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Nano Research

Mass production of two-dimensional materials beyond graphene and their applications

Monolayer MoS_2 epitaxy

Space-confined growth of metal halide perovskite crystal films

Nano Research

Young Innovator Awards in 2D Materials 2021

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Contents

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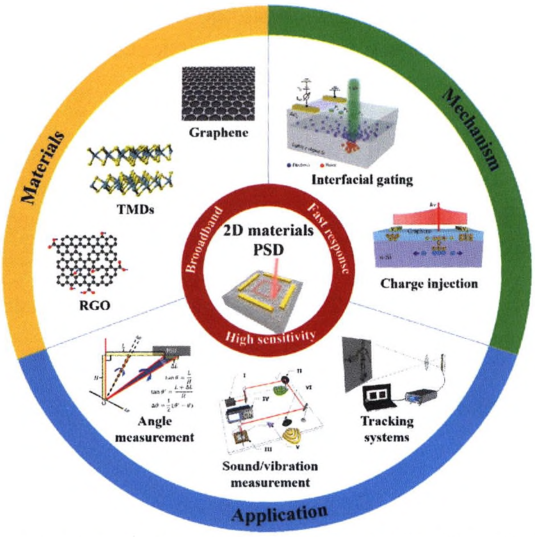
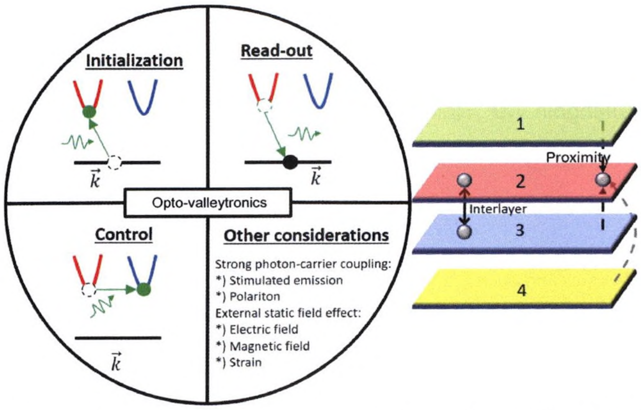
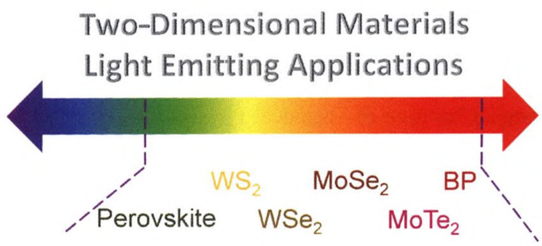


This review summarizes the structures, carrier dynamics, and applications of position-sensitive detector (PSD) based two-dimensional (2D) materials, and highlights the challenges and opportunities in this research area.



In this article, we review the current understanding of the optical valley physics in the two-dimensional (2D) heterostructure composed of transition metal dichalcogenide and other materials. The challenge of building opto-valleytronics applications using the 2D heterostructure is also discussed.

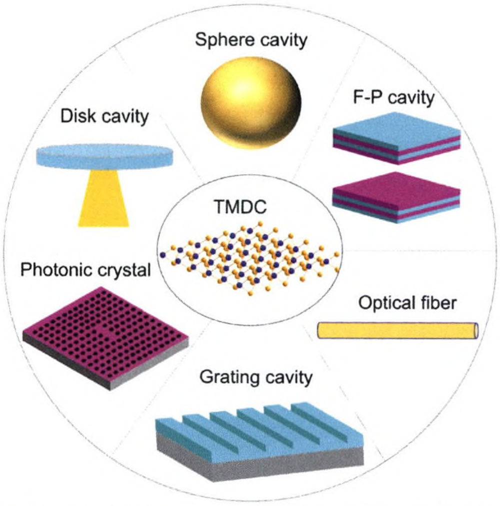


Two-dimensional materials provide tremendous opportunities for future on chip light sources.

Strong exciton–photon interaction and lasing of two-dimensional transition metal dichalcogenide semiconductors

Liyun Zhao, Qiuyu Shang, Meili Li, Yin Liang, Chun Li, and Qing Zhang*

Peking University, China



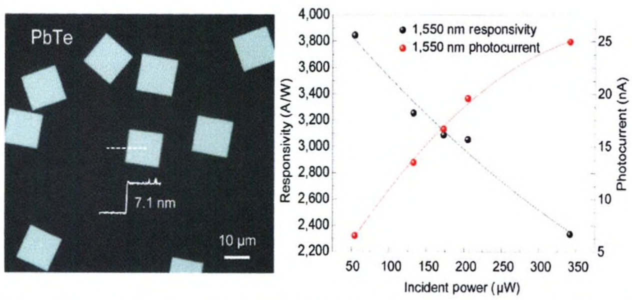
Recent advances in the strong exciton–photon interaction and lasing of two dimensional transition metal dichalcogenide semiconductors have been developed in the fields of ultra-small and low-energy consumption coherent light sources.

