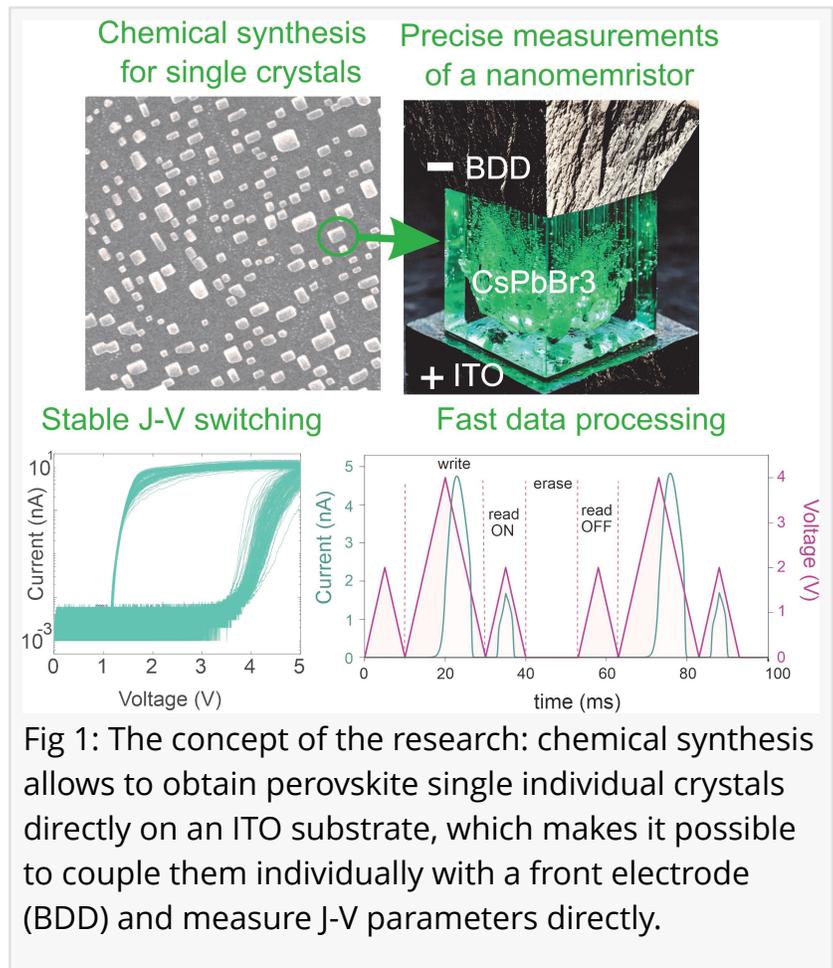


Halide perovskite volatile unipolar Nanomemristor

Miniaturization of perovskite memristors would be useful for creating high-density memory devices.

CHENGDU, SICHUAN, CHINA, November 3, 2025 /EINPresswire.com/ -- The last experimentally fundamental passive circuit element is the memristor that was originated in 2008 by Dmitri Strukov and presents a thin-film dielectric material with oxygen vacancies placed between two electrodes. This element changes its resistance based on the amount and direction of current that has flowed through it and its resistance has non-linear behavior from the current flow. [Memristors](#) are used in neuromorphic computing, data storage systems, and various devices for information processing and consume less power than basic silicon transistors. These elements are an attractive subject for modern scientific community due to their advantages of some characteristics: fast read time, quick write/erase time together with potentially infinite retention time and ability to store a large amount of data in a compact size.

These features can be used not only to develop more advanced information storage systems but also to implement memristors in data stream processing. Since processing is performed directly in the memory element, this ensures cost-effective and energy-efficient real-time computations. The application of artificial intelligence will benefit from the use of neuromorphic processors, including those based on memristors. These systems will allow neural networks to learn locally, even on smartphones. Today, researchers are developing various memristor systems that could potentially be used for machine vision, acoustic-speech systems, and even as biointerfaces.



