Multibit optoelectronic memory

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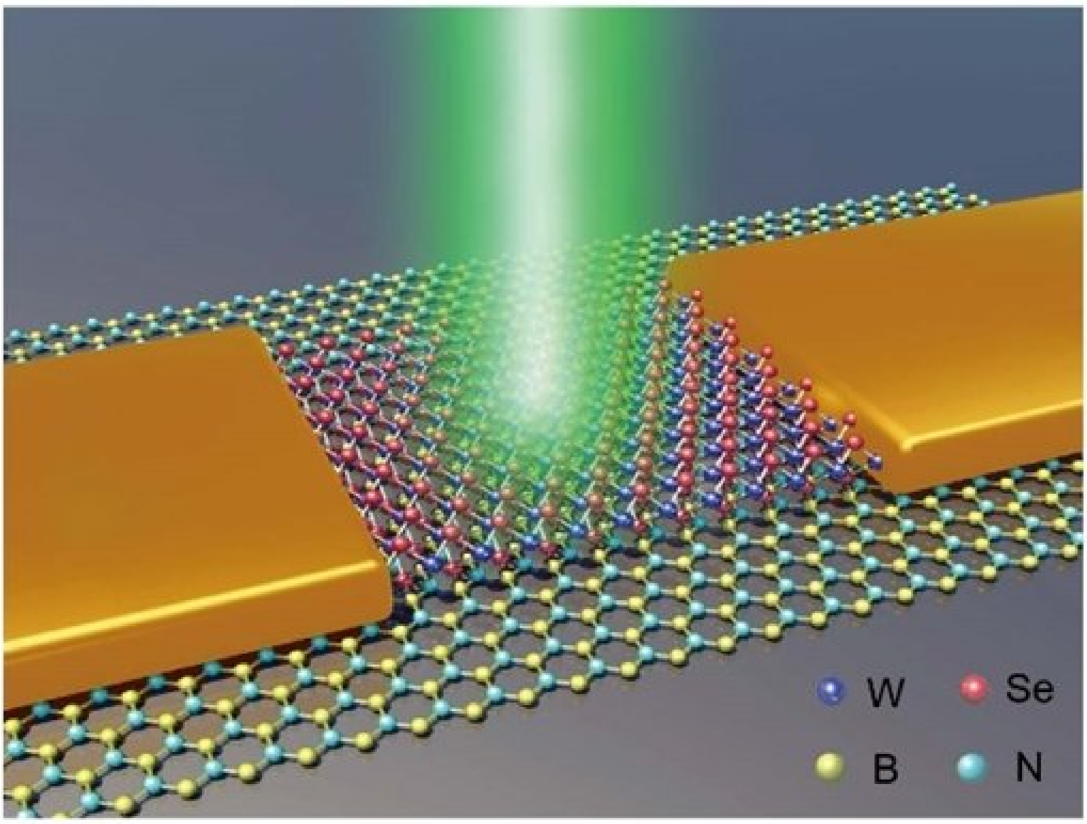

Schematic illustration of the optoelectronic memory device fabricated by layering a monolayer WSe2 on a 20-layer BN. Credit: National University of Singapore

NUS scientists have developed multibit optoelectronic memory using a heterostructure made of two-dimensional (2-D) materials for next generation devices.

Optoelectronic memories are devices which can store photon-generated charge carriers when exposed to light. The stored charges can be accessed later for information retrieval. These devices can be used in image capture and spectrum analysis systems. 2-D atomically layered materials are promising candidates for the development of next generation optoelectronic memories to meet emerging requirements for device miniaturisation and structural flexibility. However, optoelectronic memories fabricated using 2-D materials have been reported to suffer from poor data storage capability with the highest reported figure at about eight distinct storage states.

A team lead by Prof Chen Wei from both the Department of Chemistry and the Department of Physics, NUS has developed a multibit, non-volatile optoelectronic memory device that is able to store up to 130 distinct states by using a tungsten diselenide/boron nitride (WSe_2/BN) heterostructure. The heterostructure, made of 2-D materials, comprises a monolayer of WSe_2 on a 20-layer BN. The programming (store data) and erasing (delete data) functions are controlled by adjusting the applied polarity to the device. A negative polarity is applied during the programming function and it causes the photon-generated electrons from the midgap donor-like states of the BN material to transfer into the WSe_2 material. This leaves behind localised (non-mobile) positive charges in the BN material. For the erasing function, a positive polarity is applied. This causes the photon-generated electrons from the valence band in the BN material to recombine with the localised positive charges, returning it to a neutral state.

The amount of electrons transferred into the WSe_2 material is dependent on the duration of light exposure time for the device. A longer exposure time would mean that more electrons are transferred. The researchers found that the continual accumulation of electrons in the WSe_2 material corresponding up to 130 light pulses can be detected before saturation conditions set in. Each of these pulses can be treated as a distinct storage state. During performance testing, they found that the device exhibits a data retention of over 4.5×104 seconds and a cyclic programme/ erase endurance exceeding 200 cycles.

Explaining the significance of the findings, Prof Chen said, "Although there is still a performance gap when compared to commercial silicon-based memory, these devices are advantageous in electronic applications which require structural flexibility. The use of this WSe_2/BN 2-D layered heterostructure provides a method to achieve multibit memory device and may pave the way for the development of next generation optoelectronic memories."

More information: Du Xiang et al. Two-dimensional multibit optoelectronic memory with broadband spectrum distinction, *Nature Communications* (2018). DOI: 10.1038/s41467-018-05397-w

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