Supporting Information

Light-excited chemiresistive sensors integrated on LED microchips

Xiao-Xue Wang[1], Shuang Zhang[2], Yuan Liu[2], Jiang-Nan Dai[2], Hua-Yao Li[3]* and Xin Guo[1]*

1. State Key Laboratory of Material Processing and Die & Mould Technology, Laboratory of Solid State Ionics, School of Materials Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, P. R. China
2. Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan 430074, China
3. School of Optical and Electronic Information, Huazhong University of Science and Technology, Wuhan 430074, P. R. China

Fabrication Process

The figure of the detailed fabrication processes is given as follow.

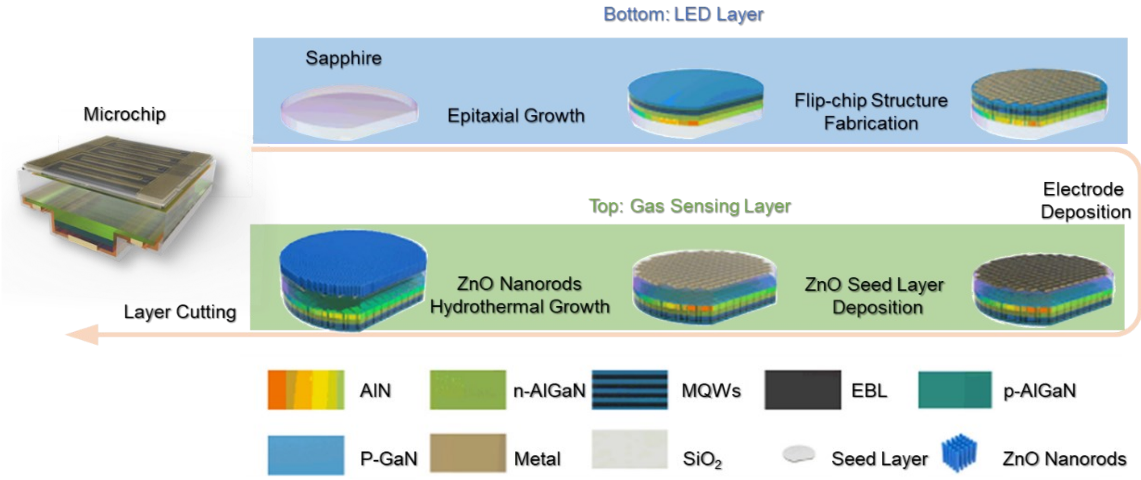

Figure S1. Schematic illustration of the structure design and fabrication process of integrated microchips.

Optical property of the LED layer

The light emitted by the LED layer is UVC with the wavelength of 280 nm.

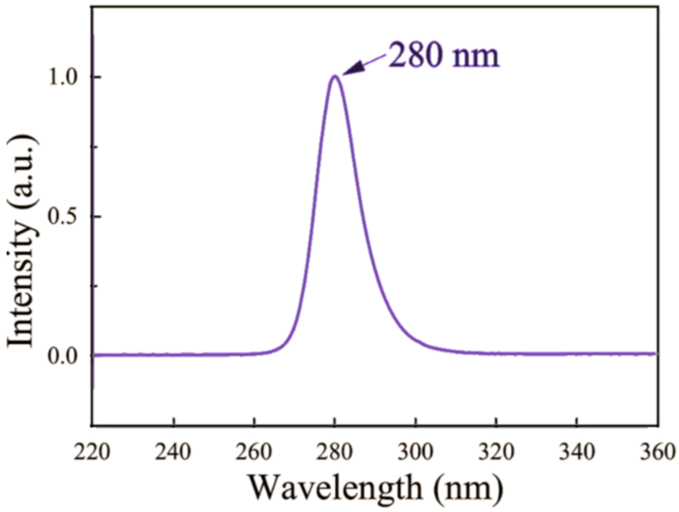

Figure S2. Wavelength spectrum of the LED layer.

UV-Vis absorption

PL spectrum and the UV-Vis absorption spectrum were applied to characterize the energy levels and light absorption properties of the ZnO nanorods.

The PL spectrum of the ZnO nanorods was obtained under the excitation source of 325 nm. Figure S3 shows that ZnO has a very strong peak near 375 nm, corresponding to the intrinsic energy level of ZnO, i.e., the bandgap of the ZnO nanorod array is 3.3 eV. A broader peak at 500 ~700 nm can also be observed in the PL spectrum, indicating more defective energy levels near 1.77-2.48 eV. Besides, another strong peak near 750 nm suggests a shallow energy level at 1.65 eV.

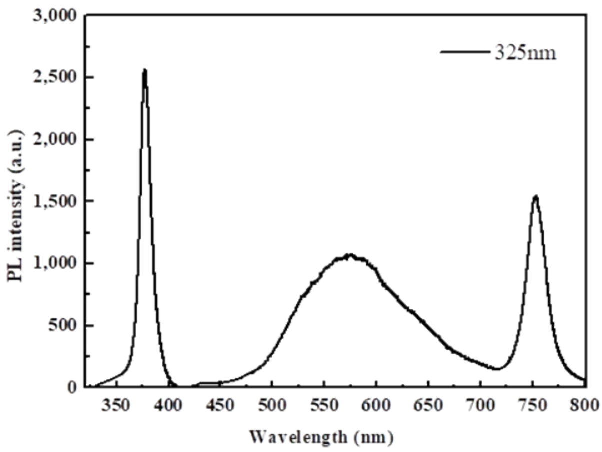

Figure S3. PL spectrum of the ZnO nanorods.

The UV-Vis absorption spectrum shows that the absorption peak of the ZnO nanorods is mainly at 365 nm, which is consistent with the result of the PL spectrum.

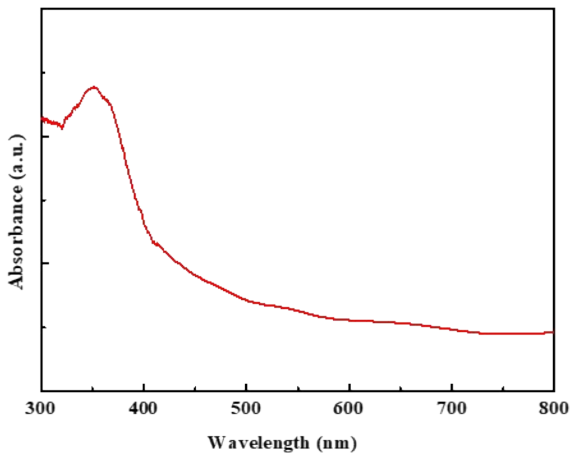

Figure S4. UV-Vis spectrum of the ZnO nanorods.

Effect of light irradiance on the gas-sensing performance

The resistance of the sensing layer to air and NO_2 were recorded under different light environments. In Figure S5, the baseline resistance of the sensing layer in the dark is ~9 MΩ. After in-situ light-excitation by the LED layer with the excitation current of 5 mA, the resistance of the sensing layer decreases by 3 orders of magnitude within 10 s. Besides, the resistance of the sensing layer in NO_2 is always higher than that in air, showing a typical n-type semiconductor response.

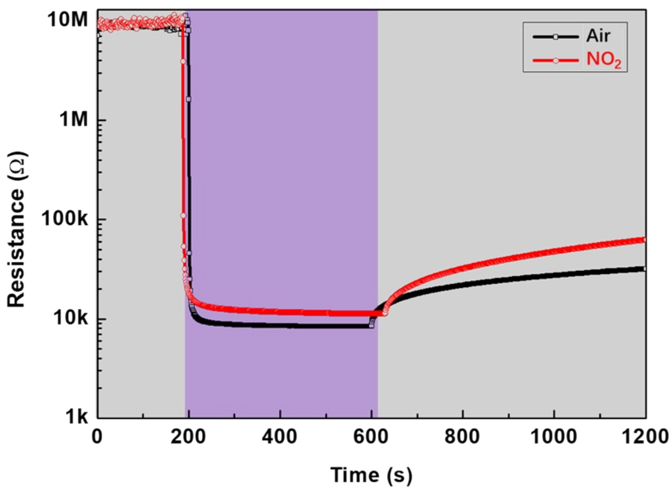

Figure S5. Resistance change of the sensing layer under 5 mA in-situ illumination from the LED layer of the integrated microchip.

By adjusting the applied current of the LED layer, the influence of the light irradiance to the sensing layer was recorded in Figure S6.

