

Wearable Gas Sensors Based on Conductive Metal-Organic Frameworks

Tianshuang Wang^{1,2}

¹ State Key Laboratory of Integrated Optoelectronics, College of Electronic Science and Engineering,
College of Integrated Circuits, Jilin University, Changchun, China

² International Center of Future Science, Jilin University, Changchun, China

*email: wangtianshuang@jlu.edu.cn

Flexible wearable gas sensors have attracted significant attention for applications in human health monitoring and embodied artificial intelligence. Nevertheless, their practical deployment remains challenging due to the high operating temperatures of conventional semiconducting metal oxide sensors, the intrinsic trade-off between sensitivity and selectivity in conductive polymer-based sensors operating at room temperature, and the reliance on bulky, battery-powered electronic systems that limit flexibility and user comfort. Therefore, there is an urgent need to develop new sensing materials, design innovative sensor architectures, and integrate them into wireless, battery-free wearable sensing systems.

In this presentation, I will introduce a materials-to-system integrated strategy based on two-dimensional conjugated metal-organic frameworks (2D c-MOFs) to overcome these limitations. First, we establish a conductivity-gas sensing performance map for HHTP-based 2D c-MOFs by systematically tuning the metal cations (Cu, Co, and Ni) in bimetallic framework. Our results reveal that the synergistic interplay of intralayer conjugation, interlayer π - π stacking, and gas adsorption capacity governs charge transport and gas-sensing performance. Guided by these insights, the optimized bimetallic Cu/Co-HHTP sensor demonstrates high sensitivity, excellent selectivity, rapid response and recovery, and outstanding baseline stability under room-temperature operation.

Second, we develop a scalable, solvent-free fabrication strategy for 2-inch flexible c-MOF thin films (FTFs) with high electrical conductivity. The c-MOF FTFs-based wearable gas sensor exhibits high sensitivity, low detection limits, and excellent mechanical robustness, maintaining stable sensing performance after repeated bending cycles. Third, to address gas cross-interference, we propose a flexible bilayer architecture by integrating Pd/SSZ-13 zeolite film onto c-MOF FTFs sensing film, enabling highly selective NH₃ detection even in the presence of interfering NO₂. Finally, we integrate wireless, battery-free technologies, including near-field communication (NFC) system and inductor-capacitor (LC) resonant circuits, to establish a fully flexible wearable sensing platform for continuous, real-time monitoring.

Overall, this work establishes a general design framework for high-performance, room-temperature wearable gas sensors, bridging fundamental materials innovation with practical device and system integration, and providing a viable pathway toward next-generation smart healthcare, environmental monitoring, and human-machine interface applications.

Keywords: 2D bimetallic c-MOFs; flexible MOF films; bilayer sensors; wireless passive patch

References

- [1] Y. Jiang, X. Hou, Y. Zhou, B. Wang, T. Wang, L. Zhao, J. Wei, P. Sun, G. Lu, *ACS Materials Lett.* **7**, 76-84 (2025).
- [2] Y. Jiang, W. Han, S.-Y. Yoon, T. Wang, X. Kou, L. Zhao, S.-Y. Jeong, P. Sun, G. Lu, *Nat. Commun.* (Accepted) (2026).
- [3] Y. Jiang, Y. Wang, T. Wang, L. Zhao, D. Li, X. Kou, P. Sun, G. Lu, *ACS Sens.* **11**, 2656-2667 (2026).