

Text. S1

Initially, air from a reference cylinder was steadily fed into the gas distribution chamber at a flow rate of 50 milliliters per minute (mL/min) to displace the existing air within the chamber, a process that continued for a duration of 10 minutes. Upon ceasing the air supply, a measured volume Q of a 37% HCHO solution was extracted using a microsyringe, subsequently injected into the evaporator located within the gas distribution chamber, and subjected to heating for complete evaporation. Ultimately, the resultant HCHO vapor was thoroughly mixed with the reference air by the action of an internal fan, ensuring a homogeneous mixture. Specifically, acetone, benzene, toluene, methanol, ethanol, and formaldehyde vapors were obtained by evaporating acetone ($\cong 99.5\%$), benzene ($\cong 99.5\%$), toluene ($\cong 99.5\%$), methanol ($\cong 99.5\%$), ethanol ($\cong 99.7\%$), and formaldehyde (37%) solution, respectively. The operating temperature of the sensor was controlled by regulating the voltage of the heating wire. The different concentrations of test gases were prepared based on the static gas distribution method. A certain volume Q of gas or liquid was injected into a testing chamber, and the evaporation system quickly volatilized the injected liquid into vapor. The volume Q can be determined by the following equation:

$$Q = \frac{V \times C \times M}{22.4 \times d \times \rho} \times 10^{-9} \times \frac{273 + T_R}{273 + T_B} \quad (S1)$$

Where V , C , M , d , ρ , T_R , and T_B are the test chamber volume (mL), vapor concentration (ppm), liquid molecular mass (g), liquid density (g/cm³), liquid purity, environmental temperature (°C), and temperature in the testing chamber (°C), respectively. The stable resistance value of the sensor in air (or test gas) is labeled as R_a (or R_g). The sensitivity is defined as $S = R_a/R_g$. The response and recovery times are calculated based on the time from its response to reach 90% variation of the total resistance.

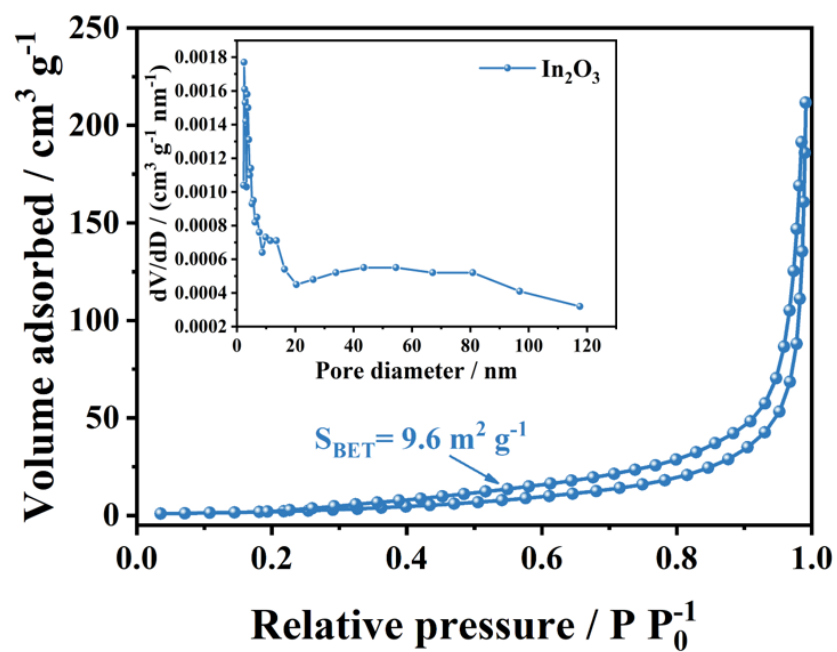


Figure S1. N_2 adsorption-desorption isotherms and pore-size distributions of pristine In_2O_3