Research Articles

Van der Waals epitaxy of ultrathin crystalline PbTe nanosheets with high near-infrared photoelectric response

Xinxin Zhao[1,2], Qing Yin[1], Hao Huang[3], Qiang Yu[2], Bo Liu[4], Jie Yang[1,2], Zhuo Dong[1,2], Zhenjiang Shen[5], Benpeng Zhu[6], Lei Liao[3], and Kai Zhang[2,*]

[1] University of Science and Technology of China, China
[2] Suzhou Institute of Nano-Tech and Nano-Bionics (SINANO), Chinese Academy of Sciences, China
[3] Wuhan University, China
[4] Osaka University, Japan
[5] Hainan Normal University, China
[6] Huazhong University of Science and Technology, China

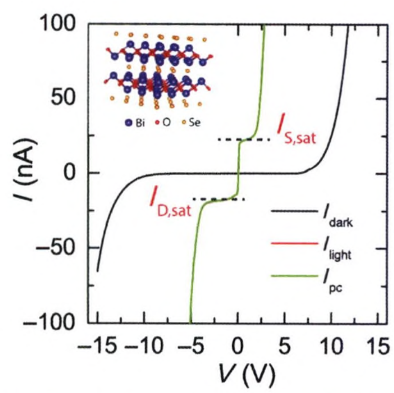


Ultrathin crystalline PbTe nanosheets in lateral size of tens of microns with thickness down to ~ 7 nm are synthesized by van der Waals epitaxy. Photodetectors based on the as-grown 2D PbTe nanosheets exhibit an ultrahigh responsivity of 3,847 A/W at the wavelength of 1,550 nm under room temperature.

Intrinsic carrier multiplication in layered Bi_2O_2Se avalanche photodiodes with gain bandwidth product exceeding 1 GHz

Vinod K. Sangwan[1], Joohoon Kang[1,†], David Lam[1], J. Tyler Gish[1], Spencer A. Wells[1], Jan Luxa[2], James P. Male[1], G. Jeffrey Snyder[1], Zdeněk Sofer[2], and Mark C. Hersam[1,*]

[1] Northwestern University, USA
[2] University of Chemistry and Technology Prague, Czech Republic
† Present address: Sungkyunkwan University (SKKU), Republic of Korea



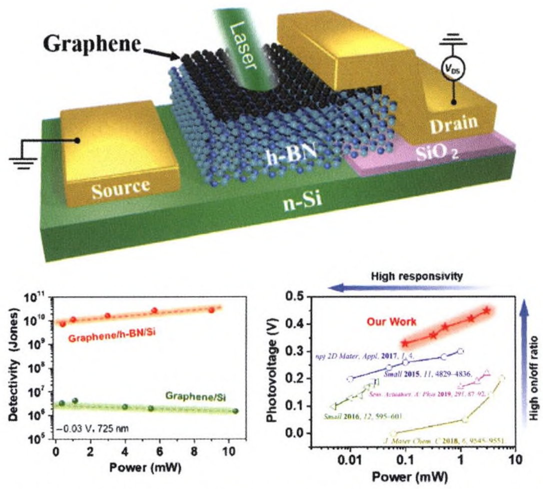
Metal-semiconductor-metal avalanche photodiodes are fabricated from layered Bi_2O_2Se crystals, yielding intrinsic carrier multiplication factors up to 400, gain bandwidth products exceeding 1 GHz, and detectivities up to 4.6×10^{14} Jones.