[The selection of a material semiconductor](#), as well as contact, the element size and quality define key physical properties and memristor long-term stability. Today lead halide perovskite polycrystalline films or microparticles can be considered as a new gold rush in terms of various semiconductor device fabrication: solar cells, photodiodes, LED, LEC, scintillators, sensors as well as a good semiconductor for memristors with and without filament generation. Despite many previous research reported about conductive filament formation in thin film perovskite films, which is responsible for switch of resistance and forms at contact with metal, it is still difficult to talk confidently about stable electric characteristics of these perovskite memristors under voltage load. Although some [perovskite-based devices](#) with metallic electrodes exhibit low stability under varying environmental conditions at room humidity and temperature-assisted penetration of metal ions, which may spoil a semiconductor material. Key issues include cycling endurance, switching optimization, power consumption reduction, and miniaturization of a single element. Another problem is the understanding of the underlying switching mechanisms, and more research is needed to elucidate the role of defects and ion migration in the performance of perovskite memristors.

About the Research Group:

The research group of Prof. Makarov under Prof. Furasova supervision from ITMO University (Russia) and Harbin Engineering University (China) introduce one of the smallest memristor based on perovskite semiconductor. Their memristor is based on a monocrystal nanocube with chemical composition of CsPbBr₃, one of the most chemically resistant lead - halide perovskite, placed between two chemically inert contacts: ITO and boron-doped diamond. Here researchers tested how the thickness of the cube affects resistive switching and power consumption. They have achieved one of the smallest value of a power consumption required for switching of memristive state - 70 – 80 nW for 130-150 nm perovskite single crystals, which make their memristors extremely energy efficient. The current difference between so called "0" and "1" states is over 10^5 and makes them clear for computation and readable. Here researchers used the well-established drift diffusion model to simulate charge carrier transport within the perovskite to explain its memristive behavior. Unlike to conventional approaches in classical semiconductors that consider only electronic charge carriers, their model incorporates two types of mobile ionic species anions and cations present in the crystal lattice. Due to their relatively slow mobility compared to electrons and holes, these ions modulate the internal electrical potential of the perovskite semiconductor over time. This modulation leads to variations in current flow depending on the rate and direction of the applied voltage sweep. Such slow ionic response gives rise to a memory effect, where the device retains information about the history of applied potential. These results highlight that this memory behavior is not solely due to ion redistribution; the interaction between mobile ions and contacts plays a crucial role by reducing the energy barrier height and facilitating electronic charge carrier tunneling. This combined ionic and interfacial mechanism underpins the observed memory functionality in the device.

About the Authors:

Abolfazl Mahmoodpoor was admitted to a second Master's program at ITMO University, where

he researched numerical modeling of solar cells. Currently, he is a fourth-year PhD student at ITMO University, investigating ions migration in perovskite semiconductors. Prokhor Alekseev has completed his Ph.D from Saint-Petersburg Electrotechnical University "LETI". He is working at Surface Optics Laboratory (Ioffe Institute) and ITMO since 2008. His work is focused on scanning probe microscopy and semiconductor physics. He has published more than 100 scientific papers. Ksenia Gasnikova started to employ scanning probe microscopy for nanostructures characterization at Ioffe Institute in 2023. She is a master student at ITMO University. Sergey Makarov has completed his Ph.D from Lebedev Physical Institute of Russian Academy of Sciences and Habilitated at ITMO University. He is the head of laboratory of Hybrid Nanophotonics and Optoelectronics at ITMO University and co-director of the International Research Center for Nanophotonics and Metamaterials at Harbing Engineering University in Qingdao Campus. His current work is focused on perovskite-based nanophotonics and optoelectronics. In total, he has published more than 400 scientific papers about semiconductor-based nanophotonics, novel methods of nanofabrication, as well as LEDs, solar cells, photodetectors, and lasers made of solution processible materials. Aleksandra Furasova has completed her Ph.D from ITMO and Tor Vergata University of Rome, she is a leader in perovskite devices fabrication and experimental characterization.

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