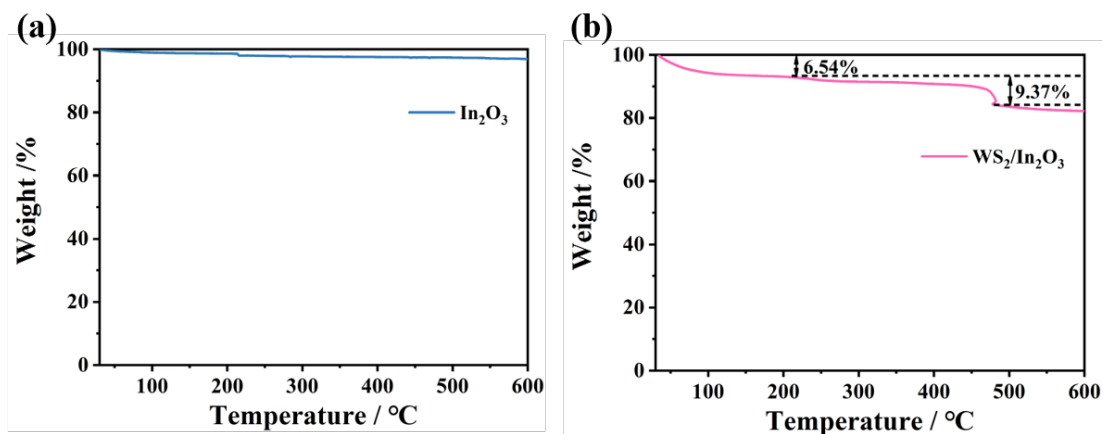


Figure S2. TGA analysis of (a) In_2O_3 and (b) $\text{WS}_2/\text{In}_2\text{O}_3$ NFs.

Thermal gravimetric (TG) analysis was conducted to understand the thermal decomposition behavior of In_2O_3 and $\text{WS}_2/\text{In}_2\text{O}_3$ NFs (Fig. S2). The In_2O_3 NFs exhibit high-heat thermal stability up to 600 °C except for the initial mass loss (Fig. S2a). In the case of $\text{WS}_2/\text{In}_2\text{O}_3$ NFs, it initially exhibits low weight loss (6.54 %) from room temperature to 210 °C, which corresponds to the release of guest species such as moisture/water molecule. The second TG mass loss of 9.37 % between 210 °C and 480 °C was caused by the detachment/elimination of the oxygen-containing functional groups (Fig. S2b)[1]. The TGA study shows that the In_2O_3 and $\text{WS}_2/\text{In}_2\text{O}_3$ NFs had good thermal stability.

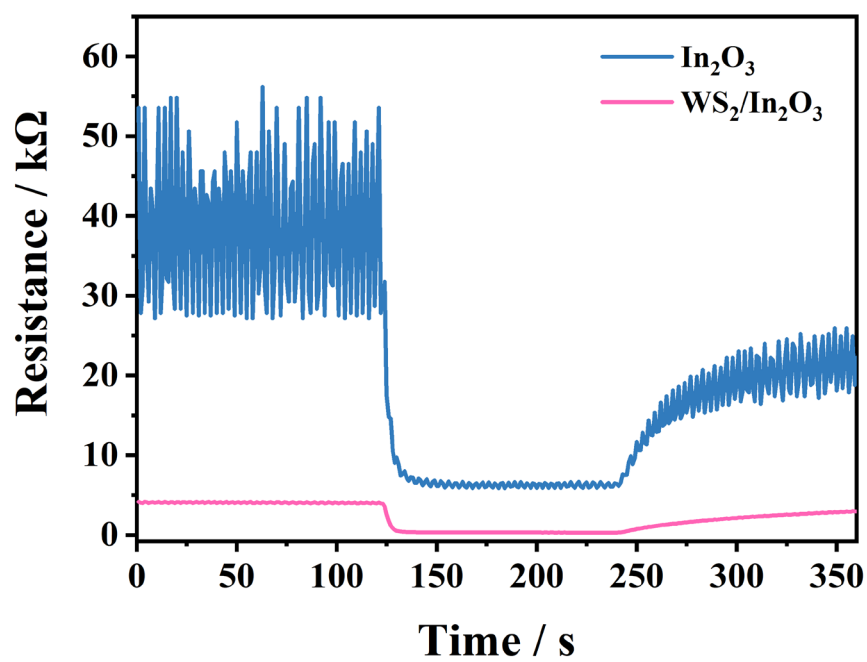


Figure S3. Response and recovery characteristics of sensors exposure to HCHO (100 ppm)

Table S1 Structural parameters for pristine In₂O₃ and WS₂/In₂O₃ NFs by considering the crystal plane from their XRD patterns.

