# Scientists lay foundations for new type of solar cell

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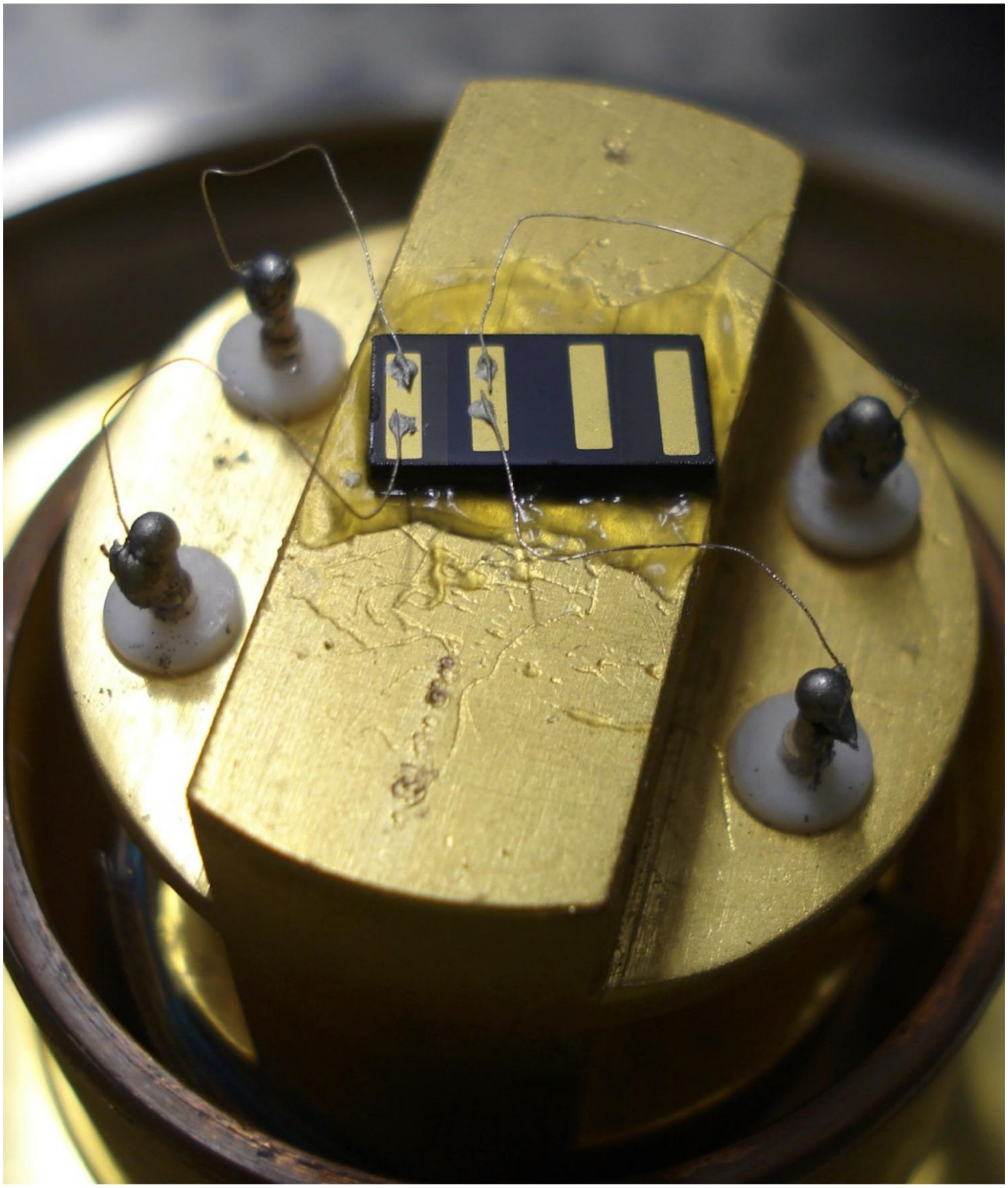

The experimental polaron solar cell in the lab. Credit: Dirk Raiser, MPIbC/DESY

An interdisciplinary team of researchers has laid the foundations for an entirely new type of photovoltaic cell. In this new method, infrared radiation is converted into electrical energy using a different mechanism from that found in conventional solar cells. The mechanism behind the new solid-state solar cell made of the mineral perovskite relies on so-called polaron excitations, which combine the excitation of electrons and vibrations of the crystal lattice.

The scientists from the research groups of Prof. Christian Jooss at the University of Göttingen, Prof. Simone Techert, Leading Scientist at DESY, Professor at the University of Göttingen and head of a research group at the Max Planck Institute for biophysical Chemistry in Göttingen, and Prof. Peter Blöchl at the Technical University of Clausthal-Zellerfeld present their work in the journal *Advanced Energy Materials*.

"In conventional solar cells, the interaction between the electrons and the lattice vibrations can lead to unwanted losses, causing substantial problems, whereas the polaron excitations in the perovskite solar cell can be created with a fractal structure at certain operating temperatures and last long enough for a pronounced photovoltaic effect to occur," explains the main author of the paper, Dirk Raiser, from the Max Planck Institute for Biophysical Chemistry in Göttingen and DESY. "This requires the charges to be in an ordered ground state, however, corresponding to a sort of crystallisation of the charges, which therefore allows strong cooperative interactions to occur between the polarons."

The perovskite solar cells studied by the team had to be cooled in the laboratory to around minus 35 degrees Celsius, in order for the effect to take place. If this effect is to be used in practical applications, it will be necessary to produce ordered polaron states at higher temperatures. "The measurements so far were made in a carefully characterised reference material, in order to demonstrate the principle of the effect. For this purpose, the low transition temperature was accepted," explains co-author Techert.

Material physicists at Göttingen are trying to modify and optimise the material in order to achieve a higher operating temperature. "Also, we might be able to achieve the cooperative state temporarily through the cunning use of additional light to produce the excitation," says Techert. If one of these strategies proves successful, future solar cells or photochemical energy sources could be made using perovskite oxide compounds, of which an abundant supply exists.

"Developing high efficiency and simply constructed solid-state solar cells is still a scientific challenge which many teams around the world are working on, in order to ensure the future of our energy supply," emphasises the research director Christian Jooss. "In addition to optimising the material and the design of existing solar cells, this also involves exploring new, fundamental mechanisms of light-induced charge transport and conversion into electrical energy. This should allow us to develop solar cells based on new operating principles."

This is precisely what the interdisciplinary team of material physicists, theoretical physicists, chemical physicists and X-ray physicists has now achieved within the collaborative research centre SFB 1073 for "Atomic-Scale Control of Energy Conversion" in Göttingen. A key factor in studying the new principle of solar cell operation was the ultra-fast methods of optical and structural analysis that were used in the current as well as in earlier work on this topic.

"Measuring dynamic processes in molecular units, like in the molecular movie approach, calls for the use of brilliant and ultra-fast X-ray sources, such as PETRA III at DESY or the European Free-Electron Laser, European XFEL, which goes into operation this year," emphasises Techert. "Examinations like these, some of which were already used in the current study, lead to a new level of understanding of charge transfer processes, which in turn makes possible new solar cell functions."

**More information:** Dirk Raiser et al, Evolution of Hot Polaron States with a Nanosecond Lifetime in a Manganite Perovskite, *Advanced Energy Materials* (2017). DOI: 10.1002/aenm.201602174

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