# Two-dimensional MXene as a novel electrode material for next-generation display

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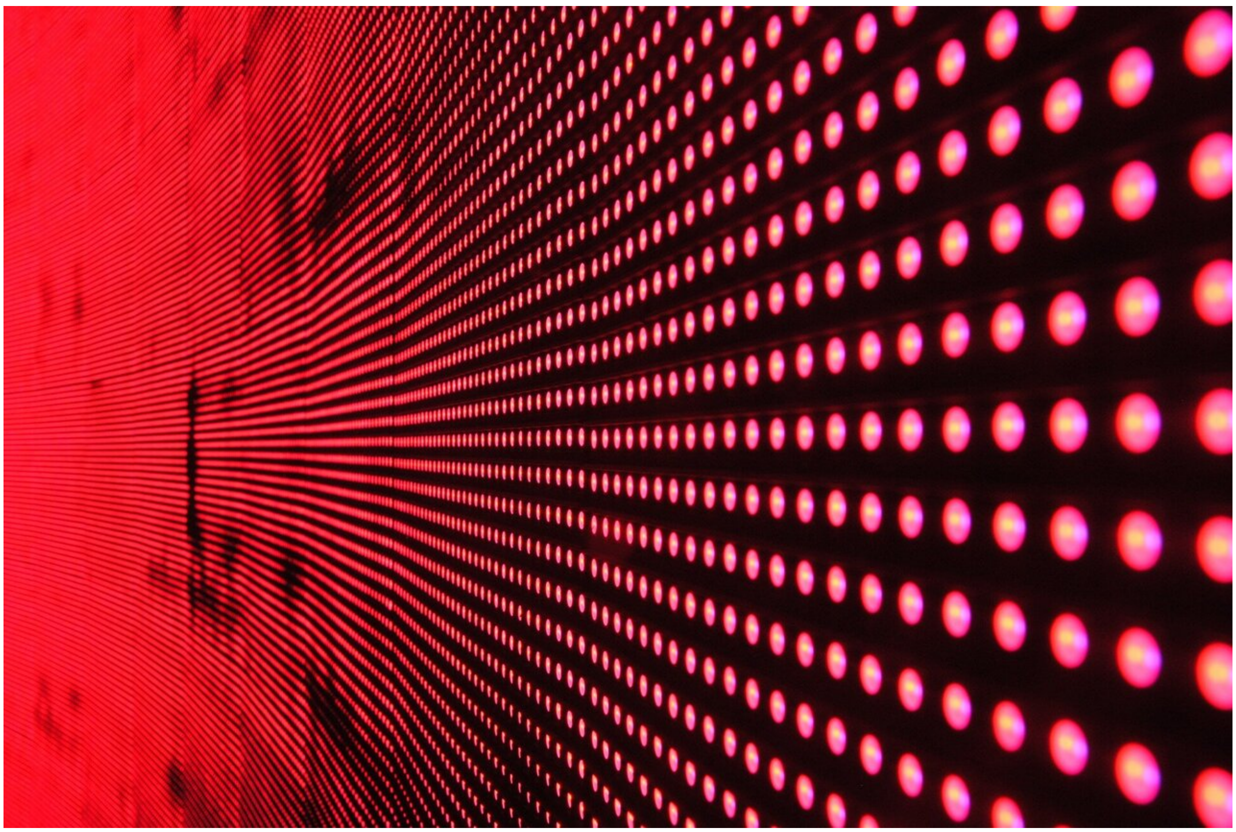

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Researchers in the US and Korea reported the first efficient flexible light-emitting diodes with a two-dimensional titanium carbide MXene as a flexible and transparent electrode. These MXene-based light-emitting diodes (MX-LED) with high efficiency and flexibility have been achieved via precise interface engineering from the synthesis of the material to the application.

Flexible displays have been developing at a fast pace and the global flexible display market has been expanding quickly over the years. Development of flexible transparent conducting electrodes (TCEs) with outstanding flexibility and electrical conductivity is one of the key requirements for next-generation displays because indium tin oxide (ITO), the conventional TCE, is brittle. Diverse materials such as graphene, conducting polymers and metal nanowires have been suggested but their insufficient electrical conductivity, low work function and complicated electrode fabrication limited their practical use.

## MXenes, a new family of two-dimensional materials

MXenes, a new class of two-dimensional materials discovered at Drexel University in 2011, consist of few-atoms-thick layers of transition metal carbides or nitrides. They have shown impressive properties such as metal-like electrical conductivity and tunable surface and electronic properties, offering new possibilities to the various fields of technology. Since their discovery, their use has been explored in a number of areas, such as metal ion batteries, sensors, gas and electrochemical storage, energy devices, catalysts and medicine. MXenes have exhibited potential as flexible electrodes because of their superior flexibility. However, exploration of MXenes in flexible electrodes of optoelectronic devices started only recently because the conventional MXene films do not meet the requirements of work function and conductivity in LEDs and solar cells, and can degrade when they are exposed to the acidic water-based hole injection layer (HIL).

# MXene for flexible LED application

An international team of scientists from Seoul National University and Drexel University, led by Tae-Woo Lee and Yury Gogotsi focused on the surface and interface modulation of the solution-processed MXene films to make an ideal MXene/HIL system. They tuned the surface of the MXene film to have high work function (WF) by low-temperature vacuum annealing and the HIL is designed to be pH-neutral and be diluted with alcohol, preventing detrimental surface oxidation and degradation of the electrode film. The MXene/HIL system suggested by the team provides advantages to the device efficiency due to efficient injection of holes to the emitting layer by forming a nearly ideal Ohmic contact.

Using the MXene/HIL system, the team fabricated high-efficiency green organic LEDs (OLEDs) exceeding 100 cd/A, which agrees well with the theoretical maximum values and is quite comparable with that of the conventional ITO-based devices. Finally, flexible MXene-LEDs on a plastic substrate show outstanding bending stability while the ITO-LEDs could not stand the bending stress. It is the first report that demonstrates highly efficient OLEDs using a single layer of 2-D titanium carbide MXene as a flexible electrode.

This research is published in the prominent journal *Advanced Materials*. The authors explain further: "The results of interface engineered MXene film and the MXene electrode-based flexible organic LEDs show the strong potential of the solution-processed MXene TCE for use in next-generation optoelectronic devices that can be manufactured using a low-cost solution-processing technology."

**More information:** Soyeong Ahn et al. A 2D Titanium Carbide MXene Flexible Electrode for High-Efficiency Light-Emitting Diodes, *Advanced Materials* (2020). DOI: 10.1002/adma.202000919

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