

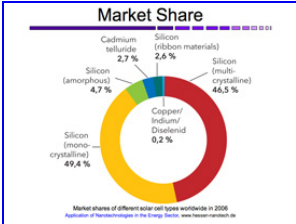
**Making use of the educational potential of nanoscale energy production and conservation**

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Beloit College  
University of Wisconsin-Madison MRSEC

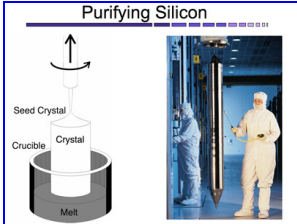
001

**Energy production**

002



003



004

**Crystalline Silicon Solar Cells**

**Advantages**

- raw material is abundant, durable, environmentally benign
- 22% efficiency (incoming light to electricity)

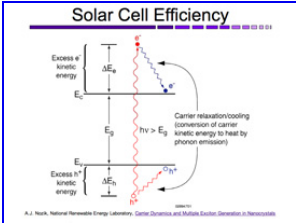
**Disadvantages**

- producing high purity silicon is expensive
- low absorptivity (100  $\mu\text{m}$  thick is heavy and rigid)
- high demand for computer chips raises price (\$100/kg)
- \$3-\$5/watt

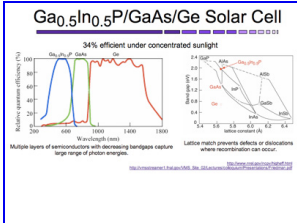
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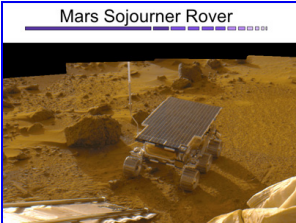
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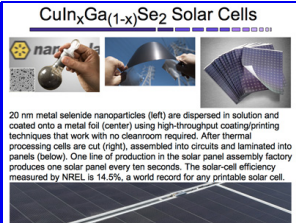
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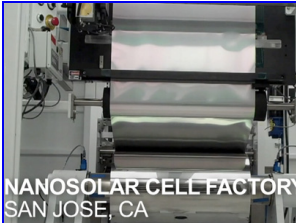
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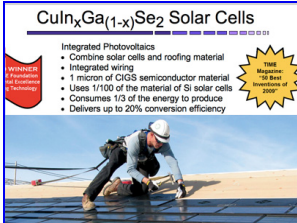
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010



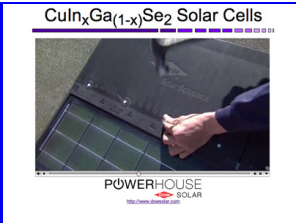
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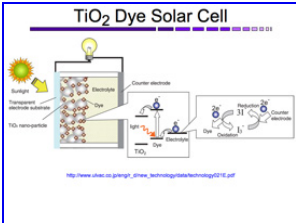
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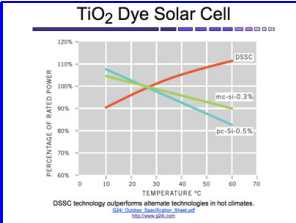
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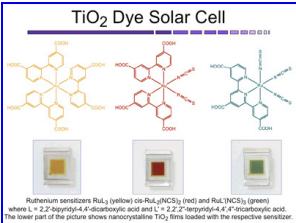
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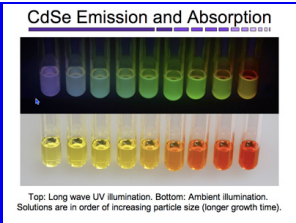
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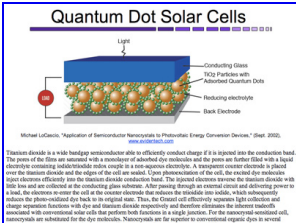
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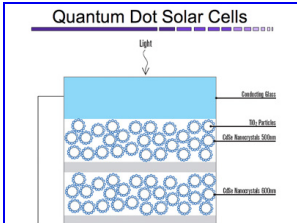
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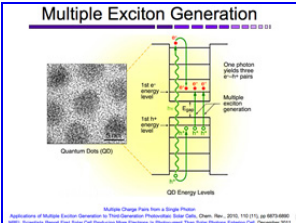
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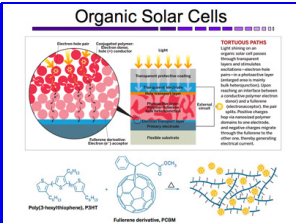
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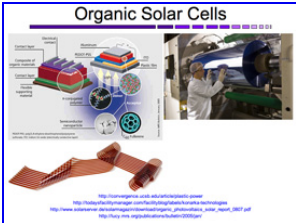
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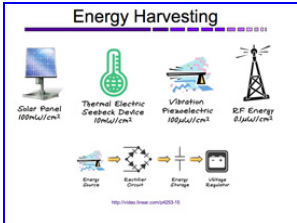
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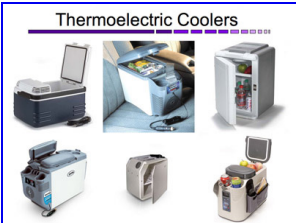
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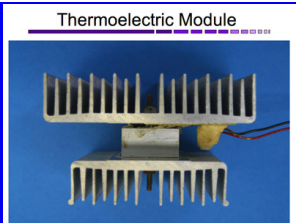
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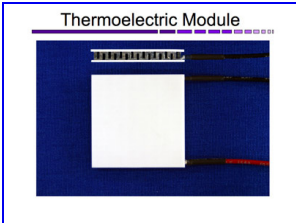
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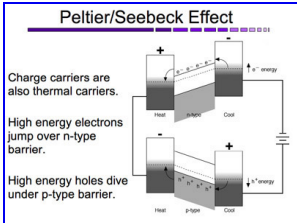
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031



