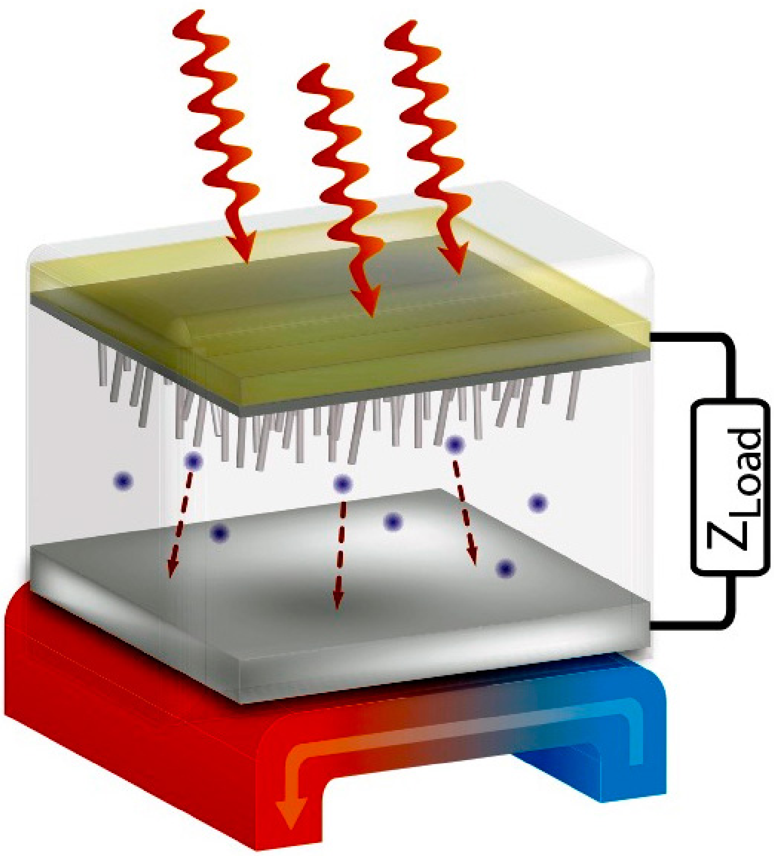
Stanford's solar cell turbocharger could boost solar power output by 50%

By Sebastian Anthony on March 20, 2013 at 12:41 pm

Scientists at Stanford University have improved the efficiency of a revolutionary solar cell by around 100 times. Unlike standard photovoltaic cells, which only capture light energy, Stanford's new device captures both light *and* heat, potentially boosting solar cell efficiency towards 60% — way beyond the 30-40% limit of traditional silicon photovoltaic solar cells.

This new device uses a process called photon-enhanced thermionic emission (PETE). In photovoltaic cells, photons strike a semiconductor (usually silicon), creating electricity by knocking electrons loose from their parent atoms. The PETE process is similar, but also very different and altogether rather complex. In essence, think of it as the photovoltaic equivalent of a turbocharger.



[1]

A diagram of Stanford's photon-enhanced thermionic emission (PETE) device. The yellow/gray sandwich at the top is the GaAs/AlGaAs cathode; the blue balls are photoexecited electrons; the gray slab is the anode; and the red/blue section represents a heat pipe, that leads to a steam turbine/Stirling engine.

To begin with, there's a gallium arsenide/aluminium gallium arsenide (GaAs/AlGaAs) semiconductor sandwich at the top of the device. (The picture at the top of the story, incidentally, is a gallium arsenide wafer.) The top half of the sandwich is tuned to gather as much sunlight as possible, creating a lot of excited electrons using the photovoltaic effect. The underside is basically a sea of nanoantennae, which emits these photoexcited electrons across a vacuum to the anode. At the anode, the electrons are gathered and turned into an electrical current.

Beneath the anode is some kind of heat pipe, which collects any leftover heat to be used by a steam turbine or Stirling engine. The vacuum seems to play an important role, ensuring there's a temperature differential between the cathode and anode.

Unlike normal photovoltaic cells which break down at high temperatures, PETE actually improves in efficiency as it gets hotter. One of the easiest applications of PETE would be in concentrating solar power plants, where thousands of mirrors concentrate light on a central vat of boiling water, which drives a steam turbine. By concentrating the light on PETE devices instead, Stanford estimates that their power output could increase by 50%, bringing the cost of solar power generation down into the range of fossil fuels.

Stanford's current device only has an efficiency of 2%, but that's up from just a few hundredths of a percent last year, and they expect to see a 10-fold gain in the future. Previously, the researchers have said that a PETE device should be able to reach an efficiency of 55-60%, most likely by incorporating metals such as barium or strontium, which will allow for operating temperatures up to 500 Celsius. The ultimate goal, of course, is to bump up the efficiency of solar power so that useful amounts of cost-effective electricity can be generated from non-desert-sized spaces. (See: Beam me down, Scotty: Space-based solar power finally comes of age [2].)

Now read: The 500MW molten salt nuclear reactor: Safe, half the price of light water, and shipped to order [3]

Research paper: doi:10.1038/ncomms2577 [4] – "Photon-enhanced thermionic emission from heterostructures with low interface recombination"

Endnotes

1. : http://www.extremetech.com/wp-content/uploads/2013/03/pete-photovoltaic-thermionic-diagram-stanford.jpg
2. Beam me down, Scotty: Space-based solar power finally comes of age: http://www.extremetech.com/extreme/149638-beam-me-down-scotty-space-based-solar-power-finally-comes-of-age
3. The 500MW molten salt nuclear reactor: Safe, half the price of light water, and shipped to order: http://www.extremetech.com/extreme/150551-the-500mw-molten-salt-nuclear-reactor-safe-half-the-price-of-light-water-and-shipped-to-order
4. doi:10.1038/ncomms2577: http://www.nature.com/ncomms/journal/v4/n3/full/ncomms2577.html

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