Predicting solar cell performance from terahertz and microwave spectroscopy

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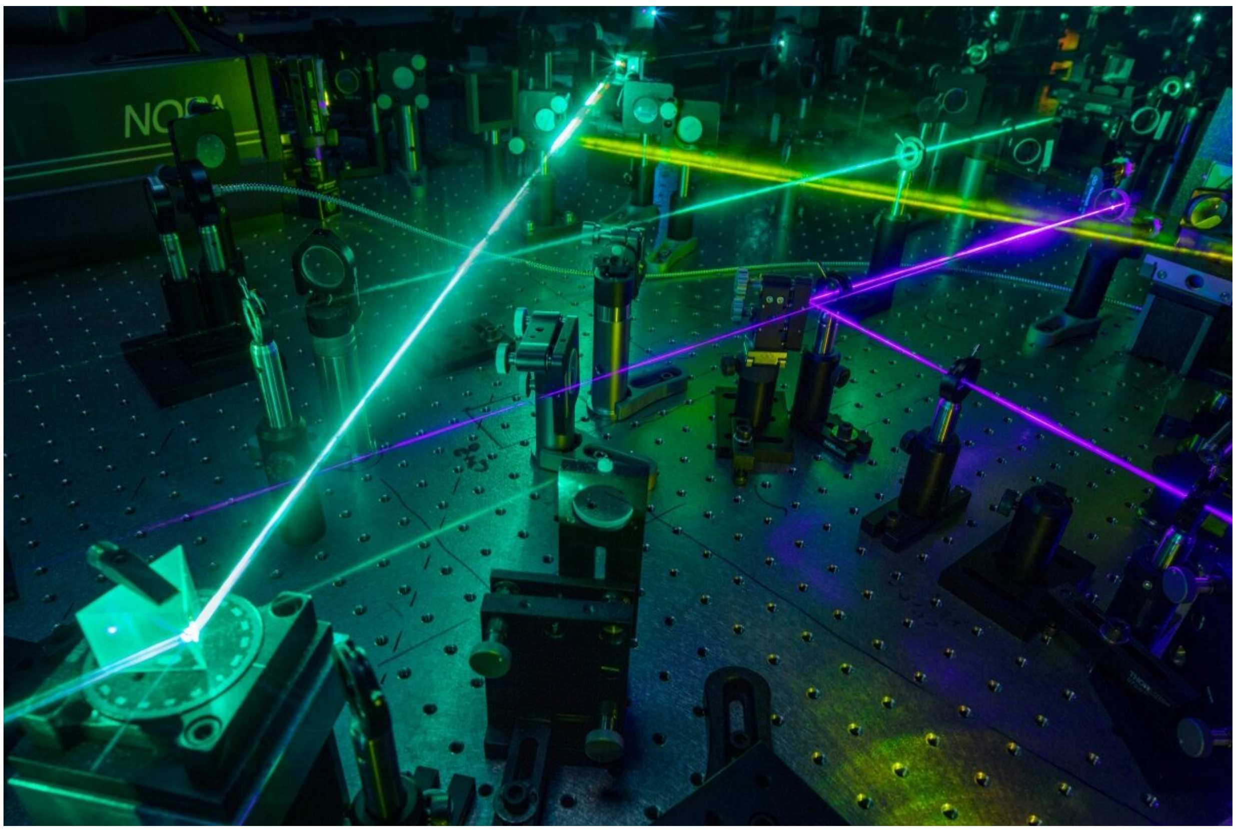

In the femtosecond laser laboratory of Dr. Dennis Friedrich at HZB, the transport properties of semiconductors can be determined using terahertz or microwave spectroscopy. For this purpose, a laser light pulse first excites the charge carriers in the material, which are then irradiated with electromagnetic waves (either THz or Microwave) and absorb some of them. Credit: HZB

The most important properties of a semiconductor to be used as a solar cell include the mobility and lifetime of electrons and "holes". Both quantities can be measured without contacts with spectroscopic methods using terahertz or microwave radiation. However, measurement data found in literature often differ by orders of magnitude. This has made it difficult to use them for reliable assessments of material quality.

Reference samples measured

"We wanted to get to the bottom of these differences, and contacted experts from a total of 15 international laboratories to analyze typical sources of error and problems with the measurements," says Dr. Hannes Hempel from the HZB team led by Dr. Thomas Unold. The HZB physicists sent reference samples produced by the team of Dr. Martin Stolterfoht at University Potsdam to each laboratory with the perovskite semiconductor compound $(Cs,FA,MA)Pb(I,Br)_3$) optimized for stability.

Better data for better prediction

One result of the joint work is the significantly more precise determination of the transport properties with terahertz or microwave spectroscopy. "We could identify some neuralgic points that have to be considered before the actual measurements takes place, which allows us to arrive at significantly better agreement of the results," Hempel emphasizes.

Another result of the study: With reliable measurement data and a more advanced analysis, the characteristics of the solar cell can also be calculated more precisely. "We believe that this analysis is of great interest for photovoltaic research, because it predicts the maximum possible efficiency of the material in a solar cell and reveals the influence of various loss mechanisms, such as transport barriers," says

Unold. This applies not only to the material class of perovskite semiconductors, but also to other new semiconducting materials, which can thus be tested more quickly for their potential suitability.

The research was published in *Advanced Energy Materials*.

More information: Hannes Hempel et al, Predicting Solar Cell Performance from Terahertz and Microwave Spectroscopy, *Advanced Energy Materials* (2022). DOI: 10.1002/aenm.202102776

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