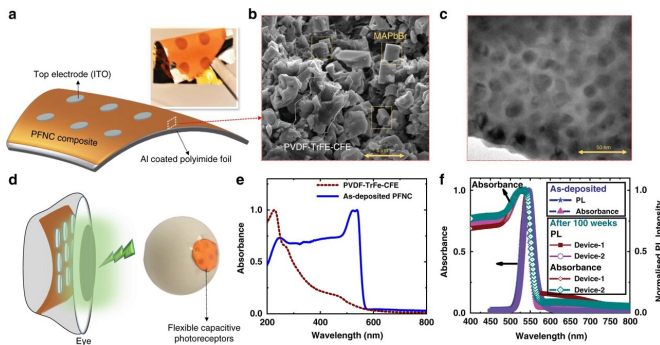


Perovskites used to make efficient artificial retina

23 February 2022



The flexible capacitive photoreceptors (CPRs) and material characterization. a Schematic of the flexible CPR showing the perovskite ferroelectric nanocomposite (PFNC) sandwiched between transparent top electrodes indium tin oxide (ITO) and aluminum (Al) coated polyimide substrate. (Inset shows the fabricated device). b The cross-sectional scanning electron microscope (SEM) image of the PFNC thin-film. c Transmission electron microscope image of the PFNC showing the perovskite nanocrystals embedded in the polymer. d Representative schematic to depict that flexible capacitor as photoreceptors of the retina and the digital photograph of the flexible CPRs array shaped into hemispherical form. e UV-VIS absorbance spectra of perovskite ferroelectric polymer nanocomposite (PFNC) and the ferroelectric polymer. f Absorbance and photoluminescence spectra of the as-deposited PFNC and devices after 100 weeks of fabrication, confirming the stability of the $\text{CH}_3\text{NH}_3\text{PbBr}_3$ in the nanocomposite. Credit: DOI: 10.1038/s41377-021-00686-4

An artificial electronic retina that can "see" in a similar way to the human vision system and can recognize handwritten digits has been built by KAUST researchers as they seek to develop better options for computer vision applications.

Mani Teja Vijjapu, an electrical engineering Ph.D. student, Khaled Nabil Salama and coworkers have designed and fabricated an [array](#) of photoreceptors that detect the intensity of visible

light via a change in electrical capacitance, mimicking the behavior of the eye's rod retina cells. When the array was connected to an electronic CMOS-sensing circuit and a spiking neural network (a single-layer network with 100 output neurons), it was able to recognize handwritten numbers with an accuracy of around 70 percent.

"The ultimate goal of our research in this area is to develop efficient neuromorphic vision sensors to build efficient cameras for computer vision applications," explained Salama. "Existing systems use photodetectors that require power for their operation and thus consume a lot of energy, even on standby. In contrast, our proposed photoreceptors are capacitive devices that don't consume static power for their operation."

The photoreceptor array is made by sandwiching a material with suitable optical and dielectric properties between a bottom aluminum electrode and a patterned top electrode of indium tin oxide to form a pixelated array of miniature light-sensitive metal-insulator-metal capacitors. The array is made on a thin substrate of polyimide so that it is flexible and can be curved as desired, including a hemispherical shape mimicking the human eye.

In selecting materials for their [photoreceptor](#), the KAUST team used a hybrid material of perovskite (methylammonium lead bromide (MAPbBr_3)) nanocrystals embedded in terpolymer polyvinylidene fluoride trifluoroethylene-chlorofluoroethylene (PVDF-TrFE-CEF). Already of great interest in solar cell research, MAPbBr_3 is a strong absorber of visible light, while PVDF-TrFE-CEF has a high dielectric constant. "We chose hybrid perovskites because of their exceptional photoelectronic properties, such as excellent light absorption, long carrier lifetime and high carrier mobility," explained Vijjapu.

Tests with a 4x4 array and LED illumination of different visible colors indicate that the optical

response of the array mimics the response of the human eye with a maximum sensitivity to green light. Importantly, the photoreceptors are also found to be highly stable, with no change in response even after being stored for 129 weeks in ambient conditions.

Future plans for the team include building larger arrays of photoreceptors, optimizing the interface circuit design and employing a multilayered [neural network](#) to improve the accuracy of the recognition functionality.

More information: Mani Teja Vijjapu et al, A flexible capacitive photoreceptor for the biomimetic retina, *Light: Science & Applications* (2022). [DOI: 10.1038/s41377-021-00686-4](#)

Provided by King Abdullah University of Science and Technology

APA citation: Perovskites used to make efficient artificial retina (2022, February 23) retrieved 4 July 2022 from <https://techxplore.com/news/2022-02-perovskites-efficient-artificial-retina.html>

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