Plasmon Enhanced Dye-Sensitized Solar Cells

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Introduction

Tandem DSSCs
- Dye-sensitized solar cells (DSSCs) utilize a light absorbing dye adsorbed to mesoporous TiO₂ to capture light and convert it into electrical energy.
- A tandem DSSC is made by connecting two DSSCs in parallel, and lining up the front of the two cells.
- Each tandem DSSC is composed of a cell using N719 (red) dye and a cell using N749 (black) dye.
- The black dye “catches” the light that doesn’t get absorbed by the red dye further increasing the light harvesting capabilities.

Plasmons
- Broad resonance Au®Ag bimetallic nanoparticles are incorporated into the mesoporous semiconductor.
- Light scattering is increased, thereby increasing the overall photocurrent of the device.

Objective

To build and fully characterize a tandem DSSC with optimal concentrations of bimetallic nanoparticles.

Materials & Methods

FTO coated glass is cut into ¾ by 1" rectangles and cleaned.

Prep

The cleaned glass is taped off and undergoes a TiCl₄ treatment.

TiCl₄

A doctor-blending method is used to apply mesoporous TiO₂ & plasmons.

TiO₂

A second TiCl₄ treatment is performed.

TiCl₄

Holes are drilled into another piece of glass which is then cleaned and coated with platinum.

Pt

Once the anode (TiO₂) and cathode (Pt) are complete, they are assembled using surlyn and a heat sealer. Electrolyte is then inserted into the holes which are then covered with surlyn.

Assembly

The cells are then tested individually and in tandem using a solar simulator to obtain JV data. A supercontinuum laser in conjunction with an acousto-optic tunable filter for purging light into narrow spectral bands was used to determine the incident photon to charge carrier efficiency (IPCE).

Testing

Results

Dye Spectra

Figure 2: Dye Absorption Spectra. The spectra depicts the reasoning behind our choice of organic dyes. The black dye absorbs in the near infrared, where the red dye is unable to, increasing the light absorption of the tandem system.

Figure 3: JV curve which is used to obtain Voc, Jsc, Fill, and FF, which are then used to calculate efficiency and fill factor. FF = FV / FP

Figure 4: Incident photon to charge carrier efficiency plot that tells us how efficiently the device converts the incident light into electrical energy at a given wavelength. IPCE % = Ip / (P(λ) / 100)

Figure 5: Tandem testing setup in tandem testing in I-V setup.

Figure 6: TEM image of Au®Ag bimetallic nanoparticles in TEM image of cube geometry and TEM image of pyramidal geometry.

Figure 7: SEM image of Au®Ag nanoparticles

Figure 8: Absorption spectra of bimetallic nanoparticles. The particles give two peaks, one for gold and one for silver.

Conclusions

- It was shown that a successful tandem DSSC was able to be constructed and the resulting efficiency was higher than that of the individual DSSCs.
- Broad resonance Au®Ag bimetallic nanoparticles of two different geometries (cubes&pyramids) can be synthesized.
- These different geometries arise from the different crystal faces of the gold nanoparticles and the affinity of KBr for those faces.

Future Work

- The main goal for future work is to now incorporate the Au®Ag bimetallic nanoparticles into the tandem DSSC in order to hopefully achieve even higher efficiencies.
- The bimetallic nanoparticles will be mixed with the TiO₂ paste with the rest of the process carried out as usual.
- Before these particles can be incorporated, they must be silica coated. Silica coating helps the particles in a few ways:
  - Enhances stability of the particles
  - Protects the particles from the corrosive electrolyte
  - Prevents electron scavenging

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References: