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A flexible room-temperature NH3 sensor for ultrasensitive, selective, and humidity-independent gas detection

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Introduction

NH3 is an irritant gas with a unique pungent odor; sub-ppm-level breath ammonia is a medical biomarker for kidney disorders and Helicobacter pylori (H. pylori) bacteria-induced stomach infections.[1,2] The humidity varies both in an ambient environment and exhaled breath and thus humidity dependence of gas sensing characteristics is a great obstacle for real-time applications. Herein, flexible, humidity-independent, and room temperature ammonia sensors are fabricated by the thermal evaporation of CuBr on a polyimide substrate and subsequent coating of a nano-scale moisture-blocking CeO2 overlayer by electron-beam evaporation.

CuBr sensors coated with a 100 nm-thick CeO2 overlayer exhibits an ultrahigh response (resistance ratio) of 68 to 5 ppm ammonia with excellent gas selectivity, rapid response, reversibility, and humidity-independent sensing characteristics at room temperature. In addition, the sensing performance remains stable after repetitive bending and long-term operation. Moreover, the sensors exhibit significant response to the simulated exhaled breath of patients with H. pylori infection; the simulated breath contains 50 parts per billion (ppb) NH3. The sensors thus show promising potential in detecting sub-ppm-level NH3, regardless of humidity fluctuations, which can open up new applications in wearable devices for in situ medical diagnosis and indoor/outdoor environment monitoring.

Sensing properties

The baseline resistance and gas response remained nearly the same in different bending modes which is very suitable for wearable devices.

Mechanism

The CeO2 layer plays the role of blocking the interaction between moisture and CuBr.

References

[1] Di Natale, C.; Paolesse, R.; Martinelli, E.; Capuano, R. Solid-State Gas Sensors for Breath Analysis: A review. Anal. Chim. Acta 2014, 824, 1-17.
[2] Krishnan, S. T.; Devadhasan, J. P.; Kim, S. Recent Analytical Approaches to Detect Exhaled Breath Ammonia with Special Reference to Renal Patients. Anal. Bioanal. Chem. 2017, 409, 21-31.

Summary

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