Electrical transients quantify charge loss in solar cells

March 13 2020, by Zhang Nannan

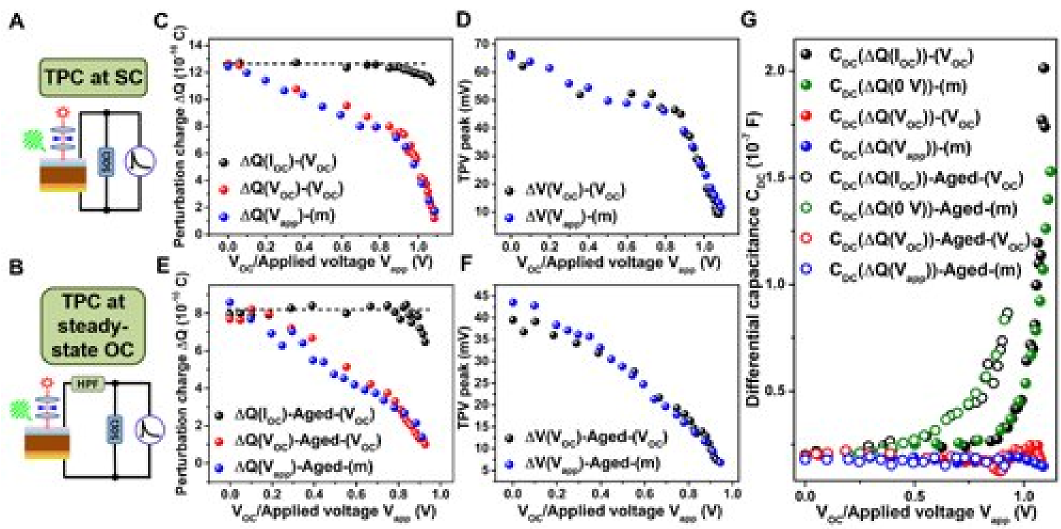

Fig.1 Accurate measurement of the CDC. Credit: Institute of Physics

Solar cells are photovoltaic devices that convert light to electricity. During the photoelectric conversion process, a photovoltaic device internally undergoes multiple charge-carrier dynamics processes. These internal charge-carrier processes intrinsically dominate the performance of a photovoltaic device itself.

So, here come the questions. How can we accurately measure these charge-carrier dynamics parameters? How can we accurately understand the physical mechanism of these dynamic processes? It is an important research topic in the fields of photo-electrics and electro-optics. It is also a significant approach to evaluate material performance and guide device structure optimization to improve performance of photovoltaic devices.

Prof. Meng Qingbo's group from Institute of Physics, Chinese Academy of Sciences has been devoting to the development of quantitative measurement and analysis methods of physics properties such as charge dynamics and defect states of solar cells while exploring new high-performance thin-film solar cells, and has achieved a series of research results.

For instance, a modulated transient photoelectric measurement system has been successfully developed, which has realized the measurement of the charge dynamics of solar cells under actual operating conditions. The measurement of ion dynamics for perovskite solar cells has also been achieved. Quantitative analysis of the interface and bulk defect distribution of solar cells has been studied and the origin of the electrical stability of perovskite solar cells has also been elucidated.

