

# Atomically thin device shows tunable electrical behavior not previously realized in conventional electronics

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As electronics approach the atomic scale, researchers are increasingly successful at developing atomically thin, virtually two-dimensional materials that could usher in the next generation of computing. Integrating these materials to create necessary circuits, however, has remained a challenge.

Northwestern University researchers have now taken a significant step toward fabricating complex nanoscale electronics. By integrating two atomically thin [materials](#) – molybdenum disulfide and carbon nanotubes—they have created a p-n [heterojunction](#) diode, an interface between two types of semiconducting materials.

"The p-n junction diode is among the most ubiquitous components of modern electronics," said Mark Hersam, Bette and Neison Harris Chair in Teaching Excellence in the Department of Materials Science and Engineering at Northwestern's McCormick School of Engineering and Applied Science and director of the Northwestern University Materials Research Center. "By creating this device using atomically thin materials, we not only realize the benefits of conventional diodes but also achieve the ability to electronically tune and customize the device characteristics. We anticipate that this work will enable new types of electronic functionality and could be applied to the growing number of emerging two-dimensional materials."

The isolation over the past decade of atomically thin two-dimensional crystals—such as graphene, a single-atom-thick carbon lattice—has prompted researchers to stack two or more distinct two-dimensional materials to create high-performance, ultrathin electronic devices. While significant progress has been made in this direction, one of the most important [electronic components](#)—the p-n junction diode—has been notably absent.

Among the most widely used electronic structures, the p-n junction diode forms the basis of a number of technologies, including solar cells, light-emitting diodes, photodetectors, computers, and lasers.

In addition to its novel electronic functionality, the p-n heterojunction [diode](#) is also highly sensitive to light. This attribute has allowed the authors to fabricate and demonstrate an ultrafast photodetector with an electronically tunable wavelength response.

The research, "Gate-Tunable Carbon Nanotube-MoS<sub>2</sub> Heterojunction p-n Diode," was published October 21 in the *Proceedings of the National Academy of Sciences*.

**More information:** Gate-tunable carbon nanotube–MoS<sub>2</sub> heterojunction p-n diode,  
[www.pnas.org/cgi/doi/10.1073/pnas.1317226110](http://www.pnas.org/cgi/doi/10.1073/pnas.1317226110)

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