Hybrid Perovskite Combined with Acceptor Material Used to Harvest Hot Electrons

Download PDF Copy

Written by AZoM Nov 19 2019

Semiconductors are used to change energy from photons (light) into an electron current. However, certain photons hold excess energy for the material to absorb. These photons create "hot electrons," and the extra energy of these electrons is turned into heat. Materials scientists have been seeking ways to harvest this extra energy.

This is a set up for ultrafast spectroscopy, as used in the study. Image Credit: Maxim Pchenitchnikov, University of Groningen.

Now, researchers from the University of Groningen and Nanyang Technological University (Singapore) have demonstrated that this may be simpler than anticipated by joining a perovskite with an acceptor material for "hot electrons." Their proof of concept was reported in the November 15th issue of *Science Advances*.

In photovoltaic cells, semiconductors will trap photon energy, but only from those photons with the correct amount of energy: very little energy and the photons travel right through the material, surplus energy and the excess amount is lost as heat. The correct amount is established by the bandgap: the variance in energy levels between the lowest unoccupied molecular orbital (LUMO) and the highest occupied molecular orbital (HOMO).

Nanoparticles

> *The excess energy of hot electrons, produced by the high-energy photons, is very rapidly absorbed by the material as heat.*
>
> *Maxim Pshenichnikov, Professor of Ultrafast Spectroscopy, University of Groningen*

To absorb the energy of hot electrons completely, it is essential to use materials that have a larger bandgap. However, this means that the hot electrons should be conveyed to this material before losing their energy.

The existing common method for harvesting these electrons is to decelerate energy loss, for instance, by employing nanoparticles rather than bulk material.

> *In these nanoparticles, there are fewer options for the electrons to release the excess energy as heat.*
>
> *Maxim Pshenichnikov, Professor of Ultrafast Spectroscopy, University of Groningen*

In collaboration with researchers from the Nanyang Technological University, where he was a visiting professor for the past three years, Pshenichnikov examined a system in which an organic-inorganic hybrid perovskite semiconductor was integrated with the organic compound bathophenanthroline (bphen), a material that has a large bandgap.

The researchers used laser light to stimulate electrons in the perovskite and analyzed the behavior of the hot electrons that were produced.

Related Stories

- Effective Ways to Research Perovskite Materials
- Colored Transparent Organic-Inorganic Hybrid Coatings
- How Hot (And Not-So-Hot) Compounds in Chili Peppers Change During Ripening

Barrier

"*We used a method called pump-push probing to excite electrons in two steps and study them at femtosecond timescales*," explains Pshenichnikov. This enabled the researchers to create electrons in the perovskites with energy levels just above the bandgap of bphen, without stimulating electrons in bphen. Thus, any hot electrons in this material would be from the perovskite.

The results demonstrated that bphen readily absorbed hot electrons from the perovskite semiconductor. "*This happened without the need to slow down these electrons and, moreover, in bulk material. So, without any tricks, the hot electrons were harvested*."

However, the researchers observed that the energy required was slightly higher than the bandgap of bphen. "*This was unexpected. Apparently, some extra energy is needed to overcome a barrier at the interface between the two materials*."

However, the study offers a proof of concept for harnessing hot electrons in the bulk perovskite semiconductor material.