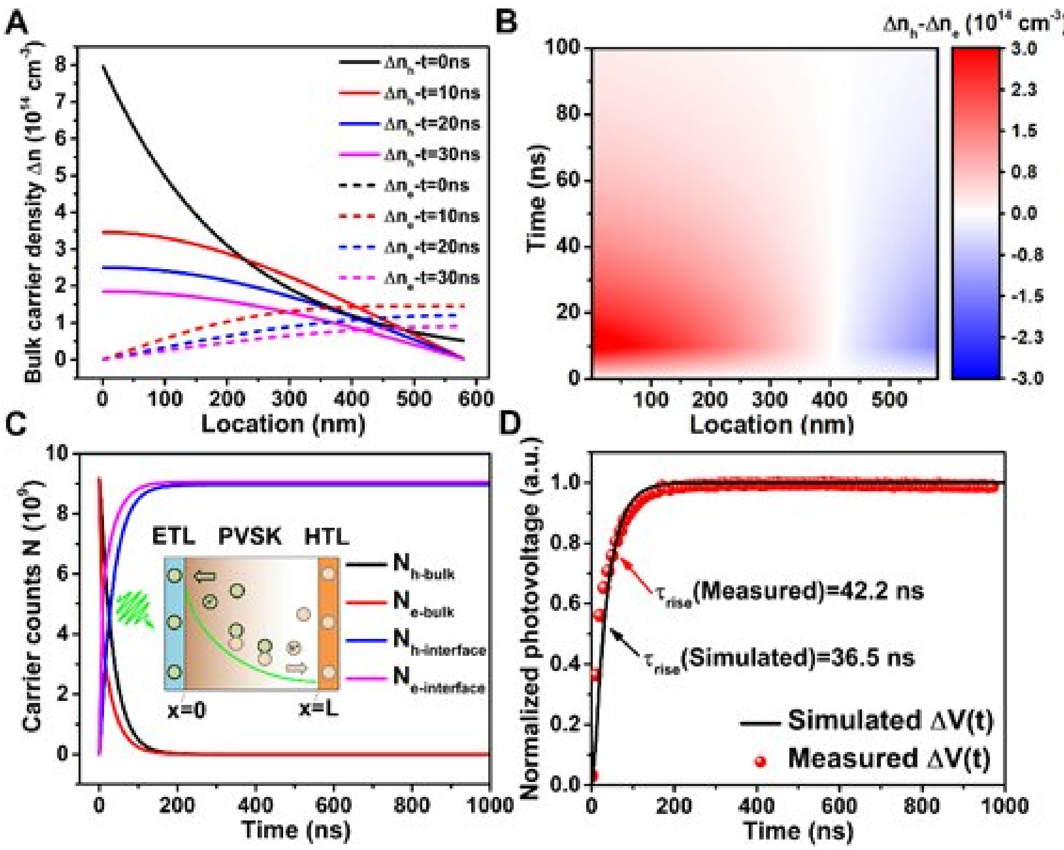

Fig.2 Simulation of the charge transport within the perovskite absorber and the establishing process of the photovoltage. Credit: Institute of Physics

Recently, Meng's group focused on the differential capacitance of photovoltaic devices to discuss the validity of conventional tail state framework based on electrical transient technologies.

They pointed out that conventional tail state model has certain unreasonable assumptions on the consistency of the measurement state of the devices and the physics process for the establishment of transient photovoltage.

Furthermore, they proved this conventional tail state framework based on the electrical transient technologies is not universal and rational in the fields of measurement and research for solar cells.

After simulating carrier dynamics and charge loss mechanism behind electrical transients through theoretical calculation, they proposed a new analysis methodology to quantitatively extract charge dynamics properties and charge loss mechanism of photovoltaic devices (such as charge extraction and collection quantum efficiency and the density of defects within the absorber) from the electrical transient technologies. This methodology is universal to study conventional silicon, emerging kesterite and perovskite solar cells herein and is able to extend to other similar photovoltaic device systems.

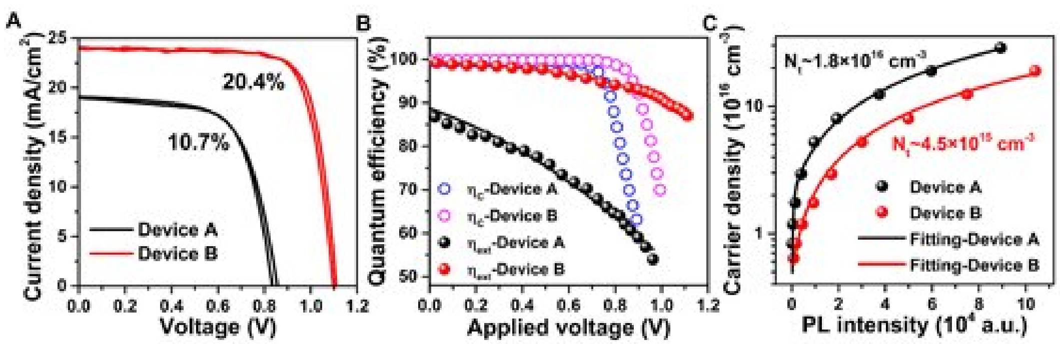

Fig.3 Electrical transients study of perovskite solar cells, such as charge extraction and collection quantum efficiency (B) and the density of defects within the absorber (C). Credit: Institute of Physics

This work provides an alluring route for a comprehensive investigation of dynamic physics processes and charge loss mechanism of solar cells and possesses potential applications for other photoelectric devices.

This study entitled "Exploiting Electrical Transients to Quantify Charge Loss in Solar Cells" was published in *Joule*.

More information: Yiming Li et al. Exploiting Electrical Transients to Quantify Charge Loss in Solar Cells, *Joule* (2020). DOI: 10.1016/j.joule.2019.12.016

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