032

### Thin Film Thermoelectrics

For a given  $\Delta T$ , the output power density is inversely proportional to the material thickness, but  $\Delta T$  is difficult to maintain as the thickness decreases.

- By controlling the transport of phonons and electrons in superlattices of  $\text{Bi}_2\text{Te}_3$ , material 100 times thinner exceeds the power density of the bulk material.

033

### Energy storage

034

### $\text{LiFePO}_4$

$\text{FePO}_4$  (left) and  $\text{LiFePO}_4$  (right, olivine structure)

- Li has a higher potential when next to a phosphate than an oxide
- Phosphate is thermally stable
- Cost is significantly less (Fe vs. Co)
- Lower electrical conductivity: maintains charge when not used
- Longer cycle life
- Faster recharge rate

035

### $\text{LiFePO}_4$

Cycle Life

**LITHIUM ION**  
**DEWALT**

036

### Ultracapacitors

**LightStorm Q1**  
Power-generating Carbon Nanotube

Versatile, Dependable, Powerful...

Featuring Carbon Ultra-Capacitor Technology, the LightStorm is the most powerful, versatile, and dependable power source available.

037

### Ultracapacitors

038

### Ultracapacitors

The capacitance of a capacitor is proportional to the area of the plates and inversely proportional to the distance between them. Ultracapacitors have a much larger surface area than conventional capacitors, allowing them to store much more energy.

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039

### Preparation of an Alkaline Fuel Cell

This project was developed by Tessa Jacques and Dr. Robert H. Holm at the University of Wisconsin-Madison. The project was funded by the National Science Foundation (NSF) and the Department of Energy (DOE).

The alkaline fuel cell is a type of fuel cell that uses an alkaline electrolyte. It is a clean, efficient, and quiet power source that can be used in a variety of applications, including portable power, backup power, and power for remote locations.

040

### Solid Oxide Fuel Cell

The solid oxide fuel cell (SOFC) is a type of fuel cell that uses a solid oxide electrolyte. It is a clean, efficient, and quiet power source that can be used in a variety of applications, including portable power, backup power, and power for remote locations.

041

### Hydrothermal Growth of $\text{ZnO}$ Nanorods

Production modified by A. Janda and D. L. Bieganski from the School of Chemical Engineering, University of Wisconsin-Madison. The project was funded by the National Science Foundation (NSF) and the Department of Energy (DOE).

Hydrothermal growth of  $\text{ZnO}$  nanorods is a process in which  $\text{ZnO}$  nanorods are grown from a solution of zinc ions and hydroxide ions. The nanorods are grown in a hydrothermal reactor, which is a sealed vessel that can be heated to high temperatures and pressures.

042

### $\text{ZnO}$ nanorods

043

### $\text{ZnO}$

Current,  $\mu\text{A}$

Time, seconds

044

### Energy efficiency

045

### LEDs and Periodic Properties

LEDs are made from semiconducting materials. The elements used in LEDs are typically found in the periodic table, and their properties are related to their position in the table.

046

### Color Strip Kit

047

### LED Color Strip

048

### LED Performance

LED performance has been so rapid that it has been described by Intel as a logarithmic trend. Light output levels from packaged LED devices have roughly doubled every two years while the cost has fallen.

049

### White LED Lighting

050

### LED lighting

051

### New Lamps for Old

052

### LED replacement bulbs

053

### Headlights

LED headlights (high beams, low beams and running lights) in the 2012 Audi A8.

054

### LED Lighting

055

### LED Street Lighting

Conversion Program from high-pressure sodium lights to LED fixtures on the 6th Street Bridge over the Los Angeles River.

056

### LED Lighting

057

### LED Street Lighting

- Power for lighting is 20-30% of total electricity consumption.
- Overwhelming majority of light generated by humans is wasted.
- LED lamps are directional.
- LED lamps turn on & off quickly (turn off when no one present).

058

### Sustainable Energy Contributions

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### Acknowledgements

NSF, DMR, RET, MRSEC

Best College  
Christian Brothers University  
Lawrence University  
Milwaukee School of Engineering  
Southern Illinois University  
University of Wisconsin-Madison

http://mrsec.wisc.edu/nano

060