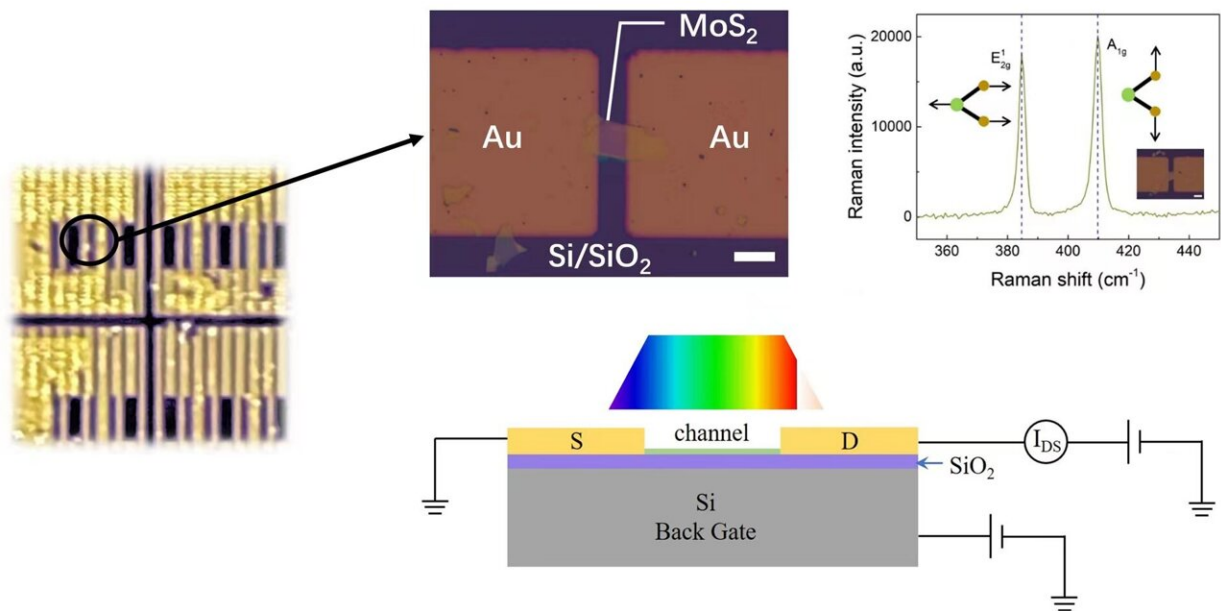


# Scientists reveal working mechanism of multilayer MoS<sub>2</sub> photodetector with broad spectral range and multiband response

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As a typical two-dimensional material, MoS<sub>2</sub> exhibits unique optical and electrical properties due to its atomic thickness in the vertical dimension, making it a research hotspot in the field of optoelectronic detection. The performance of MoS<sub>2</sub> devices highly depends on their material characteristics, device structures, and fabrication techniques. Credit: None

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electrical properties due to its atomic thickness in the vertical dimension, making it a research hotspot in the field of optoelectronic detection.

The performance of MoS<sub>2</sub> devices highly depends on their material characteristics, device structures, and fabrication techniques. Therefore, the photodetection characteristics of MoS<sub>2</sub> devices may be determined by various physical effects, which contribute to the development of wideband MoS<sub>2</sub>-based photodetectors.

A research team from the school of Electronic Science and Engineering of Southeast University has developed wideband MoS<sub>2</sub> photodetector, covering a range from 410 to 1550 nm. Through a series of electrical and optoelectronic experiments, the paper reveals the working mechanism of the multiband optical response of the MoS<sub>2</sub> device.

The work is [published](#) in the journal *Advanced Devices & Instrumentation*.

In recent years, wideband photodetectors have played an important role in various fields such as optical communication, imaging, transmission, sensing, environmental safety, and monitoring. As a typical two-dimensional material, molybdenum disulfide (MoS<sub>2</sub>), a transition metal dichalcogenide, has attracted significant attention due to its excellent electrical and optical properties, as well as its ease of processing.

