Kai Liu

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Education

Ph. D., in Physics, Tsinghua University, Beijing, China **2008**

B. S., in Applied Physics, Xi'an Jiaotong University, Xi'an, China **2003**

Research Experience

2015.05-Present, *Associate Professor*, School of Materials Science and Engineering, Tsinghua University

2011.02-2015.05, *Postdoctoral Fellow*, Lawrence Berkeley National Lab & UC, Berkeley

2008.08-2011.01, *Postdoctoral Fellow*, Department of Chemistry, Tsinghua University

Awards and Honors

Frontiers Materials Young Scientist Award, International Union of Materials Research Societies	**2021**
Science and Technology Award (First Prize), Chinese Materials Research Society	**2020**
Rising Star Speaker Award (First Prize), ICMAT 2019	**2019**
Fok Ying Tung Foundation for Young Teachers	**2018**
National Outstanding Doctoral Dissertation Award (100 winners nation-wide)	**2010**
Academic Rising Star Award, Tsinghua University (Top 10 winners of graduate students)	**2008**
Excellent Ph.D. Graduates Award, Tsinghua University	**2008**

Professional Activities

- 2020-Present, **Editorial Board Member** and **Young Scientist Committee** of *Nano Research, Rare Metals, Chinese Physics Letters, etc.*
- 2020, **Guest Editor** of *Nanomaterials* for the special issue "State-of-the-Art of Nanocomposite Materials in China".
- 2020, **Guest Editor** of *Journal of Applied Physics* for the special issue "Phase-Change Materials: Syntheses, Fundamentals, and Applications".
- **Peer Reviewer** for more than 100 papers submitted to *Nature, Nature Materials, Nature Communications*, *Science Advances*, *Advanced Materials*, *Angewandte Chemie International Edition*, *etc.*, since 2015.

Research Summary

- Focus on interface engineering of low-dimensional materials and heterostructures.
- Published more than 130 papers in *Science*, *Nature Electronics, Nature Nanotechnology, Nature Communications*, *Science Advances*, *Advanced Materials*, *etc*.

- Cited by over 10,000 times, H index is 49

(1) Interface strain engineering of low-dimensional materials

Interface strain deforms materials or even causes structural failure, and could dramatically modulate the properties of low-dimensional materials and affect their device performance. We investigate effects of interface strain in two-dimensional (2D) materials and interfaces. In our systematic studies of elastic properties of 2D materials (MoS_2, $MoTe_2$, etc.), we probed and controlled the strain-induced deformation (buckling) and fracture of these materials. We further engineered different interface geometries, including building bimorph structures and asymmetrically roughened interfaces, to modulate interface strain and realize applications in high-performance actuators and high-sensitivity tactile sensors.

(2) Engineering hetero-interfaces for high-efficiency sensing devices

Heterostructures are fundamental blocks in modern semiconductor devices. Engineering the hetero-interfaces in heterostructures can not only improve the device performance, but enable new functions in devices. We explore a novel type of hybrid heterostructures, *i.e.*, transition metal chalcogenide (TMD)/oxide (TMO) heterostructures. We combine the merit of thickness dependence of properties in the former and rich correlated electron effects in the latter, to realize high efficiency and multiple functions of heterostructural devices. Employing techniques of van der Waals stacking, natural oxidization, and direct laser writing, we fabricated a variety of TMD/TMO heterostructures, such as vertical WSe_2/VO_2, vertical NbS_2/NbO_x, and lateral NbS_2/Nb_2O_5, for dual-mode photodetectors and high-sensitivity gas sensors.

(3) Engineering interfaces for materials and devices working in harsh environments

Emerging applications in artificial intelligence or space exploration usually request materials or devices to work in harsh or extreme environments (particle irradiation, high/low temperature, etc.). However, low-dimensional materials are less stable due to their high surface-to-volume ratio, and thus are not expected to work well in these environments. The key strategy to address this problem is interface engineering, which can effectively stabilize the system or generate new nanostructures. We found that compared to single-layer material, multilayer graphene and MoS_2/graphene heterostructure are more "robust" in either elastic modulus or photoluminescence energy under high-energy particle irradiation owing to interfacial mutual enforcements. Taking advantages of the interface van der Waals forces, we also developed a lightweight, solid tape made of carbon nanotube films that are capable of working at extreme temperatures (-196℃~1000℃).