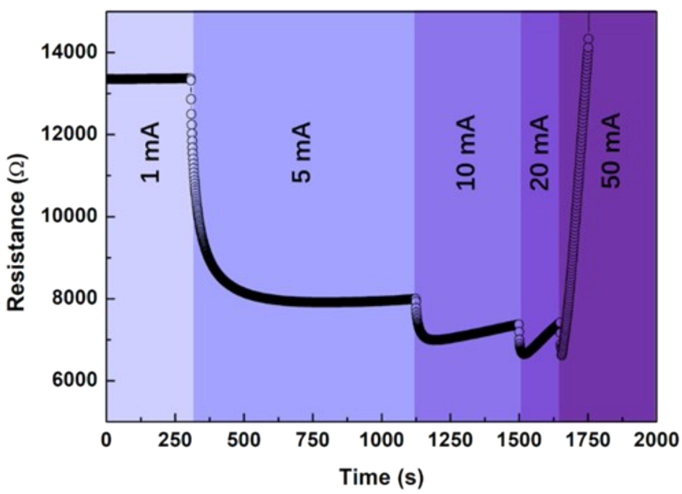

Figure S6. Resistance variation of the sensing layer under different in-situ light illuminations.

Selectivity of the microchip to ppb-level gases

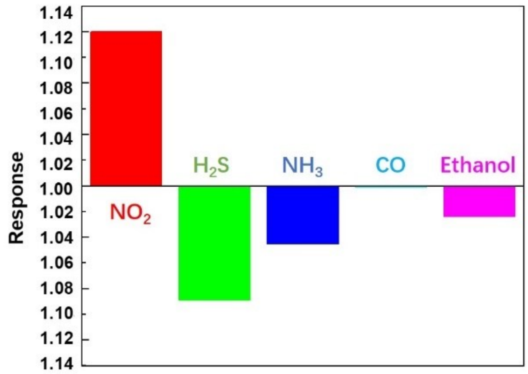

Figure S7. Selectivity of the microchip under in-situ LED illumination (gas concentration: 500 ppb).

Humidity test and long-term stability

In the field of gas sensors, the effect of different levels of water vapor is presented by the humidity test. The response to different humidities and the influence of the humidity on the sensor response to 500 ppb NO_2 are presented in Figure S8. From Figure S8, it can be figured out that the influence of low humidity is very weak, while high humidity can promote the sensing response to NO_2. Besides, the response in Figure S8 was tested after 10 months and the values keep nearly the same, which demonstrates the good long-term stability of the microchip.

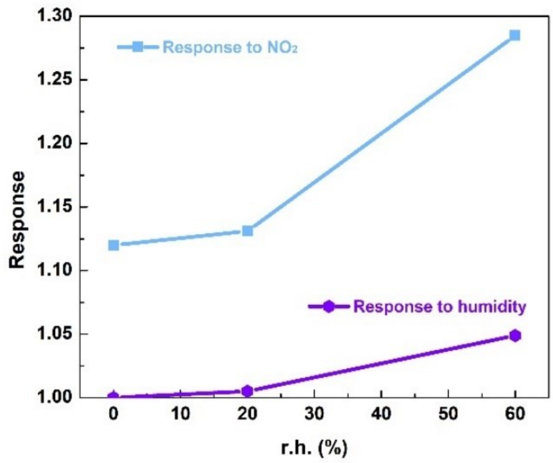

Figure S8. The response to different humidities and the influence of the humidity on the sensor response to 500 ppb NO_2.

Based on the data in Figure S7 in the manuscript, the LOD can be determined to be 3.4 ppb.

Effect of light-illumination directions on the gas-sensing performance

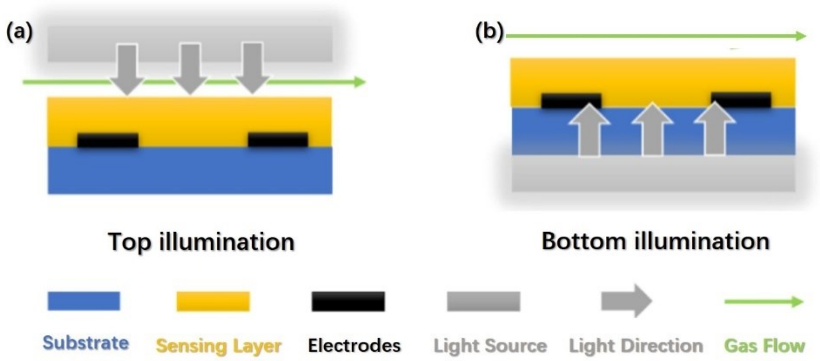

Figure S9. Schematic illustrations of top-light exposure and bottom-light exposure.