Patterning smaller junctions for ultrathin devices

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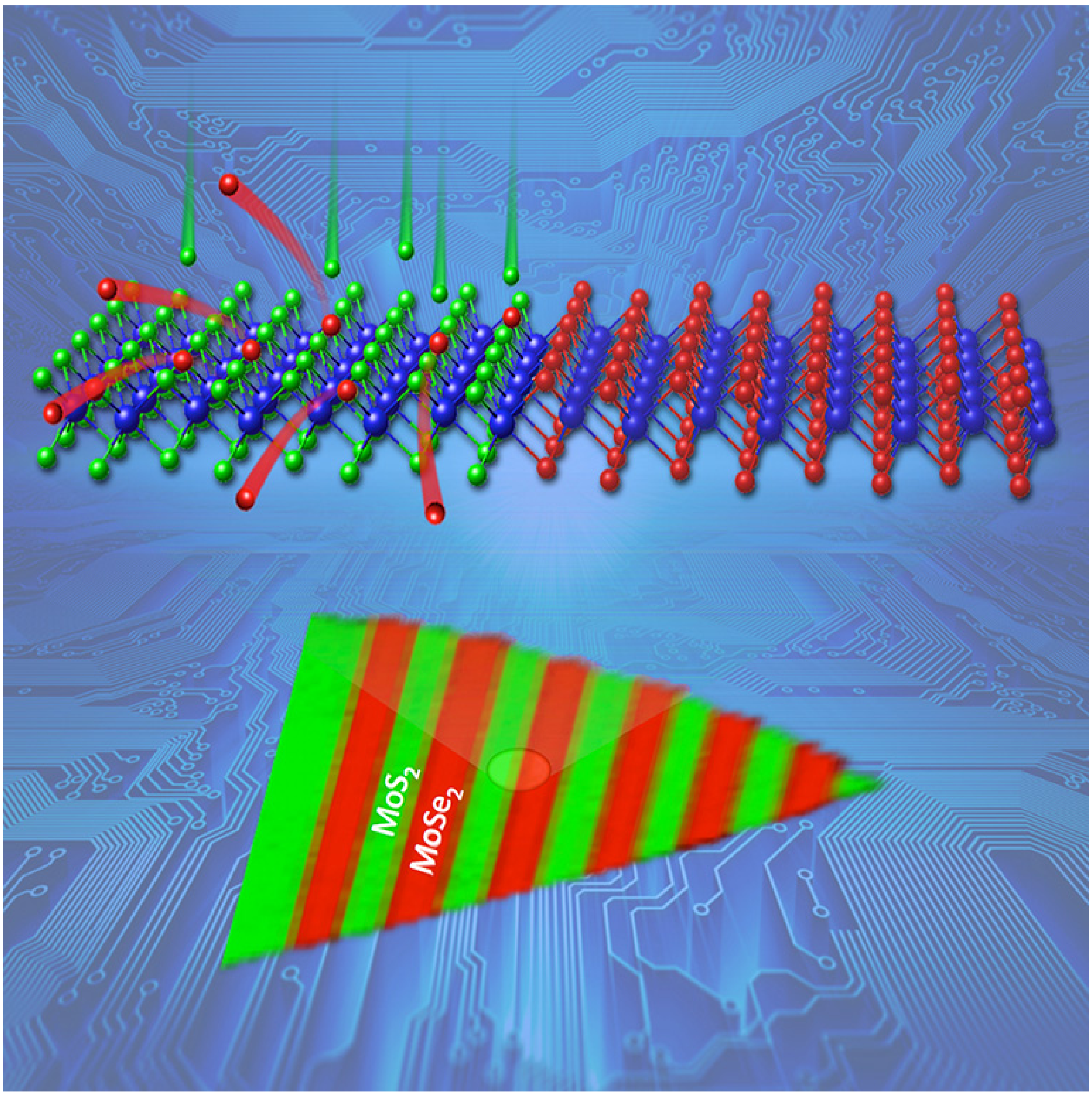

Nanometer-sized junctions between two types of two-dimensional semiconductors – for example, molybdenum diselenide ($MoSe_2$) and molybdenum disulfide (MoS_2) – could replace conventional wider three-dimensional junctions. Masking patterned regions of nanometer-thick $MoSe_2$, followed by exposure to laser-vaporized sulfur, allows the sulfur atoms (green) to replace only the exposed selenium atoms (red), creating multiple 5-nanometer-wide junctions. Chemical mapping with Raman spectroscopy (bottom) validates the controlled conversion of $MoSe_2$ to MoS_2 in the exposed regions. Credit: Oak Ridge National Laboratory

Making faster, more powerful electronics requires smaller but still uniform connections, or junctions, between different materials. For the first time, researchers created extremely small, 5-nanometer-wide junctions, which were made in a specific pattern using two different planar, or flat, semiconductors. The simple process to create these two-dimensional junctions involved selective exposure of the semiconductor to laser-vaporized material and could be extended to other systems.

Controllably creating patterned semiconductor junctions in thin planar materials could enable ultrathin microelectronics for numerous applications such as in smartphones, next-generation solar cells, and lighting.

Junctions of two-dimensional (2D) semiconductors could enable next-generation photovoltaics, lighting, and electronics. For example, current electronics rely on 10-nanometer-wide junctions between different semiconductors in three-dimensional (3D) crystals. Controllable synthetic methods are needed to create narrow junctions between different 2D materials. Now, researchers at Oak Ridge National Laboratory have developed a process for creating these junctions between different 2D semiconductors in arbitrary patterns using standard electron beam lithography techniques.

Single layers of molybdenum diselenide ($MoSe_2$) crystals less than a nanometer thick were first patterned with a silicon oxide mask and then exposed to laser-vaporized sulfur. The sulfur atoms replaced the selenium atoms in the exposed regions, selectively converting $MoSe_2$ to molybdenum disulfide (MoS_2). Chemical mapping with Raman spectroscopy confirmed the chemical conversion was uniform. Atomic-resolution electron microscopy revealed that the junctions between the different semiconductors were only 5 nanometers wide. Patterning such sharp junctions could facilitate a range of ultrathin devices from flexible consumer electronics to more efficient solar cells.

More information: Masoud Mahjouri-Samani et al. Patterned arrays of lateral heterojunctions within monolayer two-dimensional semiconductors, *Nature Communications* (2015). DOI: 10.1038/ncomms8749

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