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High-Performance Chemical Sensors Using Novel Two-Dimensional Materials

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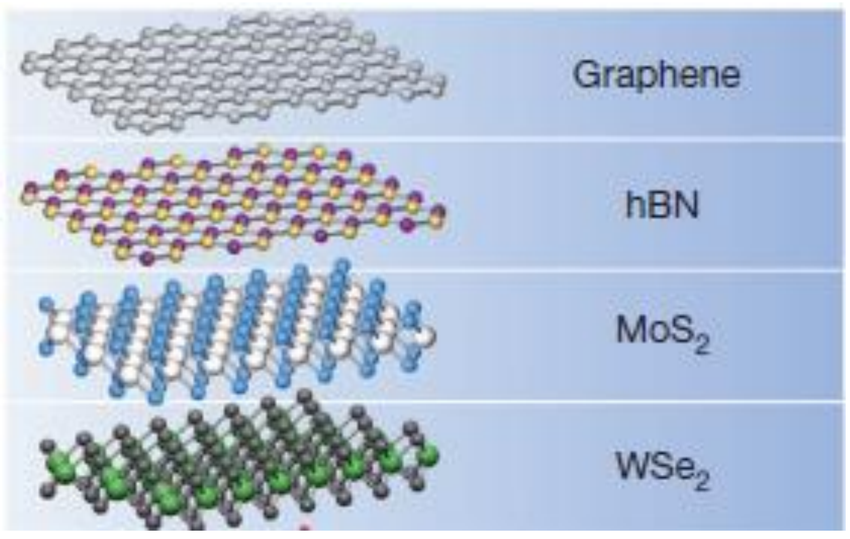
Motivation

Smog is one kind of air pollution that is highly harmful to humans. It was once a big problem around Los Angeles areas in the 1950s. And now Beijing! Scientists has discovered that smog is mostly caused by the emission of NO_x gases from cars. In this sense, an efficient gas sensor is desired to monitor these toxic gases.

Why Choosing 2D Materials?



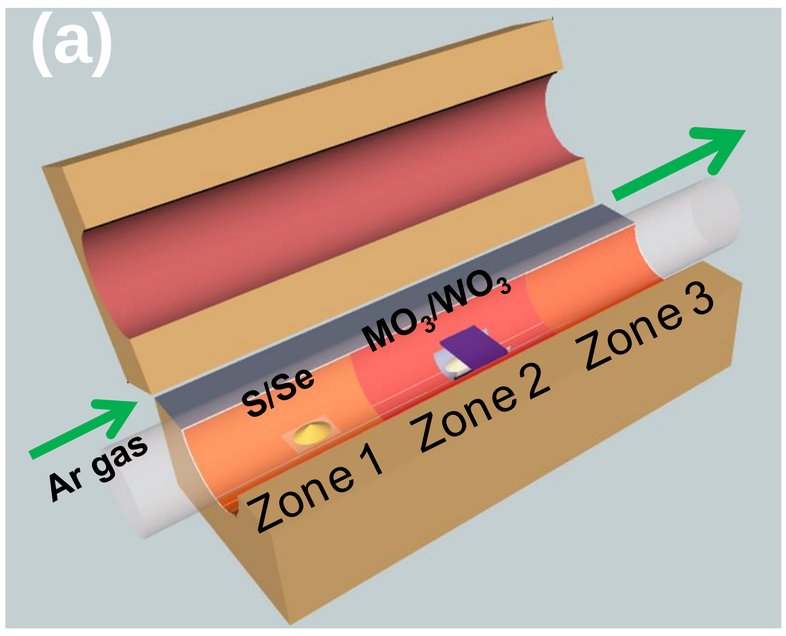
Advantages:
- Small dimension
- High surface-to-volume ratio
- Semiconducting

Transitional Metal Dichalcogenides (TMDCs):
- Semiconductor with tunable bandgap
- Direct bandgap at monolayer