However, the bandgap of MoS<sub>2</sub> limits the detection range of its photodetectors. To broaden the response range of MoS<sub>2</sub> photodetectors, various chemical treatment methods have been reported. Additionally, integration of MoS<sub>2</sub> detectors with photonic nanostructures enables enhanced and broadened light response.

Nevertheless, mechanically exfoliated MoS<sub>2</sub> photodetectors prepared without the need for chemical treatment possess irreplaceable

advantages. Achieving sub-bandgap photodetection in transition metal dichalcogenides through mechanical exfoliation has become a focus of current research. Furthermore, the performance of two-dimensional material photodetectors is closely related to device structures and fabrication methods.

In this study, a multilayer MoS<sub>2</sub> [field-effect transistor](#) (FET) photodetector was prepared using a mechanical exfoliation method, exhibiting a wide spectral detection range of up to 1550 nm. Experimental results demonstrate that the optimized MoS<sub>2</sub> FET exhibits lower resistance and more stable gate control characteristics.

By mechanically exfoliating multilayer MoS<sub>2</sub> during the pre-transfer process, high responsivity and specific detectivity were achieved under 480 nm illumination. The device exhibits good output and transmission characteristics under [incident light](#) ranging from 410 to 800 nm, and it is photosensitive. The response bandwidth can be extended to 1550 nm, enabling wideband response across multiple spectral regions.

Additionally, the carrier transport characteristics and time-dependent responses of the device at different wavelengths were analyzed. Visible light detection is based on the photoconductive and photogating effects, while infrared light detection beyond the bandgap primarily relies on the photothermal effect.

A research team from Southeast University explained the different electrical characteristics between pretransfer and post-transfer MoS<sub>2</sub> devices through the different contact modes between MoS<sub>2</sub> and Au. The surface potential difference (SPD) at the MoS<sub>2</sub>-Au junction of a post-transfer MoS<sub>2</sub> device was observed using Kelvin probe force microscopy.

Based on the measurement results of SPD and the difference in work

function, it was found that the work function of MoS<sub>2</sub> is approximately 0.05 eV smaller than that of Au. The energy band diagram before and after contact revealed the presence of a Schottky barrier at the MoS<sub>2</sub>-Au interface, which resulted in inferior electrical behavior. In the case of pretransfer devices, the MoS<sub>2</sub>-Au interface was influenced by Fermi level pinning, leading to a reduction in the work function of Au below that of MoS<sub>2</sub>. As a result, Ohmic contact was formed at the MoS<sub>2</sub>-Au interface, reducing the contact resistance and increasing the current.

This study presents an optimized mechanically exfoliated multilayer MoS<sub>2</sub> back-gated detector with multi-band photodetection capabilities. Under the optimized pre-transfer fabrication process, the device exhibits improved charge transport performance.

Without the need for chemical treatment, the MoS<sub>2</sub> detector achieves a wide spectral photodetection beyond the MoS<sub>2</sub> bandgap. The device demonstrates a maximum responsivity of 33.75 A W<sup>-1</sup> at visible light (480 nm), with a corresponding specific detectivity of 6.1×10<sup>11</sup> cm Hz<sup>1/2</sup> W<sup>-1</sup>. The response mechanism under visible light is attributed to the photogating and photoconductive effects.

Additionally, the device shows a response at 1550 nm infrared light, surpassing the bandgap limitation, which is attributed to the variation in carrier concentration caused by the photothermal effect. The wideband photodetection behavior of the [device](#) is attributed to the photoelectric effect in visible light and the photothermal effect in infrared light, providing insights for room-temperature wideband detection and demonstrating significant potential in various fields such as infrared stealth, machine vision, and environmental monitoring.

**More information:** Xia-Yao Chen et al, Multilayer MoS 2

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