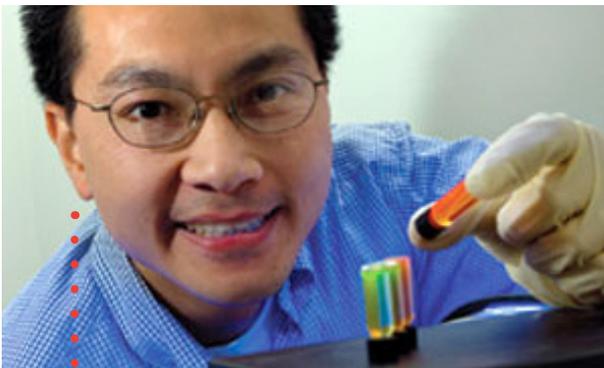


# Rice Breakthroughs in Power



• **Generation**  
• **Storage**  
• **Transmission**  
•

## Power Generation

### Quantum Dot Solar Cells (Michael Wong)

Quantum dot solar cells (QDSC) provide a more efficient conversion of solar to electrical energy. QDSCs, unlike conventional silicon panels, can produce power continuously, day and night, by absorbing light from the ultraviolet to the infrared. A novel cheap method of making QDSC has been produced through the development of four legged quantum dots called tetrapods. These tetrapods can be used for a wide variety of applications.

### Quantum Dots from Coal (James Tour)

Quantum dots are semiconductors with fluorescent properties. Graphene quantum dots (GQDs) are a form of non-toxic quantum dots that are very cheap, because they are made from readily available carbon-rich materials like coal. They also resist photo-bleaching so that after many hours of excitation, the photoluminescent response is negligibly affected. The fluorescent stability of GQDs allows them to be very effective for medical imaging.

### Solar-driven Steam Generation (Naomi Halas)

Light-capturing nanoparticles are used to convert light from the solar spectrum into heat. When submerged in water and exposed to sunlight, the particles heat up so rapidly that they instantly vaporize water to create steam. The steam produced can be used to sterilize medical waste and instruments, prepare food, and purify water.

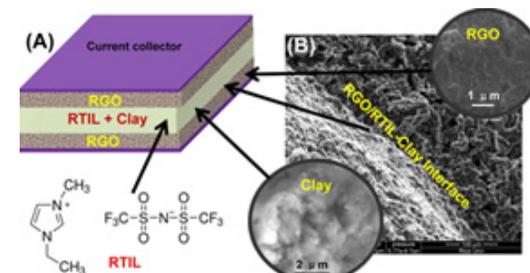
### Nanoscale Spikes (Andrew Barron)

Nanoscale spikes etched into silicon, allowing more than 99 percent of sunlight to reach the cells' active elements, where it can be turned into electricity. Chief advantage to this textured surface, compared to conventional silicon, is that it allows the cells to capture light from any angle—sunrise to sunset.

## Power Storage

### High-Temperature Capacitors (Pulickel Ajayan)

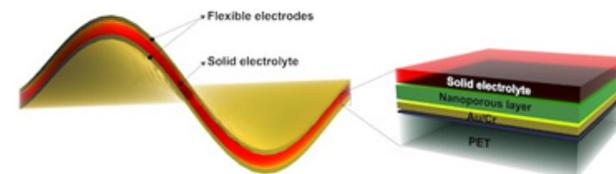
Supercapacitors are capacitors that possess a much higher capacitance value than normal capacitors. They have the ability to charge in seconds and release energy on demand over time, like a battery. Supercapacitors with a clay-based membrane electrolyte can be used in high-temperature environments (up to 200 degrees Celsius). These supercapacitors could be useful in powering devices for use in extreme environments.



Clay-based supercapacitor structure

### Flexible Batteries (James Tour)

The use of a nickel-fluoride film electrode as a replacement for a lithium electrode allows for the production of flexible batteries. The nickel-fluoride film has the flexibility of carbon nanotubes and the high electrical storage capacity found in inorganic compounds. This technology is aimed for use in flexible, portable and wearable electronics.



Flexible battery design



rsi.rice.edu



smalley.rice.edu

## Paintable batteries (Pulickel Ajayan)

Lithium ion batteries have been developed that can be painted onto virtually any surface. This technology allows one control over the choice of substrate and shape of a battery. No compartments are needed for the storage of the paintable battery allowing for a more flexible approach in the design and integration possibilities for a storage device.



Printable layers vs. standard canister format

## Silicon Anode Batteries (Lisa Biswal)

The use of porous silicon powder as the negative electrode of a battery (anode), instead of the commonly used graphite, greatly increases the efficiency of a battery. Silicon can hold 10 times more lithium ions than graphite. In addition, a battery with a silicon-based anode can achieve 600 charge-discharge cycles at 1,000 milliamp hours per gram (mAh/g), a huge difference over the 350 mAh/g capacity of current graphite anodes. These silicon anodes could make current lithium batteries low-cost, live longer, and work at higher capacities.

## Carbon Nanotube/Metal Electrodes (James Tour)

The attachment of carbon nanotubes to a metal electrode can greatly increase the surface area of an electrode. This is achieved by growing graphene on the metal electrode and subsequently growing carbon nanotubes from the graphene. The formation of this hybrid electrode gives it a much higher surface area equating to an increase in energy storage, a key factor in supercapacitors.

## Other Battery Technologies

Graphene Nanoribbons with SnO Anodes (James Tour)

Graphene-Boron Anodes (Boris Yakobson)

VaO/Graphene Cathode (Yongji Gong)

Silicon Wafer Anodes (Lisa Biswal)

## Power Transmission

### Nanotech Fibers (Matteo Pasquali)

New nanotech fibers have been developed that are stronger than steel, as flexible as textile thread, electrically conductive as gold, and as thermally conductive as the best graphite fibers. The multiple properties of these thin nanotech fibers can lead to new products with various capabilities in the aerospace, automotive, medical and smart-clothing markets.



Carbon nanotube fibers support and power lamp

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## Featured Investigators

Pulickel Ajayan	ajayan.rice.edu
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James Tour	www.jmtour.com
Boris Yakobson	biygroup.blogs.rice.edu
Michael Wong	ruf.rice.edu/~wonglab

## Featured Technologies

Quantum Dot Solar Cells  
[qmcdots.com/products/products-solar.php](http://qmcdots.com/products/products-solar.php)

Quantum Dots produced from Coal  
[tinyurl.com/o2us39a](http://tinyurl.com/o2us39a)

Steam Generation from Solar Power  
[tinyurl.com/oxkqpkn](http://tinyurl.com/oxkqpkn)

Nanoscale Spikes Enhance Solar Capture  
[tinyurl.com/mf59gng](http://tinyurl.com/mf59gng)

High-Temperature Capacitors  
[tinyurl.com/n6wygaz](http://tinyurl.com/n6wygaz)

Flexible Batteries  
[tinyurl.com/n7gthew](http://tinyurl.com/n7gthew)

Paintable Batteries  
[tinyurl.com/ov5265y](http://tinyurl.com/ov5265y)

Silicon Anode Batteries  
[tinyurl.com/mh33qjg](http://tinyurl.com/mh33qjg)

Carbon Nanotube/Metal Electrodes  
[tinyurl.com/aa9e2ux](http://tinyurl.com/aa9e2ux)

Nanotech Fibers  
[tinyurl.com/nsn9f9v](http://tinyurl.com/nsn9f9v)