Scientists discover how to control the 'excitation' of electronics

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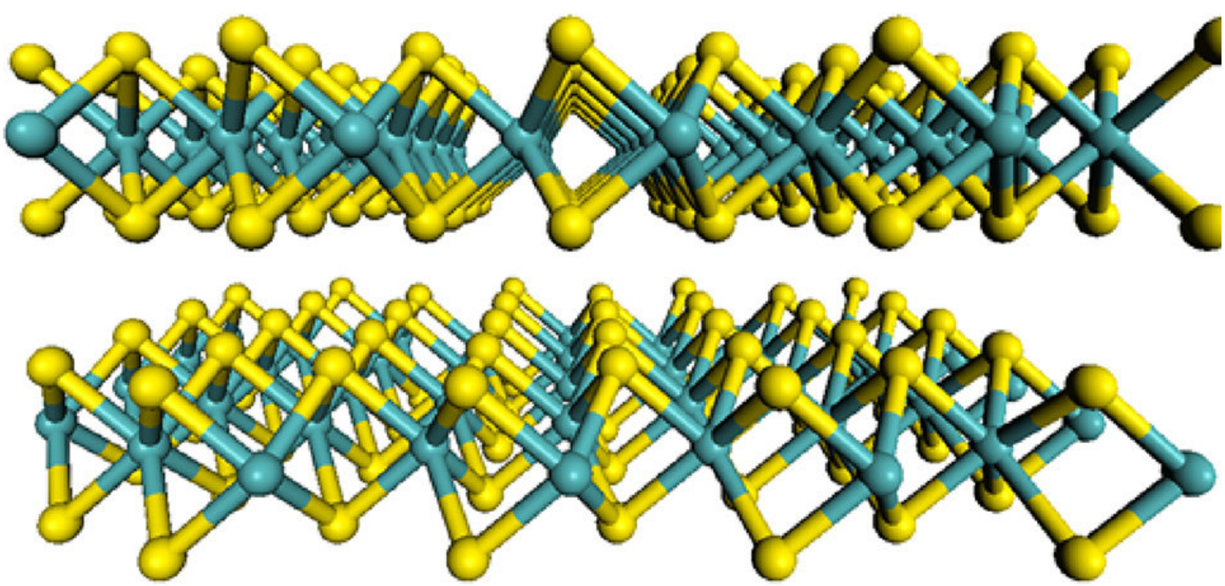
Molybdenum from Australia. Credit: © NUST MISIS

An international team of scientists, including NUST MISIS's Professor

Gotthard Seifert, has made an important step toward the control of excitonic effects in two-dimensional van der Waals heterostructures. In the future, this research could contribute to electronics with more controlled properties. The research has been published in *Nature Physics*.

One two-dimensional material with suitable electronic characteristics is two-dimensional molybdenum disulfide (MoS2), which has a single-layer structure (one atom layer) of molybdenum located between two sulfur layers. In 2017, Professor Gotthard Seifert described the mechanism of defect germination in the structure of two-dimensional molybdenum disulfide as a process that will make it possible for scientists to capitalize on two-dimensional MoS_2's full potential use in microelectronics. This work was published in the leading journal, *ACS Nano*.

Researcher now study other two-dimensional materials' properties for application in electronics. Monolayers of molybdenum disulfide (and, for example, wolframite diselenides—WSe_2) have shown exceptional optical properties due to excitons, tightly bound pairs of electron holes (quasiparticles acting as a carrier of a positive charge).



Molybdenum atoms. Credit: © NUST MISIS

At the same time, the creation of the MoS_2/WSe_2 heterostructure by layering separate monolayers leads to the appearance of a new type of exciton, where the electron and the hole are spatially divided into different layers.

Scientists have shown that interlayer excitons give a very specific optical signal display when layered. This allow scientists to study quantum phenomena, making it ideal for experiments in voltronics,a field of quantum electronics that seeks to control electrons in the "valleys" of semiconductors. In the future, these breakthroughs could lead to the most effective way to code information.

"Thanks to the use of spectroscopic methods and quantum-chemical calculations from the first principles, we have revealed a partially charged electron hole in MoS_2/WSe_2 heterostructures, as well as [the electron hole's] location. We have managed to control the radiation energy of this new exciton by changing the relative orientation of the layers," said Professor Gotthard Seifert.

According to Seifert, this result is an important step toward understanding and controlling exciton effects in Van der Waals heterostructures. The research team is continuing to study the effect of layer rotations on the material's electronic properties. In the future, this will allow for the creation of unique new materials for solar panels or electronics.

More information: Jens Kunstmann et al, Momentum-space indirect

interlayer excitons in transition-metal dichalcogenide van der Waals heterostructures, *Nature Physics* (2018). DOI: 10.1038/s41567-018-0123-y

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