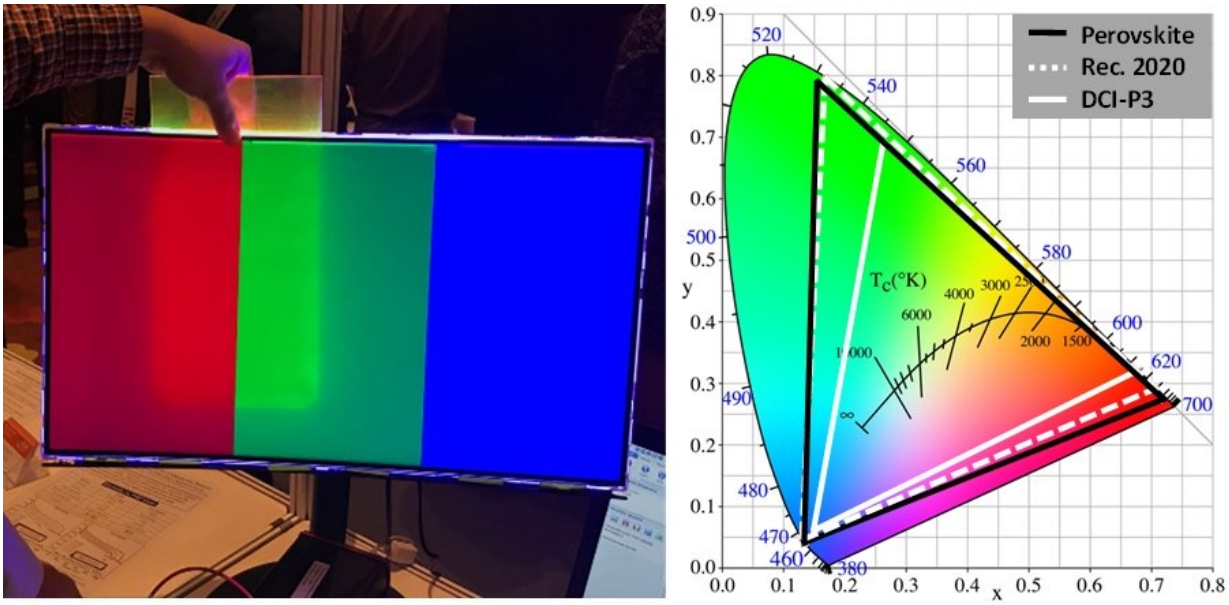
Creating displays with richer colours

July 9 2018



(Left) Photo showing the colour-enhancement effect from using a prototype of the perovskite-based film. When the film is placed between the backlight unit and the display screen, a spectrally “purer” red and green colour is observed. (Right) Figure showing the coverage of the colour space by perovskite, compared to Rec. 2020 and DCI-P3 colour standards. Credit: National University of Singapore

National University of Singapore researchers have developed a colour-enhancement film that could bring richer and more natural colours to next-generation flat-panel electronic displays.

Current commercial display technologies such as OLEDs (organic light-emitting diodes) and QLED (quantum dot light-emitting diodes) can only produce slightly more than 50 percent of the colours visible to the human eye. This limits the colour reproduction that these displays can achieve.

A research team led by Prof TAN Zhi Kuang from the Department of Chemistry and the Solar Energy Research Institute of Singapore (SERIS) at NUS has developed a colour-enhancement film that could allow future display technologies to produce more than 75 percent of all visible colours. This technology is enabled by a semiconductor material known as perovskites, which can be tuned by changing its chemical composition to emit light strongly and efficiently in a variety of colours. To make the enhancement films, the research team mixed nanometre-sized crystals of the perovskite material with a liquid monomer (precursor of plastics), and triggered a polymerisation reaction by illuminating the mixture with white light.

This process allowed the team to fabricate a strongly luminescent perovskite-polymer composite film that possesses a threefold enhancement in luminescence efficiency compared to a conventional perovskite nanocrystal film. The improved luminescence performance is a result of the increased spatial separation between the perovskite nanocrystals in the polymer composite material, which prevents the channelling of energy between crystals to the defective and non-emissive ones. This innovation allows perovskite materials to emit light more efficiently and consume less energy when deployed in a display product. Their colour performance can enable next-generation televisions and monitors to achieve the higher quality Rec. 2020 colour standard for ultra-high definition television (UHDTV), compared to the more limited DCI-P3 standard in current displays (see figure below).

In order to understand how displays produce a range of colours, it is

important to first appreciate how the human eye functions. Our eyes are able to perceive colours due to the presence of three types of cone cells that are sensitive to red, green and blue (RGB) colours. The different extent of stimulation of these cone cells allows us to see a myriad of colours. For instance, a combined stimulation of red and green cones will give the perception of yellow. Perovskite offers excellent colour performance because it is able to produce spectrally "purer" RGB light that is more specific in stimulating the three cone cells in our eyes. This greater control in cone stimulation allows displays to reproduce a wider range of colours that mimic what our eyes perceive in the real world.

Dr. WONG Ying Chieh, a member of the research team, said, "An added advantage is that perovskites are easy to synthesise, potentially facilitating their scale-up and reducing the production cost of displays. The time taken for perovskite precursor chemicals to react and form nanocrystals is typically on the order of 10 seconds."

"Perovskite materials can be coated and processed in a solution form which is similar to paints, and can potentially be used in large-area displays. Although our materials are useful in enhancing the performance of televisions and mobile devices, my vision is to put them into wall-sized displays in our living or work spaces to create realistic virtual environments with rich and natural colours," added Prof Tan.

The research team is currently working with display companies to commercialise the perovskite colour-enhancement film, and hopes to see the technology in consumer electronic products within the next two to three years.

More information: Ying-Chieh Wong et al. Perovskite-Initiated Photopolymerization for Singly Dispersed Luminescent Nanocomposites, *Advanced Materials* (2018). DOI: 10.1002/adma.201800774