Efficient photovoltaic effect in graphene/h-BN/silicon heterostructure self-powered photodetector

Ui Yeon Won[1], Boo Heung Lee[1], Young Rae Kim[1,2], Won Tae Kang[1,2], Ilmin Lee[1], Ji Eun Kim[1], Young Hee Lee[2], and Woo Jong Yu[1,*]

[1] Sungkyunkwan University, Republic of Korea
[2] Institute for Basic Science (IBS), Republic of Korea

1967–1972



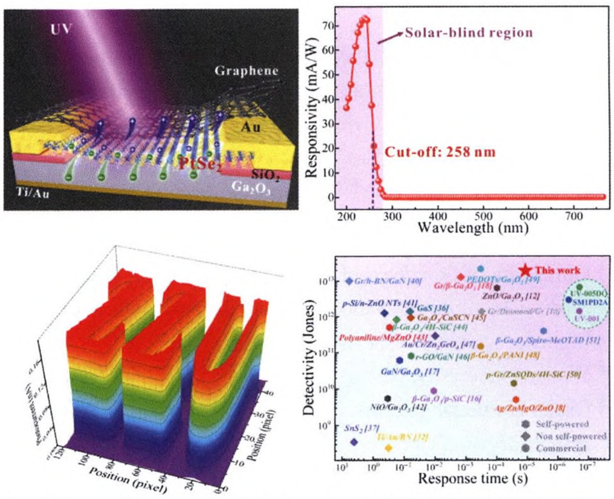
We present a vertically stacked graphene/hexagonal boron nitride/silicon (Gr/h-BN/Si) van der Waals heterostructure to enhance detectivity near-zero external bias of photodetector by inserting thin layer of h-BN to suppress dark current. We propose the mechanisms of carrier flowing in an illuminated environment for reverse and forward current regions.

Highly sensitive solar-blind deep ultraviolet photodetector based on graphene/PtSe$_2$/β-Ga$_2$O$_3$ 2D/3D Schottky junction with ultrafast speed

Di Wu[1], Zhihui Zhao[1], Wei Lu[2], Lukas Rogée[2], Longhui Zeng[2,*], Pei Lin[1], Zhifeng Shi[1], Yongtao Tian[1], Xinjian Li[1], and Yuen Hong Tsang[2,*]

[1] Zhengzhou University, China
[2] The Hong Kong Polytechnic University, Hong Kong, China

1973–1979



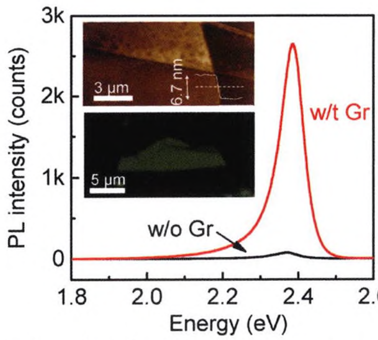
A highly sensitive solar-blind deep ultraviolet photodetector based on graphene/PtSe$_2$/β-Ga$_2$O$_3$ Schottky junction is demonstrated, which shows a large detectivity and an ultrafast response speed.

Giant enhancement of photoluminescence quantum yield in 2D perovskite thin microplates by graphene encapsulation

Wancai Li, Jiaqi Ma, Xue Cheng, and Dehui Li*

Huazhong University of Science and Technology, China

1980–1984



We observed the photoluminescence quantum yield of two-dimensional (2D) perovskite thin microplates has been enhanced 28 times by graphene encapsulation. The enhancement mechanism is the reduced quantum confined Stark effect due to the reduced surface depletion field, which leads to the enhanced radiative recombination efficiency.

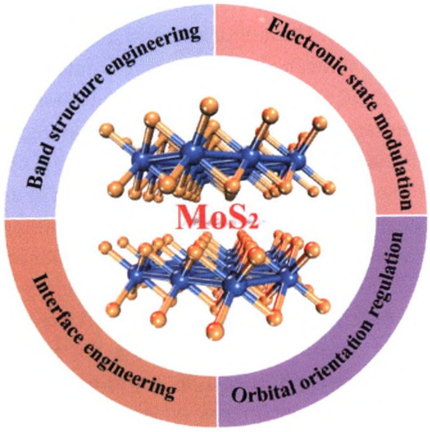
Catalysis/Energy

Review Articles

Two-dimensional MoS_2 for hydrogen evolution reaction catalysis: The electronic structure regulation

Shuwen Niu, Jinyan Cai, and Gongming Wang*

University of Science and Technology of China, China



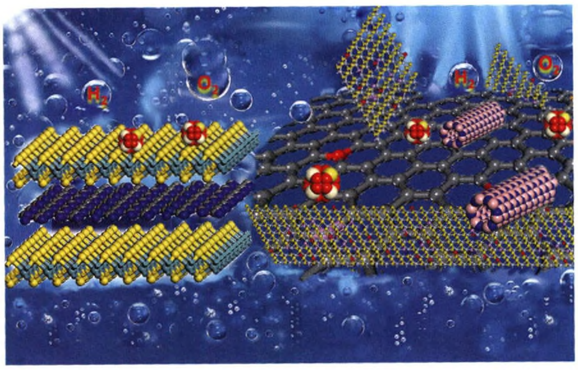
In this review, we summarize the recent process of the electronic structural modulation of MoS_2 for hydrogen evolution catalysis.

