Rational transparent conductor design provides a boost to carbon nanotubes application

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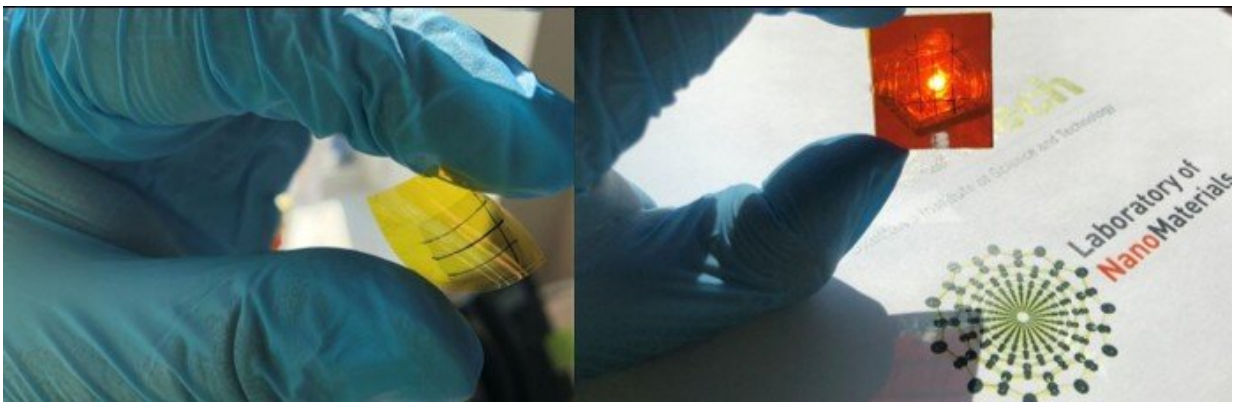

Scientists at the Skolkovo Institute of Science and Technology (Skoltech) chose to address this by developing a novel rational design of unifying a multilayered combination of films with carbon nanotubes, conductive polymers, transition metal oxides and carbon nanotube fibers. Credit: Skolkovo Institute of Science and Technology

An international team of scientists led by researchers from the Laboratory of Nanomaterials at the Skoltech Center for Photonics and Quantum Materials (CPQM) has rationally designed a novel p-type flexible transparent conductor using single-walled carbon nanotubes. This opens new avenues for its applications in next generation opto-electronics and energy technologies. The results of the study were

published in *Nano Energy*.

Most of the optical and electronic devices encountered daily are constituted of transparent conductors. However, all the presently available transparent conductors are n-type semiconductors, thus restricting technological advancement. The emergence of carbon nanotubes as p-type transparent conductors has been promising. Its further development will be tremendously instrumental for various opto-electronics and energy technologies.

The Skoltech team together with its partners from Aalto University (Finland), DLR Institute of Networked Energy Systems (Germany) and Tallinn University of Technology (Estonia) utilized this newly developed p-type transparent conductor in solar cells. "We discovered the use of thin multicomponent layers and the introduction of carbon nanotube fibers in a dramatic improvement in the p-type transparent conductor development. Moreover, carbon nanotube fibers by themselves can be used as a replacement for traditional metal contacts. However, the most fascinating result was the solar cells fabricated at room temperature using the developed p-type transparent conductor and amorphous silicon, which are classified specially as hybrid devices and yield a record power conversion efficiency (conversion efficiency of sunlight to electricity) of 8.8 percent. This is an effective 16 percent increase over the traditional amorphous silicon solar cells, thus highlighting the efficacy of the developed p-type transparent conductor. We have progressed from the initial 1.6 percent and 3.4 percent reported previously in 2016 and 2018 respectively to 8.8 percent in 2019 using our newly developed p-type transparent conductor for such hybrid thin film solar cells," says the first author of the study and Ph.D. Student at Skoltech, Pramod M. Rajanna.

"We have developed a p-type transparent conductor with a state-of-the-art sheet resistance of 17 Ω/sq at a transmittance of 90 percent in the middle of the visible spectrum and a high degree of mechanical

flexibility. The newly developed conductor is certainly revolutionary for various single-walled carbon nanotube applications. We anticipate that this will open new avenues for its application in widespread technologies such as optoelectronics, photonics and energy," explains Albert Nasibulin, Professor of RAS and Head of Skoltech's Laboratory of Nanomaterials.

More information: Pramod M. Rajanna et al. Rational design of highly efficient flexible and transparent p-type composite electrode based on single-walled carbon nanotubes, *Nano Energy* (2019). DOI: 10.1016/j.nanoen.2019.104183

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