Mystery of negative capacitance in perovskite solar cells solved

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On the verge of outcompeting current thin-film solar cells, perovskite solar cells seem to embody an ideal solar cell with high efficiency and low cost. However, they have poor long-term stability, which remains a challenge. Related to this are peculiar phenomena occurring in

perovskite materials and devices, where very slow microscopic processes cause a kind of "memory effect."

For instance, measuring the efficiency of a perovskite solar cell can depend on things like how long the device is illuminated prior to measurement or how the voltage was applied. A few years ago, this effect, known as current-voltage hysteresis, led to disputes on accurately determining the efficiency of perovskites. Another example of these obscure processes is a (partial) recovery of a previously degraded solar cell during day-night cycling.

Such effects are a concern when measuring solar cell performance as a function of frequency, which is a typical measurement for characterizing these devices in more detail (impedance spectroscopy). They lead to large signals at low frequencies (Hz to mHz) and giant capacitance values (mF/cm^2), including strange, "unphysical" negative values that are still a puzzle to the research community.

Now, chemical engineers from the lab of Anders Hagfeldt at EPFL have solved the mystery. Led by Wolfgang Tress, a scientist in Hagfeldt's lab, they found that the large perovskite capacitances are not classical capacitances in the sense of charge storage, but just appear as capacitances because of the cells' slow response time.

The researchers show this by measurements in the time domain and with different voltage scan rates. They find that the origin of the apparent capacitance is a slow modification of the current passing the contact of the solar cells, which is regulated by a slow accumulation of mobile ionic charge. A slowly increasing current appears like a negative capacitance in the impedance spectra.

The work sheds light onto the interaction between the photovoltaic effect in these devices and the ionic conductivity of perovskite materials.

Gaining such in-depth understanding contributes to the endeavor to tailored, stable perovskite solar cells.

More information: Firouzeh Ebadi et al. Origin of apparent light-enhanced and negative capacitance in perovskite solar cells. *Nature Communications* 05 April 2019. DOI: 10.1038/s41467-019-09079-z

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