1985–2002

Transition metal dichalcogenide-based mixed-dimensional heterostructures for visible-light-driven photocatalysis: Dimensionality and interface engineering

Xiaorong Gan[1], Dangyuan Lei[2,*], Ruquan Ye[2], Huimin Zhao[3], and Kwok-Yin Wong[4]

[1] Hohai University, China
[2] City University of Hong Kong, Hong Kong, China
[3] Dalian University of Technology, China
[4] The Hong Kong Polytechnic University, Hong Kong, China



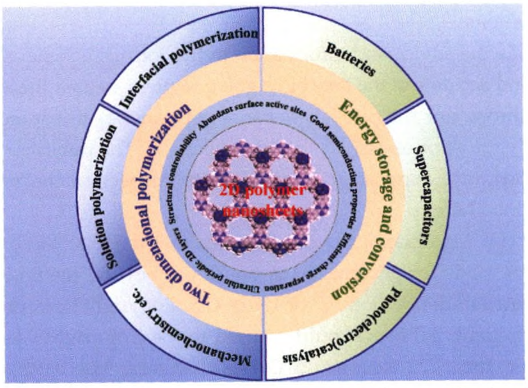
The photoactivity of two-dimensional transition metal dichalcogenide heterostructures for visible-light-driven photocatalytic water splitting can be regulated through dimensionality and interface engineering.

2003–2022

Two-dimensional polymer nanosheets for efficient energy storage and conversion

Yumei Ren[1,2,3], Chengbing Yu[1,*], Zhonghui Chen[3,4,*], and Yuxi Xu[3,*]

[1] Shanghai University, China
[2] Zhengzhou University of Aeronautics, China
[3] Westlake University, China
[4] Henan University, China



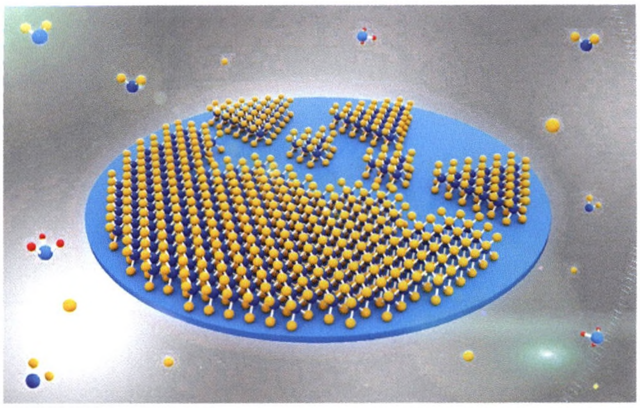
The recent research progress in the preparation methods of two-dimensional (2D) polymer nanosheets, mainly including interfacial polymerization and solution polymerization has been summarized. The structure–property relationships of various 2D polymers are thoroughly discussed. Their applications in the fields of energy storage and conversion, and the future perspectives have also been presented.

2023–2036

Monolayer MoS_2 epitaxy

Zheng Wei[1,2], Qinqin Wang[1,2], Lu Li[1,2], Rong Yang[1,2,3], and Guangyu Zhang[1,2,3,*]

[1] Beijing National Laboratory for Condensed Matter Physics and Institute of Physics, Chinese Academy of Sciences, China
[2] University of Chinese Academy of Sciences, China
[3] Songshan Lake Materials Laboratory, China

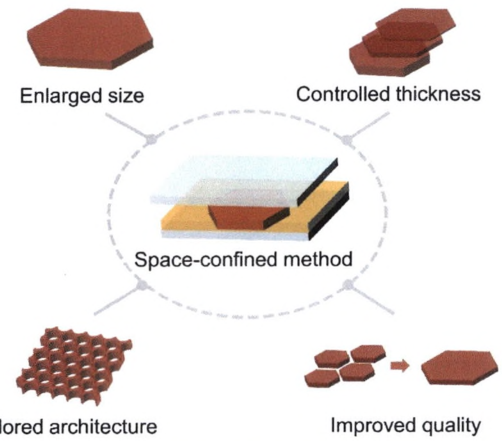


This article reviews the epitaxial growth of monolayer MoS_2 with a particular focus on large-scale and high-quality films.

