Ultrahigh-performance humidity-boosted NO_2 sensing using atomically sharp MoS_2 edges

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We developed sub-ppb level NO_2 sensors using multilayer, nanopatterned honeycomb MoS_2 nanomeshes with precise zigzag edges, created through advanced lithography.[1] These nanomeshes, with ribbon thicknesses from hundreds to under ten nanometres, demonstrate uniformity and precision. Our study focused on NO_2 concentrations of 2.5–10 ppb, under the U.S. EPA's threshold.[2] We found that the NO_2 sensing efficiency of the nanomeshes correlates with the density of hexagonal etching pits, showing optimal response at 200°C due to the exposed zigzag edges and electrical response quality. These sensors exhibit high selectivity for NO_2, with theoretical detection limits between 4 and 400 ppt, and enhanced performance in 70% humidity, even without UV light. This humidity-induced sensitivity boost, also noted for other gases like CO, CH_4, H_2, and C_2H_6, though to a lesser extent than NO_2, suggests a universal mechanism potentially involving H_2O and O_2 competition on the MoS_2 surface under UV light.[3]

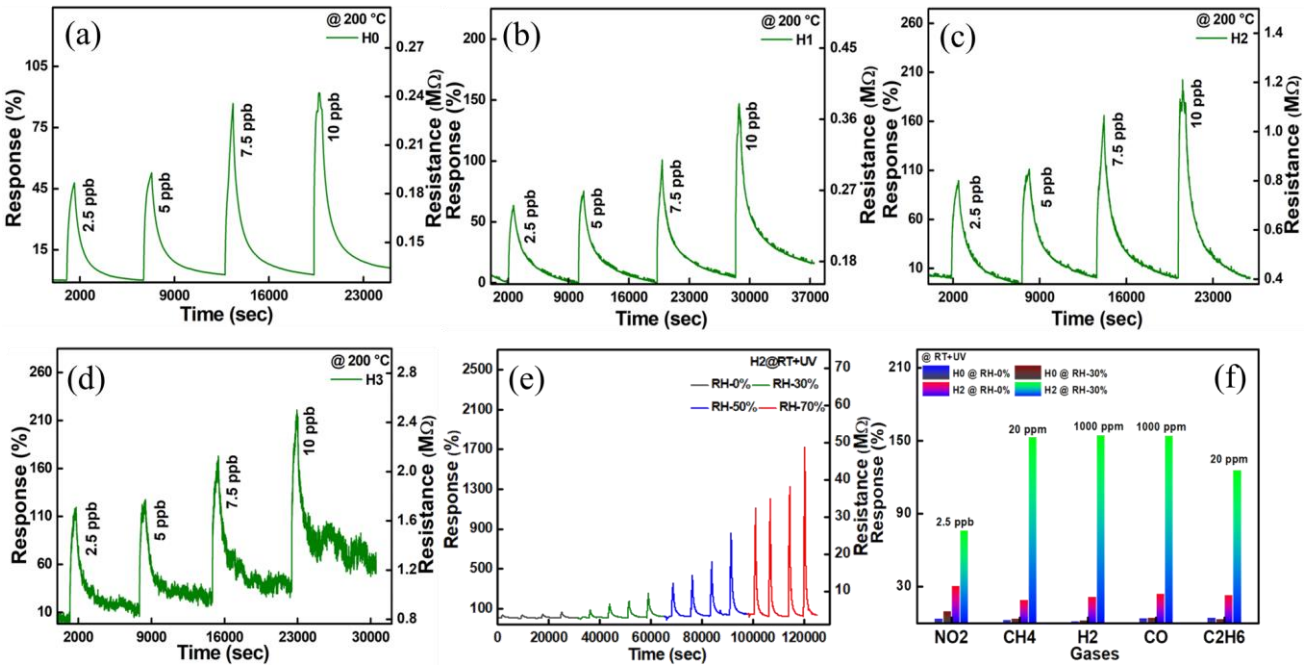

Figure 1: (a-d) The dynamic NO_2 sensing response (2.5-10 ppb) at 200 °C. (e) The broad dynamic NO_2 sensing response (2.5-10 ppb) at RT under UV illumination obtained from the honeycomb nanomesh device. (f) The selectivity profile of nanomesh MoS_2 under 0% and 30% RH for various gases under RT with UV illumination.

References

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[2] Esworthy, R.; McCarthy, J. E. EPA's 2006 Revisions and Associated Issues. 2013.
[3] Park, H.; Lee, J.; Han, G.; Al Mutairi, A.; Kim, Y.-H.; Lee, J.; Kim, Y.-M.; Kim, Y. J.; Yoon, Y.; Kim, S. Communications Materials 2021, 2, 94.