A. K. Geim, I. V. Grigorieva, Van der Waals heterostructures. Nature, 2013, 499, 419-425

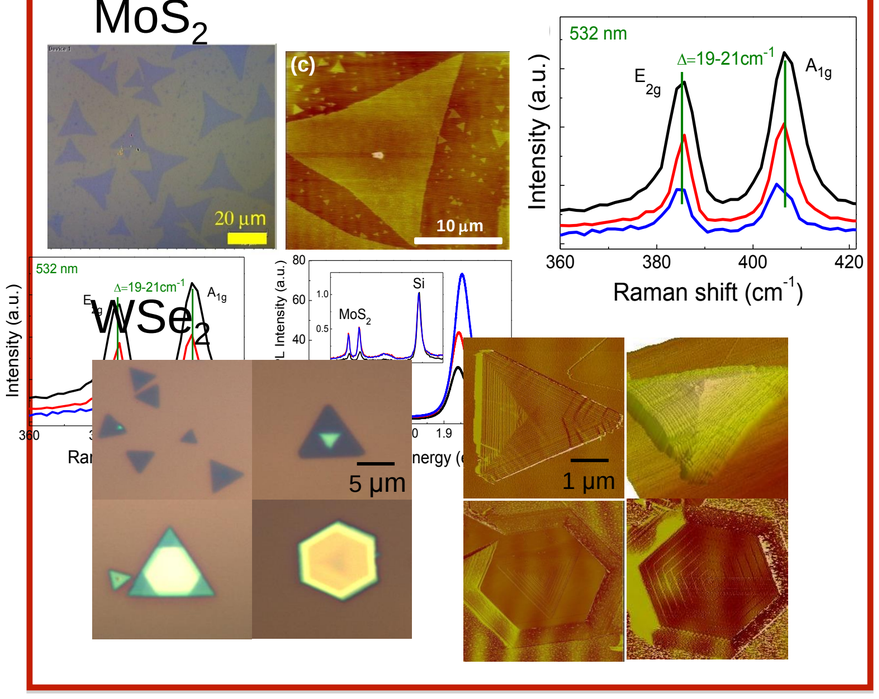
2D MoS_2 and WSe_2 Synthesis

Chemical Vapor Deposition (CVD)



