Electronic Supplementary Information (ESI)

Zero-dimensional Heterostructures: N-Doped Graphene Dots/SnO_2 for Ultrasensitive and Selective NO_2 Gas Sensing at Low Temperatures

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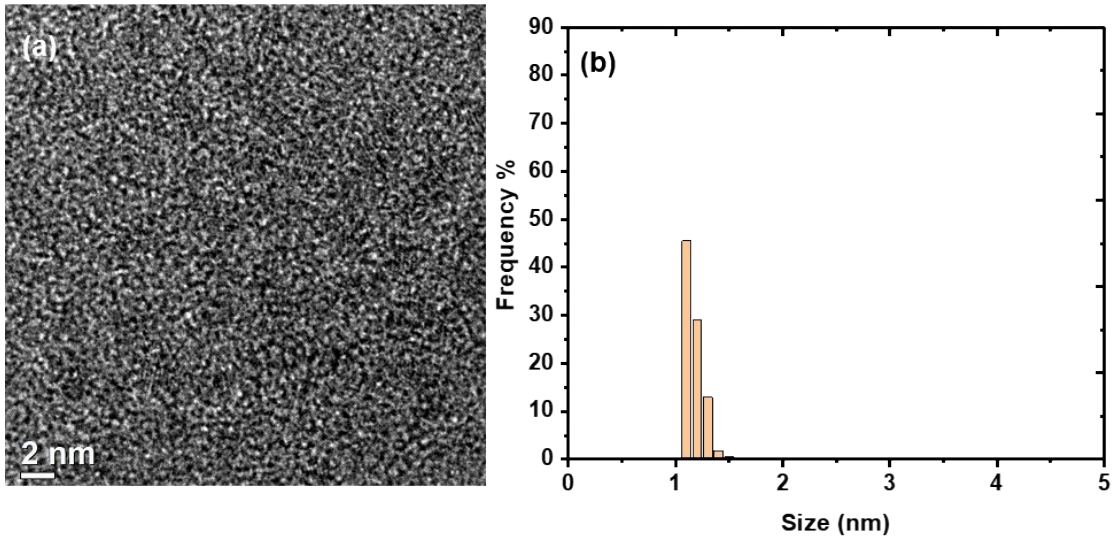

Figure S1 HR-TEM image and size distribution of N-doped graphene dots obtained in the area.

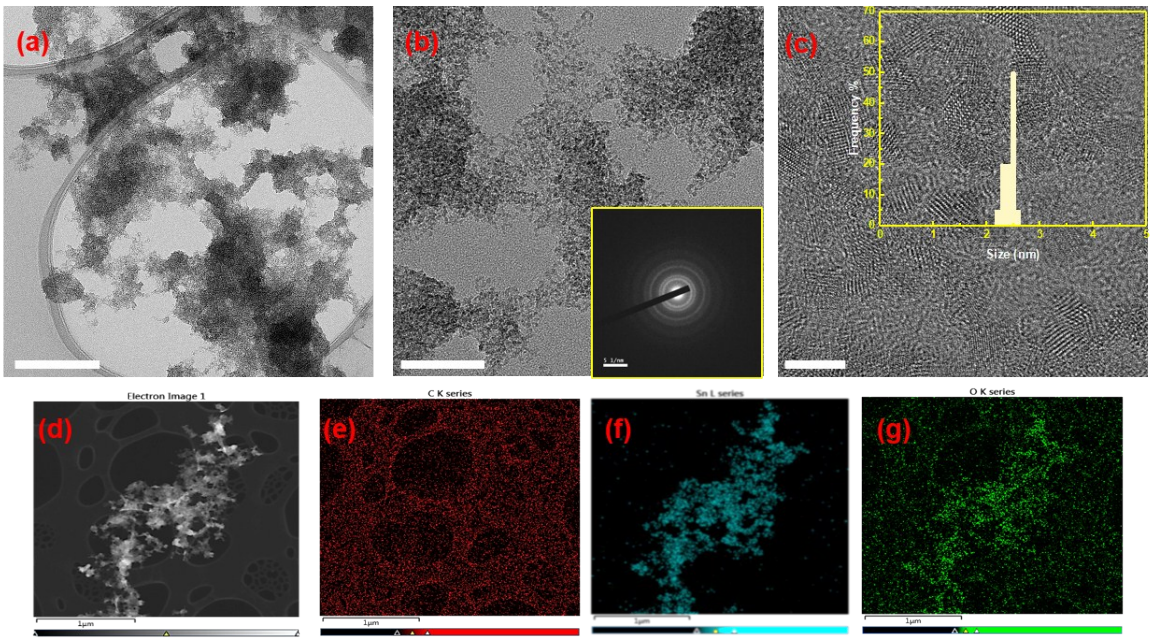

Figure S2 (a-b) TEM image (inset of b SAED pattern), (c) HR-TEM images with size distribution of pristine SnO_2 NPs, (d-g) STEM-EDS mapping of Sn, O, C elements (Scale bar of (a-b) 50 nm, (c) 5 nm, (d-g) 1 μm.)