Materials	2Theta (degree)	FWHM (degree)	Grain size (nm)	Dislocation density (nm ⁻²)
In ₂ O ₃	30.513	0.494	16.67	0.0035
WS ₂ /In ₂ O ₃	30.544	0.519	15.86	0.0040

The structural parameters of pristine In₂O₃ and WS₂/In₂O₃ NFs have been taken into account by considering the most intense peak (222) according to the XRD patterns as shown in Figure 4a. These structural parameters were calculated using Scherrer's formula and Bragg's law as follows and shown in Table S1:

$$D = 0.9\lambda/\beta\cos\theta \quad (1)$$

$$\delta = 1/D^2 \quad (2)$$

where λ represents the incident wavelength of X-ray in nm, β represents the full width at half maximum (FWHM) in radians, θ represents the Bragg angle in radians, D represents the grain size in nm, and δ represents the dislocation density in nm⁻². The calculated grain sizes and FWHM values along with dislocation density of pristine In₂O₃ and WS₂/In₂O₃ NFs are shown in Table S1. The FWHM values were found as 0.494° and 0.519° for pristine In₂O₃ and WS₂/In₂O₃ NFs, respectively. And the decrease in crystallite size and increment dislocation density for WS₂/In₂O₃ NFs is attributed to the formation of WS₂/In₂O₃ heterojunctions, which caused structural disordering and increased dislocation density [2].

Table S2. The relative percentages of three different oxygen species for pristine In₂O₃, and WS₂/In₂O₃ NFs.

Sample	Oxygen Species	Relative
		Percentage (%)
pristine In ₂ O ₃	O _L	10.9
	O _v	40.8
	O _c	48.3
WS ₂ /In ₂ O ₃	O _L	12.5
	O _v	48.4
	O _c	39.1

Table S3. The molecular structure and the bond dissociation energies of various gases molecules

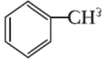
Gas type	Formaldehyde	Methane	H ₂ S	Ethanol	Methanol	Benzene	Toluene	Acetone	CO
Structural	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}=\text{O} \end{array}$			$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{O}-\text{H} \\ \\ \text{H} \end{array}$			$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \quad \\ \quad \quad \text{O} \quad \quad \text{H} \end{array}$	
Bond	H-CHO	C-H	H-S H	H-OCH ₂ C H ₃	H-OCH ₃ H-CH ₂ H-CH	H-C ₆ H ₅	CH ₃ -C ₆ H ₅	H-CH ₂ C OCH ₃	C-O
Bond dissociation energy (kJ mol ⁻¹)	364	416	381	436	436.8 473 452	431	389	393	1071

Table S4. Comparison of HCHO gas sensing performance with other gas sensors

Materials	Temperature / °C	Concentration / ppm	Response	$t_{\text{res}}/t_{\text{rec}}$ / s	Ref.
SnO ₂ /Fe ₂ O ₃	220	20	4.5	9 / 34	[3]
Co ₃ O ₄ /ZnO	120	10	6.17	6 / 4	[4]
Au-In ₂ O ₃	240	100	37	3 / 8	[5]
Co ₃ O ₄ -ZnO core-shell	220	100	5.3	6 / 9	[6]
Co ₃ O ₄	170	100	12	46 / 98	[7]
Ni-In ₂ O ₃ /WS ₂	25	5	-	76/ 123	[8]
WS ₂ /In ₂ O ₃ NFs	140	100	12.6	30 / 43	This work

References

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