Atomic Layer Semiconducting 2D Nanoelectromechanical Systems (2D NEMS)

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Atomically thin crystals derived from new classes of layered materials have rapidly emerged to enable two-dimensional (2D) nanostructures with unusual electronic, optical, mechanical, and thermal properties. While graphene has been the forerunner and hallmark of 2D crystals, newly emerged compound and single-element 2D semiconductors also offer very attractive attributes beyond some of graphene's (*e.g.*, including sizeable and tunable bandgaps covering a wide spectrum with technological importance). In this presentation, I will describe my research team's latest efforts on investigating how mechanically active atomic layer semiconducting nanostructures interact with optical and electronic interrogations, and on engineering such structures into ultrasensitive transducers and ultralow-power signal processing building blocks at radio-frequencies (RF). I will show the demonstrations of highly tunable multimode resonant 2D nanoelectromechanical systems (NEMS) and vibrating-channel transistors using atomic layer transition metal dichalcogenides (TMDCs). I will describe spatially resolved mode shapes and Brownian motion detection in these atomic layer multimode nanoresonators at room temperature, along with the device physics and coupling effects that govern the signal transduction. I will also present black phosphorous 2D devices that exploit the crystal's unique and strong in-plane anisotropy, and its effects on electromechanical coupling in these devices. Finally, I will show the perspectives of emerging applications, including ultrasensitive detection in fundamental physics studies, ultralow-power transducers, and 2D nanosystems.

References

[1] Wang, Jia, Feng, *et al.*, *Nano Lett.* **16**, 5394-5400 (2016).
[2] Jia, Yang, Feng, *et al.*, *Nanoscale* **8**, 10677-10685 (2016).
[3] Yang, Islam, Feng, *Nanoscale* **7**, 19921-29 (2015).
[4] Wang, Lee, Feng, *Nature Comm.* **5**, 5158 (2014).
[5] Lee, Krupcale, Feng, *Appl. Phys. Lett.* **108**, 023106 (2016).
[6] Wang, Jia, Feng, *et al.*, *Nanoscale* **7**, 877-884 (2015).
[7] Lee, Wang, Feng, *et al.*, *ACS Nano* **7**, 6086-6091 (2013).

Figures

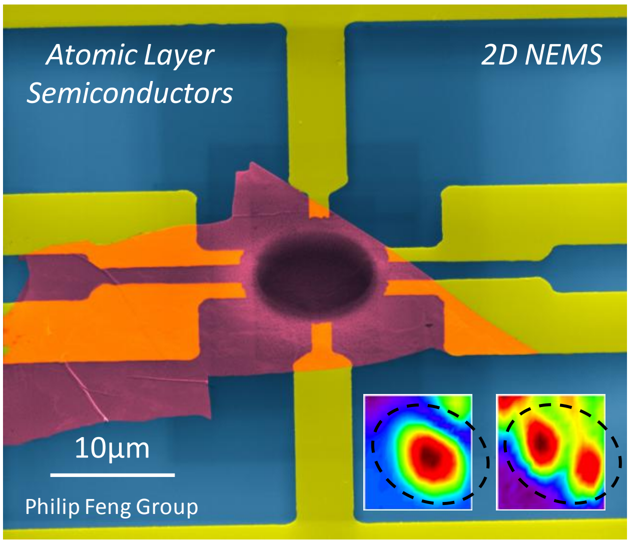

Figure 1: A representative 2D NEMS device with atomic layer semiconductor in contact with lithographically patterned electrodes. The suspended region makes a circular drumhead. The insets (color maps of measured data) show spatially resolved resonant mode shapes.