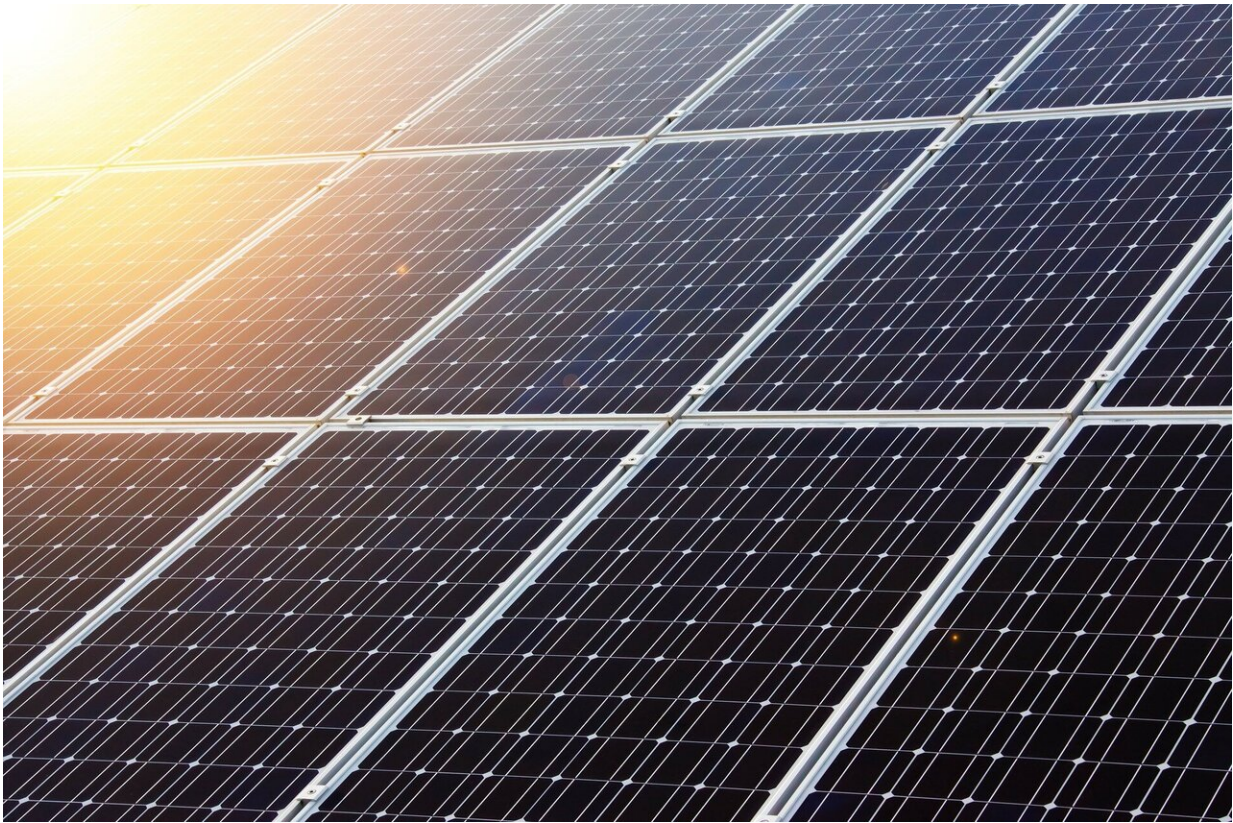


New carbon dot-based method for increasing the efficiency of solar cells and LEDs

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An international group of scientists, including some from ITMO University, has proposed a method that allows for significantly increasing the efficiency of solar cells and light-emitting diodes. The

scientists managed to achieve this result by augmenting the auxiliary layers of the devices responsible for electron transport rather than working with the main active layer. The work has been published in the journal *Advanced Functional Materials*.

The struggle to preserve the environment and sharp fluctuations in oil and gas prices lead to the fact that investors are increasingly looking towards [renewable energy](#). That is why scientists in different countries are actively working to make the process of generating energy from renewable sources as efficient as possible. For instance, work is currently underway to increase the efficiency of solar [cells](#), one of the most popular green energy sources in the world.

Typically, scientists work with the active layer of the cells, which is responsible for absorbing luminous energy—they are made from silicon, gallium arsenide, perovskite and other materials. But the efficiency, cost and durability of a solar cell depend not only on the active layer but also the auxiliary ones. Increasing their efficiency while simultaneously decreasing production costs can allow us to boost competitive advantages of a device.

The auxiliary layers of a solar cell can be of an [electron-transport](#) or hole-transport type. When sunlight reaches the active layer, pairs of electrons and electron holes, in other words, a negative and a positive charge, are formed in it. After that, they need to be taken to their corresponding electrodes. And this is where the auxiliary layers come in: the electron-transport one is responsible for extracting and transferring the negative charge from the active layer, while the hole-transport layer performs the same operations with the positive one. An international group of scientists, including those from ITMO University, has proposed a new method for the creation of auxiliary layers for solar cells and light-emitting diodes based on perovskite. They used [carbon dots](#)—an environmentally friendly and relatively cheap material that can easily be

obtained both in laboratory and industrial conditions.

"Carbon dots are carbon-based nanoparticles with a diameter of two to ten nanometers," explains Aleksandr Litvin, a senior research associate at ITMO University and a co-author of the research. "Their surface always contains various functional groups that largely determine the properties of this material. The application of carbon dots in solar batteries isn't something new, what's important is the modification of their surface by means of working with the functional groups. A different ratio of these groups on the surface determines the electronic configuration of carbon dots. Consequently, tailoring this allows us to get the optimal values of the working functions of the electrodes and the energy levels of the transport layers on which they are applied. This makes it possible to obtain optimal configuration with maximum efficiency. This approach is universal for different types of devices, which for the first time has allowed the use of carbon dots for increasing the operational efficiency of light-emitting diodes."

Obtained in this way, the material can be used not only for solar cells but also the auxiliary layers of light-emitting diodes. The latter have a broadly similar structure, but the process there is reversed: electrons and holes don't have to be removed from the active layer but, instead, injected into it in order to create electron-hole pairs the recombination of which in the active layer will ensure luminescence. In both cases, international colleagues of ITMO University scientists obtained a significant increase in efficiency of the devices created with the use of auxiliary layers made from the carbon dots.

"Devices have been created, and their properties have been tested," concludes Aleksandr Litvin. "In the case of perovskite-based solar cells, we managed to obtain an increase in efficiency from 17.3% to 19.5%, that is, by almost 13%. In the case of light-emitting diodes, depending on the material of the emission [layer](#), the external quantum efficiency (the

ratio of the number of photons emitted by an LED to the number of electrons injected into it) increased by 2.1—2.7 times."

More information: Xiaoyu Zhang et al, Energy Level Modification with Carbon Dot Interlayers Enables Efficient Perovskite Solar Cells and Quantum Dot Based Light-Emitting Diodes, *Advanced Functional Materials* (2020). [DOI: 10.1002/adfm.201910530](https://doi.org/10.1002/adfm.201910530)

Provided by ITMO University

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