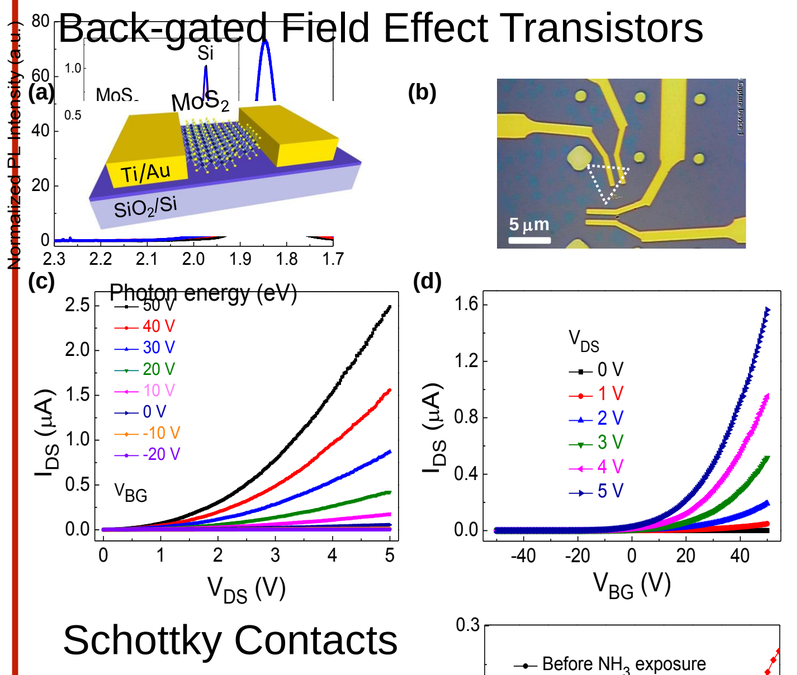
Optical, AFM, Raman

MoS_2

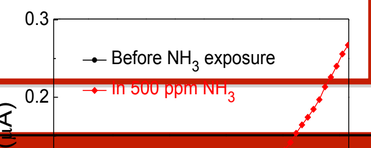


Sensing Devices

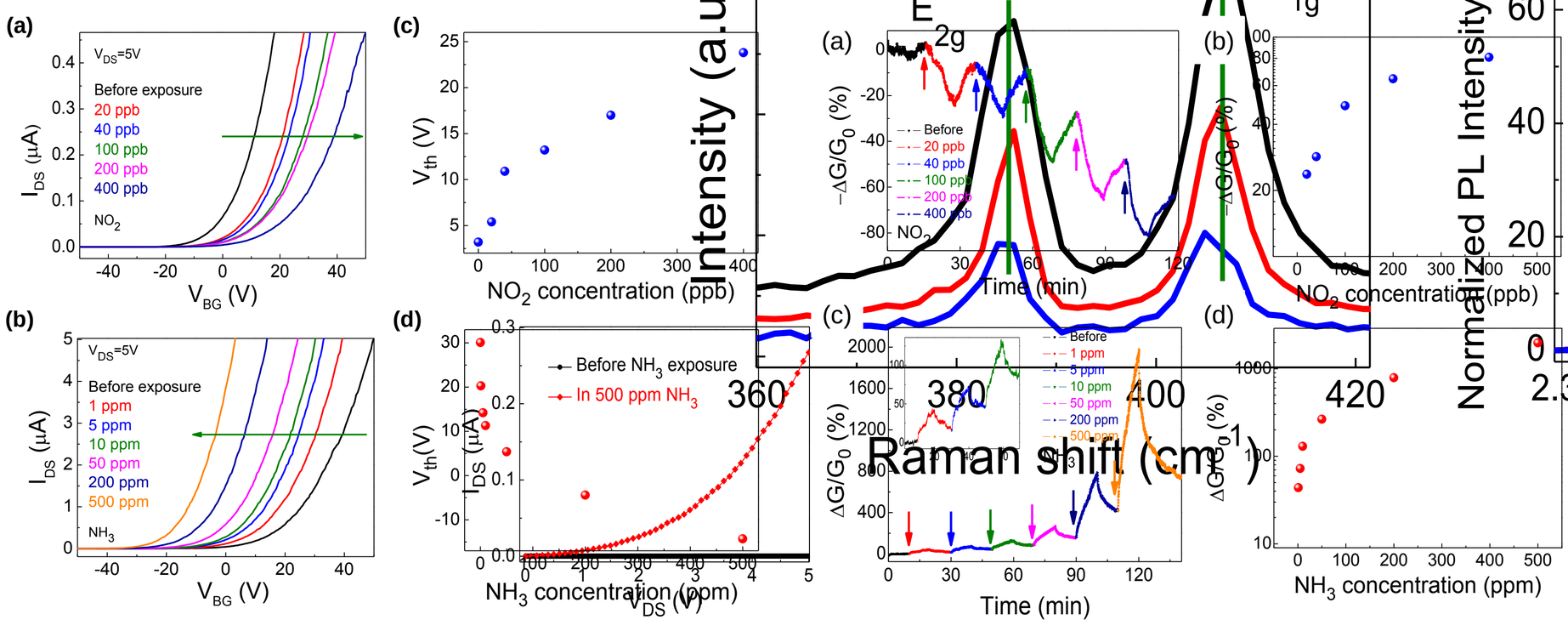
Back-gated Field Effect Transistors



Schottky Contacts



NO_2 and NH_3 Sensing and Sensing Mechanism



Subthreshold voltage shifts upon gas exposure

Real time sensing results

Schottky barrier modulation after gas absorption

Conclusion

We have successfully synthesized two-dimensional atomic layers of TMDC materials using CVD method, which facilitates the future large scale fabrication of high density gas sensing arrays. High performance NO_2 and NH_3 gas sensors using Schottky contacted 2D materials were demonstrated. Results show that the detection limits can be down to 20 ppb for NO_2 and 1 ppm for NH_3, which are superior to most of the other gas sensors.

1. **Bilu Liu,† Liang Chen,† Gang Liu, Ahmad N. Abbas, Mohammad Fathi, and Chongwu Zhou*, High-Performance Chemical Sensing Using Schottky-Contacted Chemical Vapor Deposition Grown Monolayer MoS_2 Transistors. *ACS Nano*, 2014, 5, 5304-5314.**
2. **Liang Chen,† Bilu Liu,† Ahmad N. Abbas, Yuqiang Ma, Xin Fang, Yihang Liu, Chongwu Zhou*, Screw-Dislocation-Driven Growth of Two-Dimensional Few-Layer and Pyramid-like WSe_2 by Sulfur-Assisted Chemical Vapor Deposition. *ACS Nano*, 2014, Accepted.**

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