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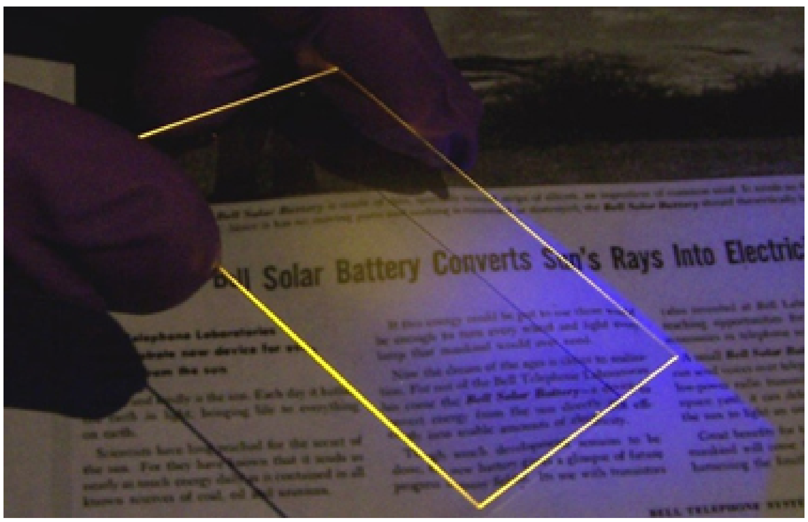
Doped semiconductor nanocrystals boost solar concentrators

Researchers at the University of Washington and Western Washington University in the US have designed a new, high-performance and transparent luminescent solar concentrator based on "zero self-absorption" doped quantum dots. The device could be used to make cheaper, more efficient solar cells and might even be ideal in applications like smart windows.



(http://images.iop.org/objects/ntw/news/13/4/4/image1.jpg)
Doped quantum dot LSC (http://images.iop.org/objects/ntw/news/13/4/4/image1.jpg)

A luminescent solar concentrator (LSC) is a device that contains a thin sheet of material (usually a polymer such as polymethylmethacrylate (PMMA), doped with luminescent species such as organic dyes, quantum dots or rare-earth complexes) that absorbs sunlight over a large area. The sheet then re-emits the absorbed light (at a different wavelength) and directs it to photovoltaic cells mounted on the edges of the material layer. These cells convert the directed light into electricity.

LSCs could replace solar cells in standard flat-plate photovoltaic panels, and so reduce their cost. LSCs can absorb both direct and diffuse solar radiation, which means that they do not need to track the Sun. They are also ideal for cloudier northern European climes.

Self-absorption is a problem

Although researchers have been working on LSCs since the 1970s, these devices are still not efficient enough to be employed in real-world applications. Their main drawback is so-called self-absorption. Here, the luminescent dyes in the devices absorb one another's emitted light and in a large concentrator this phenomenon prevents most of the harvested light from ever reaching the edge cells. "Our zero self-absorption doped quantum dots could be one way of overcoming this long-standing fundamental problem," explained co-team leader David Patrick (http://www.chem.wwu.edu/dpatrick/patrick.shtml).

"The doped quantum dots we are developing absorb high-energy UV light and re-emit it at lower energies," he told *nanotechweb.org*. "These energies are too low to be re-absorbed by other quantum dots within the concentrator, so the light can now travel to the edges of the concentrator relatively unimpeded. In turn, this allows for larger, more highly concentrating and more efficient solar light collection."

Glowing brightly orange

The researchers looked at colloidal ZnSe semiconductor nanocrystals with ZnS shells containing small amounts of luminescent Mn(II) ions. They prepared the crystals using a technique called solution-phase synthesis, and are easily able to produce them in large quantities. They then dispersed the dots in an acrylic polymer and applied them to a sheet of glass.

"The nanocrystals absorb UV wavelengths from sunlight and transfer this energy to the Mn(II) ions, which emit orange-coloured light," explained Patrick. "This results in a clear plastic-coated glass sheet whose edges glow brightly orange when exposed to the Sun."

The device can efficiently concentrate light, which means that far fewer solar cells are required to produce the same amount of electricity, he adds. Indeed, for a large concentrator, the photovoltaic cell area might be 15 times smaller than usual – which would make it much cheaper to produce and run. "What is more, the concentrator works equally well with both diffuse and specular light, making it ideal for cities and cloudy regions," said co-team leader Daniel Gamelin (http://depts.washington.edu/chem/people/faculty/gamelin.html). "It does not need to track the Sun either, and so contains no moving parts."

Smart windows and energy-harvesting coatings

The concentrator is transparent to visible light wavelengths too, which means that it can be used as a window coating, he adds. Here, the glass surface collects sunlight that is then converted by photovoltaic cells contained in the surrounding window frame, for example.

Other applications include energy-harvesting coatings for display screens and portable electronics.

In this work, the Washington researchers mainly looked at doped quantum dots that are able to selectively harvest UV light for use in transparent concentrators. Indeed, the study is the first to exploit doped semiconductor nanocrystals for such applications. “We are now busy trying to obtain higher overall light-to-power efficiencies in our concentrators by developing doped-nanocrystal materials that absorb across a broader spectral range. Although these devices will no longer be as transparent, they will produce more energy.”

The current work is described in *ACS Nano* (http://pubs.acs.org/doi/abs/10.1021/nn406360w).

About the author

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Further reading

Nanoparticles scatter light in solar cells (Dec 2008) (http://nanotechweb.org/cws/article/tech/36935)
Auger effect boosts doped devices (Apr 2011) (http://nanotechweb.org/cws/article/tech/45785)
Magnetic semiconductors for optospintronics (Aug 2011) (http://nanotechweb.org/cws/article/tech/46785)