Selective Publications

1. Peng, Ruixuan; Wu, Yonghuang; Wang, Bolun; Shi, Run; Xu, Longlong; Pan, Ting; Guo, Jing; Zhao, Bochen; Song, Cheng; Fan, Zhiyong; Wang, Chen; Zhou, Peng; Fan, Shoushan; Liu, Kai*. Programmable graded doping for reconfigurable molybdenum ditelluride devices. ***Nature Electronics***, 6, 852 (2023).
2. Wu, Yonghuang; Xin, Zeqin; Zhang, Zhibin; Wang, Bolun; Peng, Ruixuan; Wang, Enze; Shi, Run; Liu, Yiqun; Guo, Jing; Liu, Kaihui; Liu, Kai*. All-transfer electrode interface engineering towards harsh-environment-resistant MoS_2 field-effect transistors. ***Advanced Materials***, 35, 2210735 (2023).
3. Wang, Enze#; Xiong, Zixin#; Chen, Zekun; Xin, Zeqin; Ma, Huachun; Ren, Hongtao; Wang, Bolun; Guo, Jing Guo; Sun, Yufei; Wang, Xuewen; Li, Chenyu; Li, Xiaoyan*; Liu, Kai*. Water nanolayer facilitated solitary-wave-like blisters in MoS_2 thin films. ***Nature Communications***, 14, 4324 (2023).
4. Sun, Yufei; Wang, Yujia; Wang, Enze; Wang, Bolun; Zhao, Hengyi; Zeng, Yongpan; Zhang, Qinghua;

Wu, Yonghuang; Gu, Lin; Li, Xiaoyan*; Liu, Kai*. Determining the interlayer shearing in twisted bilayer MoS_2 by nanoindentation. ***Nature Communications***, 13, 3898 (2022).

5. Li, Chenyu; Wang, Zhijie; Liu, Mingda; Wang, Enze; Wang, Bolun; Xu, Longlong; Jiang, Kaili; Fan, Shoushan; Sun, Yinghui*; Li, Jia*; Liu, Kai*. ***Nature Communications***, 13, 3338 (2022).
6. Wang, Enze; Chen, Zekun; Shi, Run; Xiong, Zixin; Xin, Zeqin; Wang, Bolun; Guo, Jing; Peng, Ruixuan; Wu, Yonghuang; Li, Chenyu; Ren, Hongtao; Li, Xiaoyan*; Liu, Kai*. Humidity-Controlled Dynamic Engineering of Buckling Dimensionality in MoS_2 Thin Films. ***ACS Nano***, 16, 14157 (2022).
7. Wang, Xuewen; Wang, Bolun; Zhang, Qinghua; Sun, Yufei; Wang, Enze; Luo, Hao; Wu, Yonghuang; Gu, Lin; Li, Huanglong; Liu, Kai*. Grain-Boundary Engineering of Monolayer MoS_2 for Energy-Efficient Lateral Synaptic Devices. ***Advanced Materials***, 33, 2102435 (2021).
8. Ma, He; Xiao, Xiao; Wang, Yu; Sun, Yufei; Wang, Bolun; Gao, Xinyu; Wang, Enze; Jiang, Kaili; Liu, Kai*; Zhang, Xinping*. Wafer-scale freestanding vanadium dioxide film. ***Science Advances***, 7, eabk3438 (2021).
9. Wang, Bolun; Wang, Xuewen; Wang, Enze; Li, Chenyu; Peng, Ruixuan; Wu, Yonghuang; Xin, Zeqin; Sun, Yufei; Guo, Jing; Fan, Shoushan; Wang, Chen; Tang, Jianshi; Liu, Kai*; Monolayer MoS_2 Synaptic Transistors for High-Temperature Neuromorphic Applications, ***Nano Letters***, 21, 10400 (2021).
10. Wang, Bolun; Peng, Ruixuan; Wang, Xuewen; Yang, Yueyang; Wang, Enze; Xin, Zeqin; Sun, Yufei; Li, Chenyu; Wu, Yonghuang; Wei, Jinquan; Sun, Jingbo; **Liu, Kai***. Ultrafast, Kinetically Limited, Ambient Synthesis of Vanadium Dioxides through Laser Direct Writing on Ultrathin Chalcogenide Matrix. ***ACS Nano***, 15, 10502 (2021).