Space-confined growth of metal halide perovskite crystal films

Linyi Li, Jinxin Liu, Mengqi Zeng, and Lei Fu*

Wuhan University, China

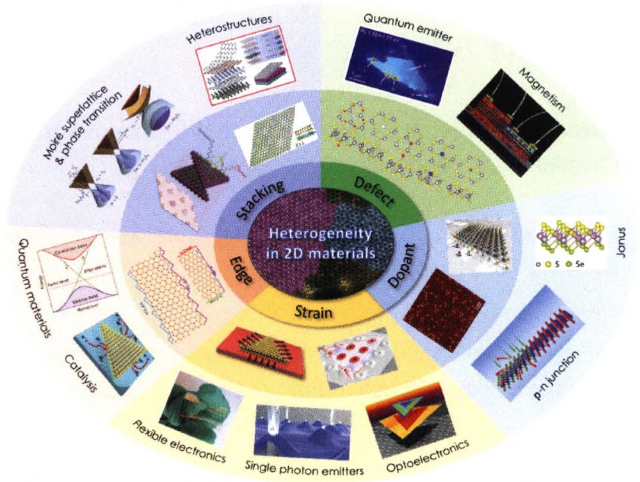


The size, thickness, quality and structure of the perovskite crystal film could be optimized through the space-confined method with various modified strategies.

Heterogeneities at multiple length scales in 2D layered materials: From localized defects and dopants to mesoscopic heterostructures

Hui Cai, Yiling Yu, Yu-Chuan Lin, Alexander A. Puretzky, David B. Geohegan, and Kai Xiao*

Oak Ridge National Laboratory, USA



This paper provides a comprehensive review of controlled synthesis and processing of heterogeneities at multiple length scales and their impact on the macroscale properties and functionalities of two-dimensional (2D) materials.

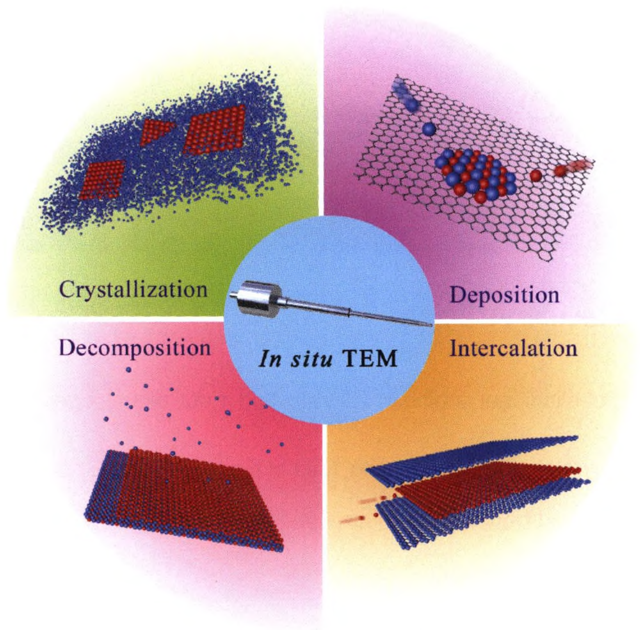
1625–1649

Atomic-scale insights into the formation of 2D crystals from *in situ* transmission electron microscopy

Yatong Zhu[1], Dundong Yuan[1], Hao Zhang[1], Tao Xu[1,*], and Litao Sun[1,2,*]

[1] Southeast University, China

[2] Southeast University-Monash University Joint Research Institute, China



Here we review the recent *in situ* transmission electron microscopy (TEM) works on the formation of two-dimensional (2D) crystals under electron irradiation, thermal excitation as well as voltage bias. The underlying mechanisms are also elucidated in detail, providing key insights into the nucleation and formation of 2D crystals.

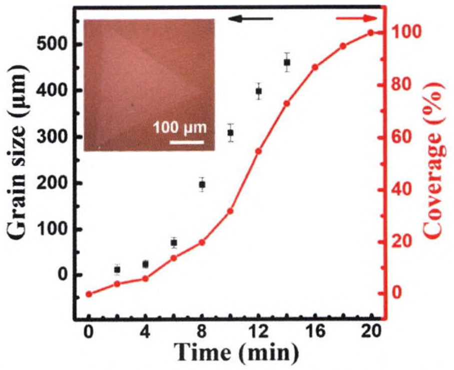
1650–1658

Research Articles

Fast growth of large single-crystalline WS_2 monolayers via chemical vapor deposition