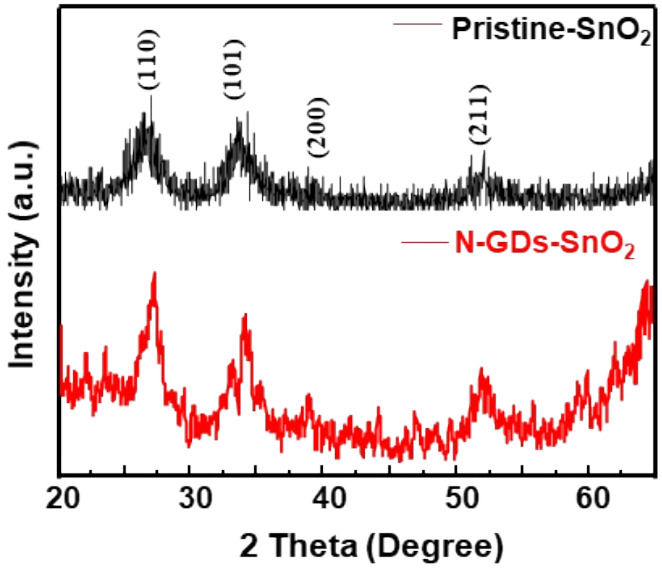

Figure S3 XRD spectra of pristine SnO_2 and N-GDs-SnO_2

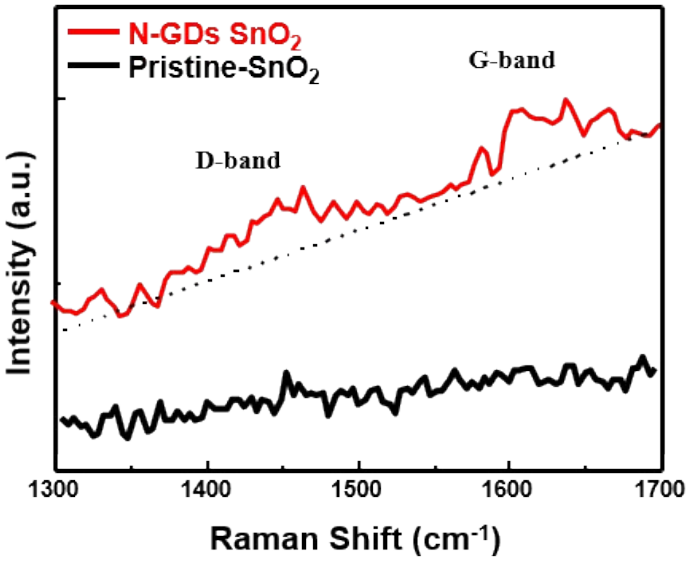

Figure S4 Raman spectra of pristine SnO_2 and N-GDs-SnO_2.

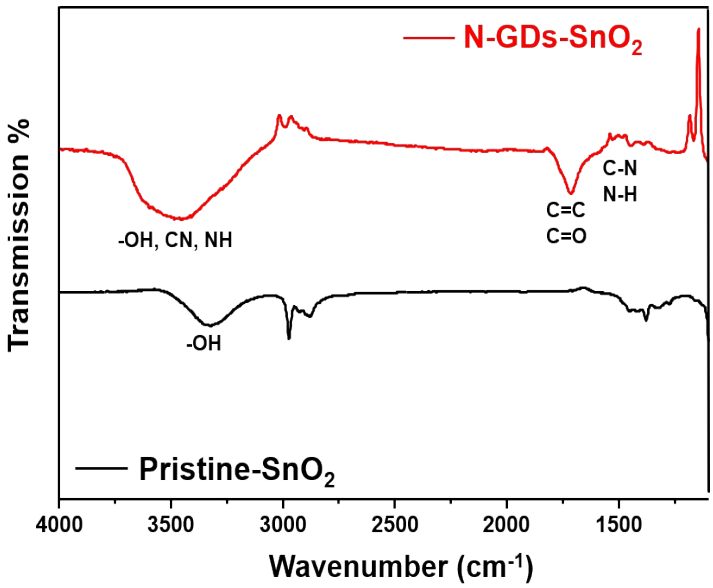

Figure S5 FT-IR spectra of pristine SnO_2 and N-GDs-SnO_2.

