PHOTOCHEMICAL AND PHOTOVOLTAIC CELLS BASED ON NANOSTRUCTURED WIDE BANDGAP SEMICONDUCTORS

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CRYSTAL STRUCTURE OF ANATASE AND RUTILE TiO$_2$

- Fujishima and Honda discovered TiO$_2$ photocatalysis in 1972
**TiO$_2$ as Photocatalysts**

- 3.0-3.4eV band gap and absorbance in UV

**Oxidative:**
- Air urification
- Waste water treatment
- Anti-fogging, anti-bacterial, and self-cleaning surfaces

**Redox:**
- Hydrolysis, solar hydrogen generation

**Reductive:**
- Reduction of CO$_2$ into hydrocarbons

Nanoprotect Inc., [http://www.nanoprotect.co.uk/photocatalyst.html](http://www.nanoprotect.co.uk/photocatalyst.html)
Electrochemical Potential and Proposed Reaction Mechanisms

Hydrolysis of H₂O:

Proposed Photoreductive Mechanism:

Photoreduction of CO₂:

SCHEMES FOR CATALYTIC ENHANCEMENT OF TiO$_2$ MEMBRANES

Catalytic Efficiency Hindered by Recombination:

Semiconductor Composite:

Metallic/Nanotube Composites:

**Dye-Sensitized Solar Cells**

- Lower materials (dye, TiO$_2$) cost than traditional silicon and thin film photovoltaics
- Efficiency above 10% have been demonstrated
- Can be made flexible using flexible substrates and thin electrodes

MANUFACTURE OF THIN FILM AND DYE-SENSITIZED SOLAR CELLS

Roll to Roll CIGS Processing:

Dye Sensitized Solar Cell Electrodes are Screen Printed:

CIGS Panel Geometry:

Top Left: Nanosolar Inc., http://www.nanosolar.com
Bottom Left: Solyndra, Inc., http://www.solyndra.com
Right: International Paper Knowledge Center: http://glossary.ippaper.com
PHOTOVOLTAIC TESTING AND EFFICIENCY DETERMINATION

Extraterrestrial and Atmospheric Solar Spectrum:

- Dye-sensitized solar cells are colored depending on the dye absorbance

I-V Curves and Efficiency Extraction:

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Top Left: Newport Corp., [http://www.newport.com](http://www.newport.com)
Bottom Left: Solaronix, Inc., [http://www.solaronix.com](http://www.solaronix.com)
OPTICAL ABSORBANCE OF DYE-SENSITIZED CELL COMPONENTS

Fig. 1: Schema of dye-sensitized solar cell

Absorbance (a.u.)

Wavelength (nm)

soloronix anatase
ru-535 dye

Open Loop Dye Sensitized Solar Cells: http://www.loop.ph/bin/view/Openloop/DyeSensitizedSolarCells
SCHEMES FOR IMPROVING ELECTRON TRANSPORT IN TiO$_2$

Back reflecting unabsorbed low wavelength light:

One dimensional electron transport confinement:

DEVELOPMENT OF STABLE “BLACK” DYES

Increase Near IR Absorbance:

Ruthenium 535 (N3): Absorbs up to 750nm

Ruthenium 620-1H3TBA: Absorbs up to 920nm

Solaronix Inc., http://www.solaronix.com
Flexible Substrate Incorporation and Electrolyte Sealing

- Flexible substrates available for Electrode Deposition:
  - Stainless Steel (2.4%)
  - ITO coated PET
- Device Lifetimes not proven

- Molten salt electrolytes with efficiency up to 8.2%
- Suffers from decreased open cell voltage and decreased flux