Supporting Information

Formaldehyde Gas Sensor with Extremely High Response Employing Cobalt-Doped SnO$_2$ Ultrafine Nanoparticles

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Figure S1  The actual picture of the test device and gas sensor.
Figure S2 The Raman spectra of SnO$_2$ NPs, 0.5%Co-SnO$_2$ NPs, 1%Co-SnO$_2$ NPs, 2%Co-SnO$_2$ NPs.
Figure S3 The response transient curves of the (a) 1%Co-SnO$_2$ NPs, (b) 2%Co-SnO$_2$ NPs, (c) SnO$_2$ NPs at 90°C and different formaldehyde concentration.
Figure S4 (a) The change curves of resistance $R_a$ of samples in air with temperature, (b) the resistance change curves of the samples with 30 ppm formaldehyde at 90°C.
The sensor noise ($RMS_{\text{noise}}$) is usually calculated from the standard deviation of the sensor baseline. From figure 6 (b), 270 points were collected before the sensor was placed on the target gas, and the calculated standard deviation ($S$) was 0.0128.

$$RMS_{\text{noise}} = \sqrt{\frac{S^2}{N}}$$  \hspace{1cm} (S1)

where $N$ is the number of data points. The value of $RMS_{\text{noise}}$ is 0.00078. The ratio of signal ($S$) to noise ($N$) ($S/N$) is 3 (International Union of Pure and Applied Chemistry (IUPAC) definition) and the slope is 4259.0 (From figure 9 (b)), therefore:

$$LOD = \frac{RMS_{\text{noise}}}{\text{Slope}} = 3 \times \frac{0.00078}{4259} = 0.00000055 \text{ ppb}$$  \hspace{1cm} (S2)

in this work, the theoretical detection limit of formaldehyde was estimated to be about $5.5 \times 10^{-7}$ ppb.

**Calcualtion of the Debye lengths of SnO$_2$**

$$\lambda_D = \sqrt{\frac{\varepsilon k_B T}{q^2 N_0}}$$ \hspace{1cm} (S3)

$\varepsilon_{\text{SnO}_2} = 13.5 \times 8.85 \times 10^{-12} \text{ Fm}^{-1}$

$k_B = 1.38 \times 10^{23} \text{ JK}^{-1}$

$T = 363 \text{ K}$

$q = 1.6 \times 10^{-19} \text{ C}$

$N_{\text{SnO}_2} = 3.6 \times 10^{18} \text{ cm}^{-3}$

$\lambda_{\text{SnO}_2} = 2.55 \text{ nm}$