Shengxue Zhou[1,2], Lina Liu[1], Shuang Cui[3], Xiaofan Ping[1], Dake Hu[1], and Liying Jiao[1,*]

[1] Tsinghua University, China
[2] Ningxia Normal University, China
[3] Sinopec Beijing Research Institute of Chemical Industry, China

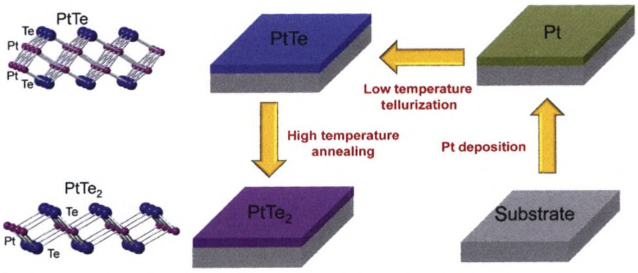


The fast growth of single crystalline WS_2 monolayered flakes with a side length of up to ~ 500 μm was achieved via chemical vapor deposition using K_2WS_4 as the growth precursor.

Growth of large scale PtTe, $PtTe_2$ and $PtSe_2$ films on a wide range of substrates

Kenan Zhang[1], Meng Wang[1], Xue Zhou[1], Yuan Wang[1], Shengchun Shen[1], Ke Deng[1], Huining Peng[1], Jiaheng Li[1], Xubo Lai[1], Liuwan Zhang[1], Yang Wu[1], Wenhui Duan[1,2], Pu Yu[1,2], and Shuyun Zhou[1,2,*]

[1] Tsinghua University, China
[2] Collaborative Innovation Center of Quantum Matter, China



A convenient experimental method for growing centimeter-scale $PtSe_2$, $PtTe_2$ films and the hitherto-unreported PtTe film via deposition of Pt film followed by selenization or tellurization is reported. A phase control between the new PtTe phase and $PtTe_2$ phase is also achieved by annealing under Te flux.

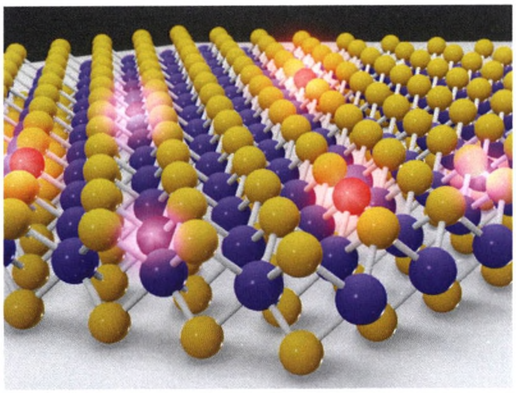
Doping/Electronic Property Modulation

Review Articles

Substitutional doping in 2D transition metal dichalcogenides

Leyi Loh, Zhepeng Zhang, Michel Bosman*, and Goki Eda*

National University of Singapore, Singapore

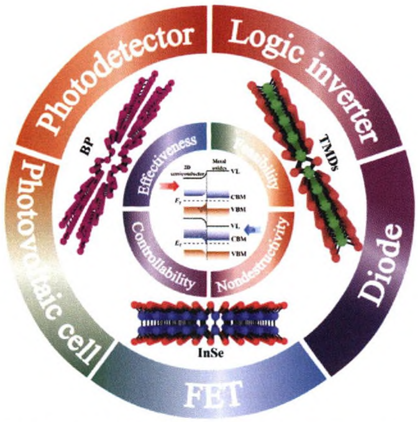


Substitutional doping in two-dimensional (2D) group 6 transition metal dichalcogenides (MX_2, M = Mo, W; X = S, Se, Te) is key to enabling novel functionalities of these materials. We review the recent progress in the understanding of the physical effects of doping.

Surface charge transfer doping for two-dimensional semiconductor-based electronic and optoelectronic devices

Yanan Wang[1], Yue Zheng[1,2], Cheng Han[2,*], and Wei Chen[1,3,4,*]

[1] National University of Singapore, Singapore
[2] Shenzhen University, China
[3] International Campus of Tianjin University, China
[4] National University of Singapore (Suzhou) Research Institute, China



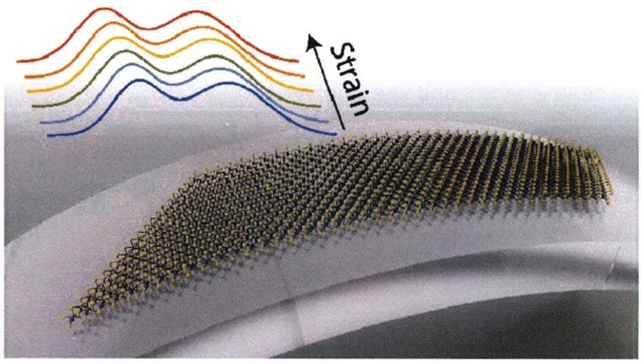
Surface charge transfer doping (SCTD) is emerging as an effective and non-destructive doping technique to provide reliable doping capability for two-dimensional (2D) materials as well as to tune their electronic and optical properties, which facilitates the rational design and construction of 2D-based functional devices with the optimized performance.