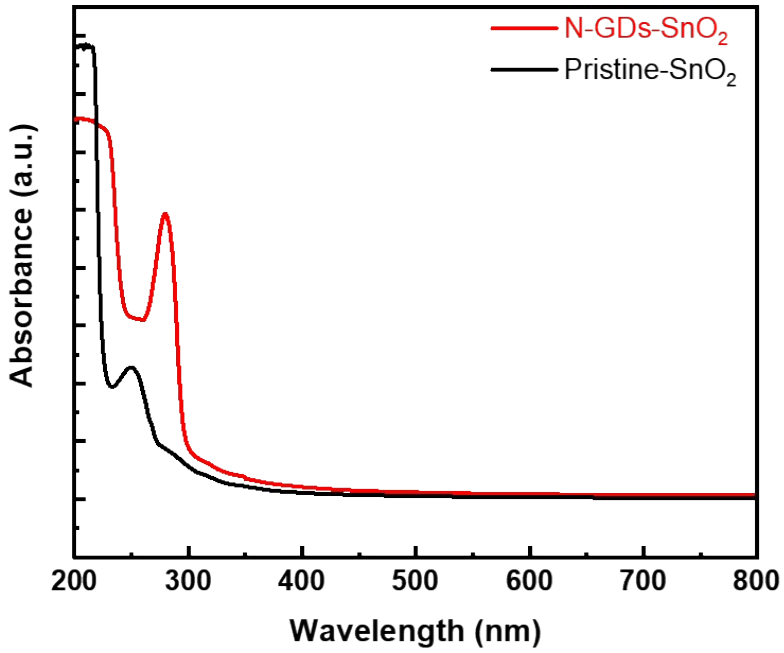

Figure S6 UV-vis spectra of pristine SnO_2 and N-GDs-SnO_2.

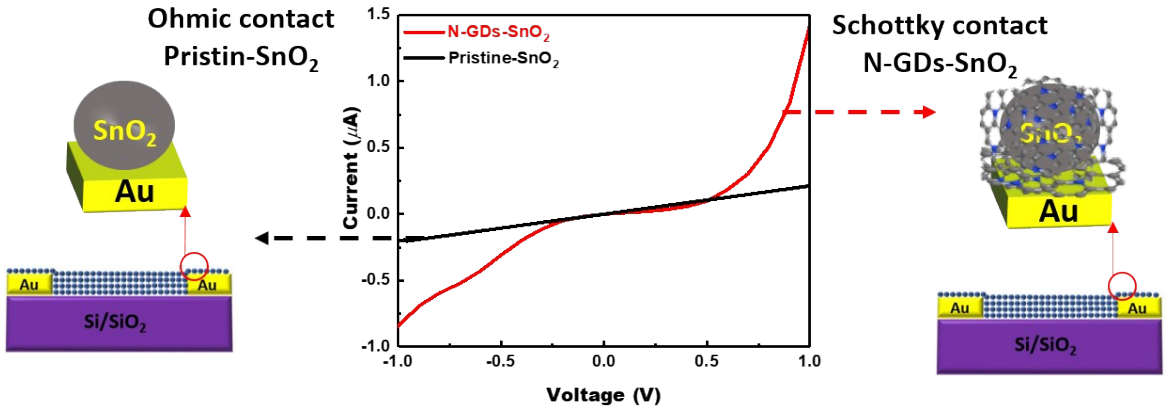

Figure S7 *I-V* characteristics of pristine SnO_2 and N-GDs-SnO_2 at room temperature with schematic interface.

Table S1: Calculated sensing response, Response time, recovery time of P-SnO_2 and N-GDs-SnO_2.

	P-SnO_2			**N-GDs-SnO_2**		
Temp.	Response time (min)	Recovery time (min)	Response (R_g/R_a)	Response time (min)	Recovery time (min)	Response (R_g/R_a)
Room	**26**	**NO**	**NO**	**27.3**	**more than 120 min**	**419**
50	**21**	**6**	**1**	**8.8**	**6.4**	**4336**
100	**15**	**35**	**4**	**7.8**	**3.2**	**2746**
150	**9**	**8.2**	**6**	**3.1**	**0.81**	**292**
200	**6**	**3.11**	**6**	**3.5**	**0.80**	**53**
250	**2.8**	**0.79**	**3**	**2.8**	**0.75**	**5**

