Photodoping in 2-D materials for fabrication of logic devices

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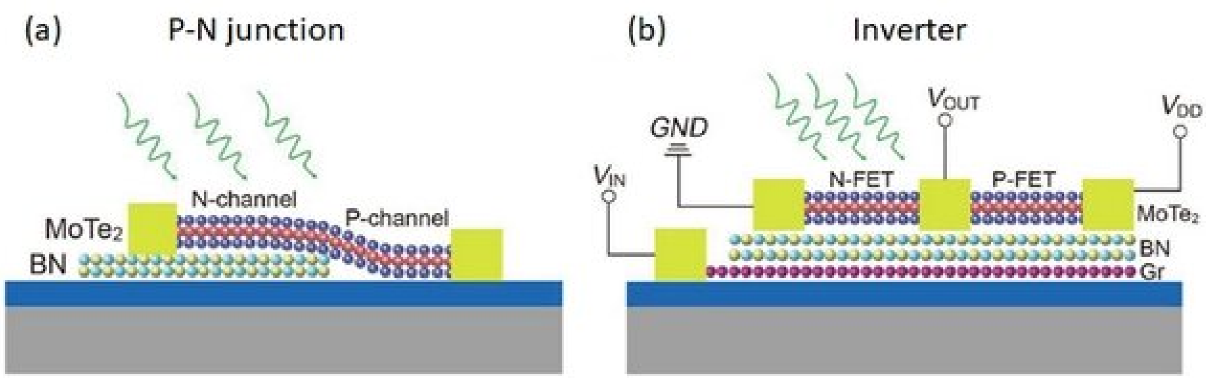

Figures (a) and (b) show the schematic illustration of a p-n junction and an inverter, respectively. Under light illumination and negative bias conditions, localized positive charges are left behind in the BN layer after the excited electrons travel into the MoTe2 layer. This induces doping effects in the MoTe2 layer. Credit: Advanced Materials

National University of Singapore scientists have discovered a method for photoinduced electron doping on molybdenum ditelluride ($MoTe_2$) heterostructures for fabricating next generation logic devices.

Two-dimensional (2-D) transition metal dichalcogenides (TMDs) are promising building blocks for the development of next generation electronic devices. These materials are atomically thin and exhibit unique electrical properties. Researchers are interested to develop n- and p-type field effect transistors (FET) using the 2-D TMDs for building fundamental logic circuit components. These components include p-n junctions and inverters.

A team lead by Prof Chen Wei from both the Department of Chemistry and the Department of Physics, NUS has discovered that light illumination can be used to induce doping effects on a $MoTe_2$-based FET to modify its electrical properties in a non-volatile and reversible manner. The FET made of a $MoTe_2$/BN heterostructure is fabricated by layering a thin flake of $MoTe_2$ onto a boron nitride (BN) layer and attaching metal contacts to form the device. The doping of the device can be changed by modifying the applied polarity to the BN layer under light illumination conditions. When the device is illuminated, the electrons occupying the donor-like states in the BN bandgap become excited and jump into the conduction band. By applying a negative bias to the BN layer, these photon-excited electrons travel into the $MoTe_2$ layer, effectively doping it into an n-type semiconductor. The positive charges which are left behind in the BN layer create a positive bias which helps to maintain the electron doping in the $MoTe_2$ layer. The research team found that without any external disturbance, the photodoping effect can be retained for more than 14 days.

The team has developed p-n junctions and inverters without the use of photoresist by selectively controlling the photodoping regions on the $MoTe_2$ material. From their experimental measurements, the $MoTe_2$ diode had a near-unity ideality factor of about 1.13, which is close to that for an ideal p-n junction.

Explaining the significance of the findings, Prof Chen said, "The discovery of a 2-D heterostructure-based photodoping effect provides a potential method to fabricate photoresist-free p-n junctions and inverters for the development of logic electronic devices."

More information: Tao Liu et al. Nonvolatile and Programmable Photodoping in MoTe2 for Photoresist-Free Complementary Electronic Devices, *Advanced Materials* (2018). DOI: 10.1002/adma.201804470

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