Native Oxide $MoSe_2$– MoO_2 Heterostructure-based photoinduced Self-powered Gas Sensor for Selective NO_2 and H_2 detection

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Detection of toxic and flammable gases at room temperature with minimal power consumption is critical for environmental monitoring and safety. Two-dimensional (2D) materials and their heterostructures offer unique opportunities for such applications due to their high surface sensitivity, tunable interfaces, and compatibility with low-power device architectures [1]. Here, we report a one-step chemical vapor deposition route to synthesize $MoSe_2$-MoO_2 heterostructure flakes and demonstrate their use as self-powered, highly selective gas sensors [2]. Comprehensive structural and spectroscopic characterization, like Raman and PL spectroscopy, AFM, HRTEM, EDS, XPS and UPS, confirms a well-defined $MoSe_2$-MoO_2 interface and compositional gradation within individual flakes. Two distinct device types emerged from the same growth: S1 (MoO_2 dominant, metallic) and S2 ($MoSe_2$-MoO_2, heterostructure). The heterostructure (S2) exhibits ultrabroadband photoresponse with external quantum efficiency ≈10^4 %, fast ON-OFF kinetics <200 ms, and a pronounced, reversible response to NO_2 under visible-light illumination, reaching a limit of detection ≈10 ppm at room temperature. In contrast, the MoO_2-rich flakes (S1) show a selective response towards H_2 at room temperature. Crucially, S2 operates at zero or few-millivolt external bias, due to the photogenerated carriers separated by the built-in electric field at the $MoSe_2$-MoO_2 junction which produce the sensing current, enabling true self-powered operation. Moreover, light exposure not only amplifies sensitivity and shortens response/recovery dynamics but also improves the NO_2 limit of detection [3],[4]. Additionally, in the presence of humidity, the response is further enhanced, making the device robust in real-world conditions. The complementary selectivity (NO_2 for light-activated heterostructure, H_2 for metallic MoO_2) and the ability to operate with negligible external power highlight the potential of the native-oxide 2D heterostructure devices for low or self-powered, MEMS-compatible gas sensors and on-chip environmental monitors. This work demonstrates a scalable materials and device strategy for selective, room-temperature, self-powered gas detection in practical sensing applications.

References

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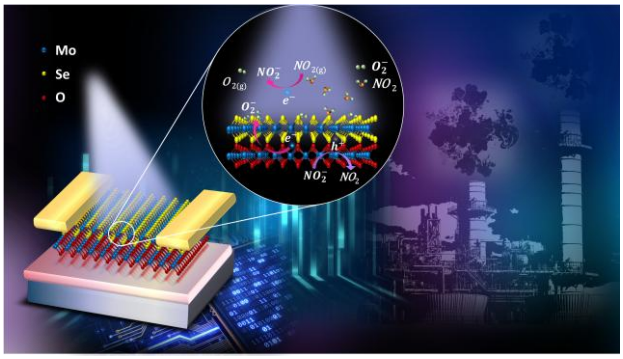

Figure 1: Schematic of the $MoSe_2$-MoO_2 device for light-induced NO_2 detection.