Research Articles

Strain engineering in single-, bi- and tri-layer MoS_2, $MoSe_2$, WS_2 and WSe_2

Felix Carrascoso, Hao Li, Riccardo Frisenda*, and Andres Castellanos-Gomez*

Consejo Superior de Investigaciones Científicas, Spain

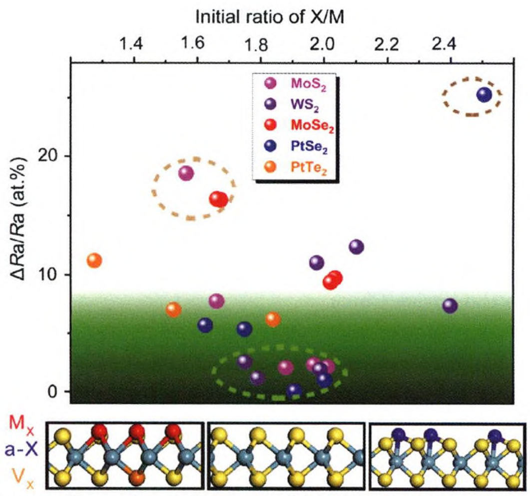


We systematically study how uniaxial strain modifies the optical properties of single-, bi- and tri-layer transition metal dichalcogenides.

Enhancing stability by tuning element ratio in 2D transition metal chalcogenides

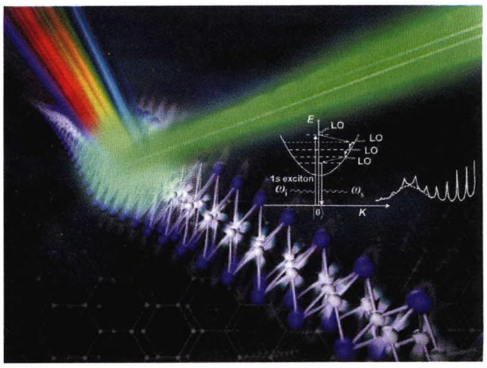
Zhenjia Zhou[1], Tao Xu[2], Chenxi Zhang[1], Shisheng Li[3], Jie Xu[1], Litao Sun[2,*], and Libo Gao[1,*]

[1] Nanjing University, China
[2] Southeast University, China
[3] National Institute for Materials Science (NIMS), Japan

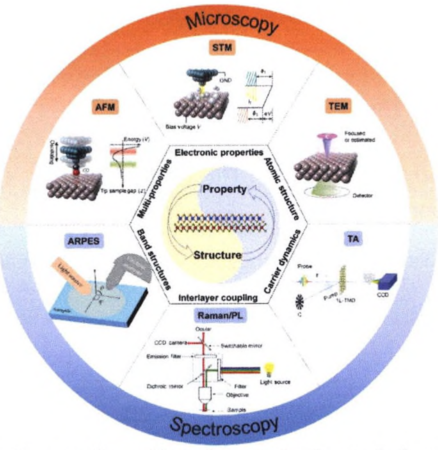


Stable two-dimensional (2D) transition metal chalcogenides rely on their stoichiometric bonded element ratio. Vacancy defects with X atoms, antisite defects with M atoms, and additive X atoms all reduce the environmental stability.

Review Articles



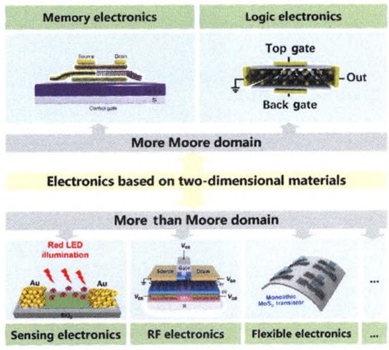
Inelastic light scattering provides a powerful experimental tool to explore electron–phonon interaction in solid materials. This review gives an overview of basic theory and experiment advances of Raman and Brillouin scattering in two-dimensional (2D) materials.



