Traditional Solar Cells Are Outperformed by New Material

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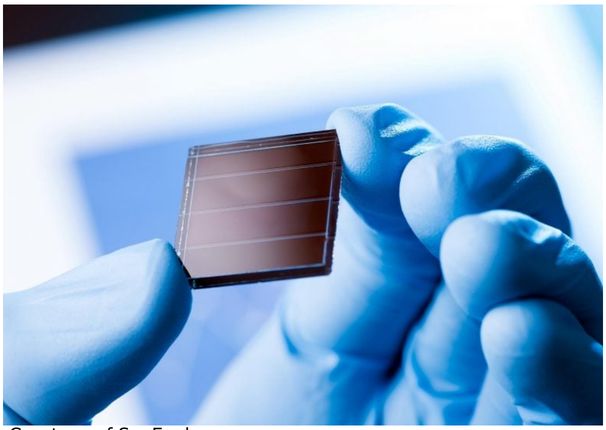
Courtesy of SynEvol

A unique phenomenon known as the bulk photovoltaic (BPV) effect may enable some materials to outperform conventional p-n junctions in solar cells. The BPV effect in alpha-phase indium selenide (α-In2Se3) along the out-of-plane direction has just been empirically proven for the first time by Japanese researchers, which is in line with previous theoretical predictions. Their α-In2Se3 device's remarkable conversion efficiency is a major advancement for photosensors and next-generation solar cell technology.

The design and development of solar cells is based on a thorough understanding of the photovoltaic effect, which is the process by which light can be transformed into useable electrical energy. The majority of solar cells used today use p-n junctions, which take advantage of the photovoltaic effect that happens at the interface of various materials. However, such designs are constrained by the Shockley–Queisser limit, which puts a hard cap on their theoretical maximum solar conversion efficiency and imposes a tradeoff between the voltage and current that can be produced via the photovoltaic effect.

Nonetheless, a fascinating phenomenon called the bulk photovoltaic (BPV) effect is present in some crystalline materials. Electrons stimulated by light can migrate coherently in a particular direction rather than reverting to their initial places in materials that lack internal symmetry. The BPV effect is created as a result of what are referred to as "shift currents." Alpha-phase indium selenide (α-In2Se3) has not yet been experimentally studied, despite experts' predictions that it would exhibit this feature.

A Japanese research team headed by Associate Professor Noriyuki Urakami from Shinshu University set out to investigate the BPV effect in α-In2Se3 in order to close this knowledge gap. The journal Applied Physics Letters has published their findings.

Because of its potential to produce a shift current, this material has recently gained a lot of attention in the field of condensed matter physics. This prediction has never been experimentally proven before, according to our findings," Prof. Urakami says.

Initially, a thin α-In2Se3 layer was positioned between two transparent graphite layers to create a layered device. In order to monitor any currents produced by light irradiation, these graphite layers were used as electrodes and coupled to an ammeter and a voltage source. It is noteworthy that the researchers utilized this particular layer configuration because they concentrated on the shift currents in the α-In2Se3 layer that were occurring in the out-of-plane direction.

The presence of shift currents in the out-of-plane direction was confirmed by the researchers after testing with varying external voltages and incident light frequencies, hence validating the predictions described above. The BPV effect was present across a broad spectrum of light frequencies.

Above all, the researchers measured the BPV effect's potential in α-In2Se3 and contrasted it with that of other materials. Prof. Urakami says, "Our α-In2Se3 device demonstrated a quantum efficiency that is comparable to that of low-dimensional materials with enhanced electric polarization, and several orders of magnitude higher than other ferroelectric materials." "This discovery will direct the selection of materials for the development of functional photovoltaic devices in the near future," he continues.

By advancing the field of renewable energy generation, the research team hopes that their work will eventually have a good environmental impact. One of the most important technologies for environmental energy harvesting and a promising path towards a carbon-neutral future, solar cells, could be further accelerated by our results, Prof. Urakami says with optimism.

In addition to improving the design of sensitive photodetectors, we expect that this discovery opens the door for future research aimed at utilizing the BVP effect to significantly boost solar cell performance.