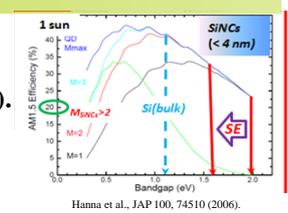
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## Motivation

- ◆ Silicon nanocrystals (SiNCs) compatible with current silicon photovoltaic technologies (non-toxic element, abundant, cheap,....).
- ◆ Surfactant free surface engineering (SE) of SiNCs with strong quantum confinement size (< 3nm).
- ◆ Stable and well separated SiNCs are important features for efficient solar cells fabrication.
- ◆ Surface engineering induces an important factor for multiple exciton generations and carriers extraction.



## Pulsed laser surfactant free surface engineering of SiNCs

ns laser: 20 ns, 245 nm,  $1.7 \times 10^{-6} \text{ cm}^{-1}$

fs laser: 90 fs, 360 nm,  $1.1 \times 10^{-6} \text{ cm}^{-1}$

As prepared: 50 μm, 10 nm

After processing ns laser: 5 μm, 0.2 μm

After processing fs laser: 100 μm

Raman Intensity / a.u. vs Raman Shift / cm<sup>-1</sup>

**ns laser pulses**

As prepared → 55 min (d=350nm) Si-H, + → Si spheres

Surface chemistry: → very weak

**fs laser pulses**

As prepared → 55 min (d=3 nm) Si-NCs

Surface chemistry: Si-H → Si-OH → Si-O-R → Si-O-R-(OH)<sub>x</sub>

- ◆ 3 mg of SiNCs micrograins prepared by electrochemical etching and suspended in deionized water.
- ◆ Processed by pulsed lasers (55 min) at laser average energy 25 J/cm<sup>2</sup>.
- ◆ ns laser processing spherical particles > 300 nm.
- ◆ fs resulted to well separated SiNCs < 3 nm.

Svrcek et al., J. Phys. Chem. C 120, 18822 (2016).

## Surfactant free surface engineered SiNCs for thin solar cells

Engineered surface Si-NCs

Substrate

Deposition chamber

PL Intensity / a.u. vs Wavelength / nm

Time-resolved PL Intensity / a.u. vs Time / μs

Current Density / mA/cm<sup>2</sup> vs Voltage / V

JVCE % vs Wavelength / nm

- ◆ fs processing well separated SiNCs.
- ◆ Quantum confinement size, strong PL and thin film solar cells.
- ◆ Stable performance (after 3 months).

## Conclusions

- ◆ Elucidation of ns/fs laser processing in water.
  - ◆ ns laser processing resulted to crystalline spheres with diameter >300 nm.
  - ◆ fs laser processing resulted to surfactant free surface engineering and well separated quantum SiNCs < 3 nm.
  - ◆ Photoluminescent, transparent and stable solar cells based on surfactant free surface engineered SiNCs.
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