Developing the coupling effect characterization techniques to unveil the structure–property–performance relationship of van der Waals (vdW) heterostructures is crucial for fundamental science and practical applications.

Electronics

Review Articles



More Moore and More than Moore are proposed as two paths to maintain the development of the semiconductor industry. Two-dimensional materials are proposing to be applied in future electronic devices by the More Moore and More than Moore paths.

Research Article

Magnetic/Magnetoelectronics

Review Articles

Research Article

Optoelectronics

Review Articles

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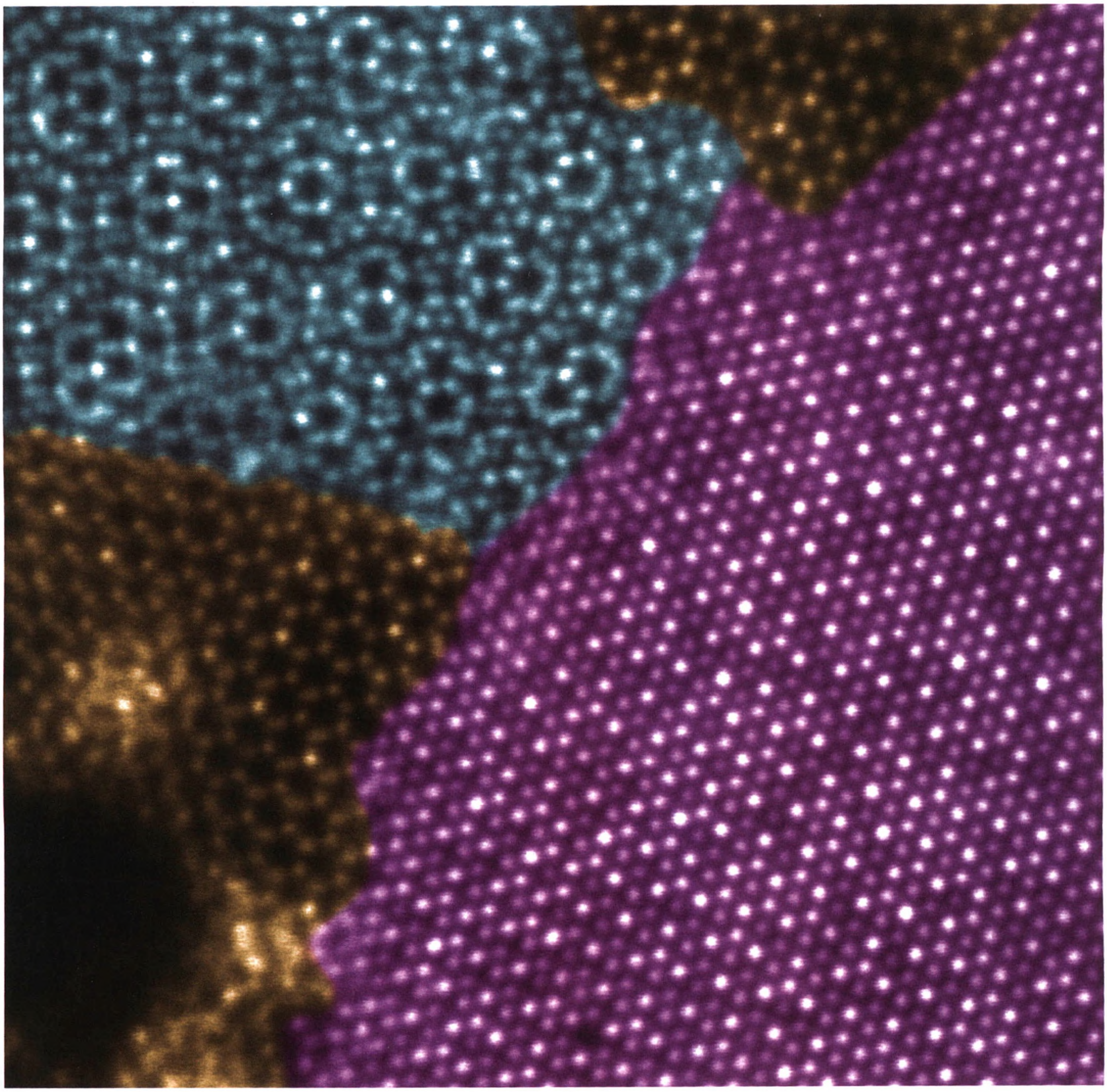

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