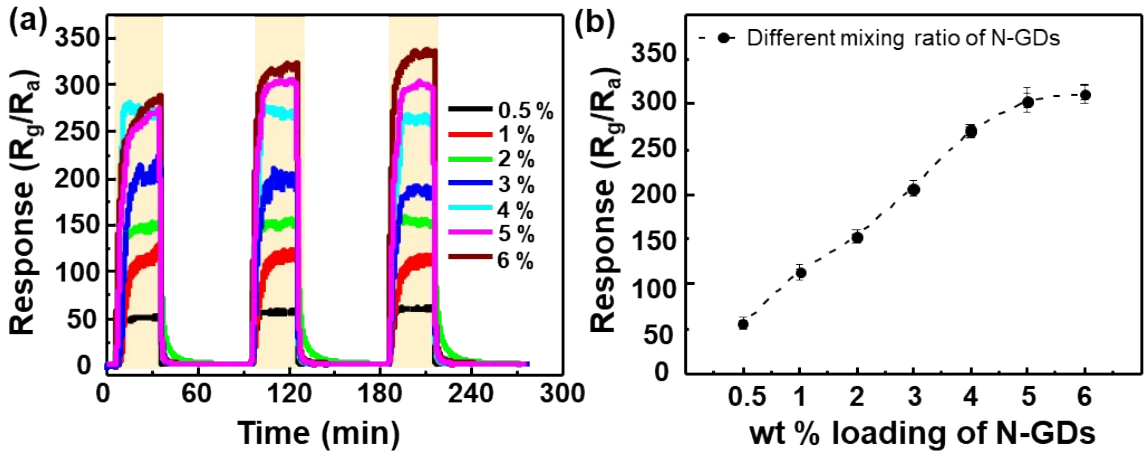

Figure S8 (a) NO_2 gas sensing characteristics with different N-GDs mixing ratio (0.5 % (50 µl), 1 % (100 µl), 2 % (200 µl), 3 % (300 µl), 4 % (400 µl), 5 % (500 µl), 6 % (600 µl)) with 10 ml SnO_2 composites and tested sensing device at 150°C towards 100 ppb NO_2, (b) the average response of NO_2 gas sensing as a function of different N-GDs concentration.

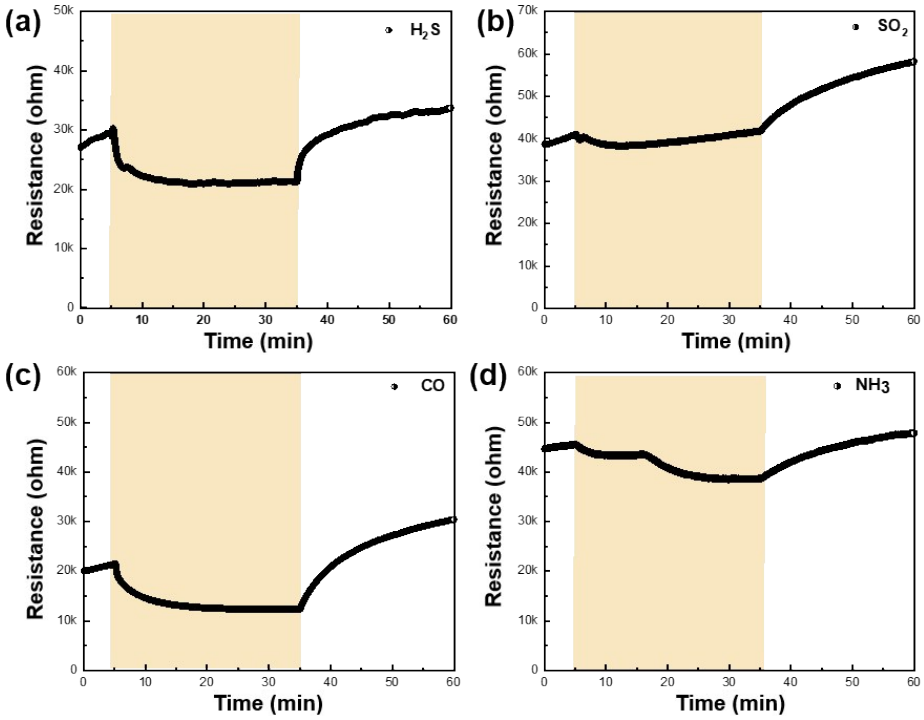

Figure S9 Selectivity of N-GDs-SnO_2 towards 1 ppm (a) H_2S, (b) SO_2 (c) CO (d) NH_3 gases.

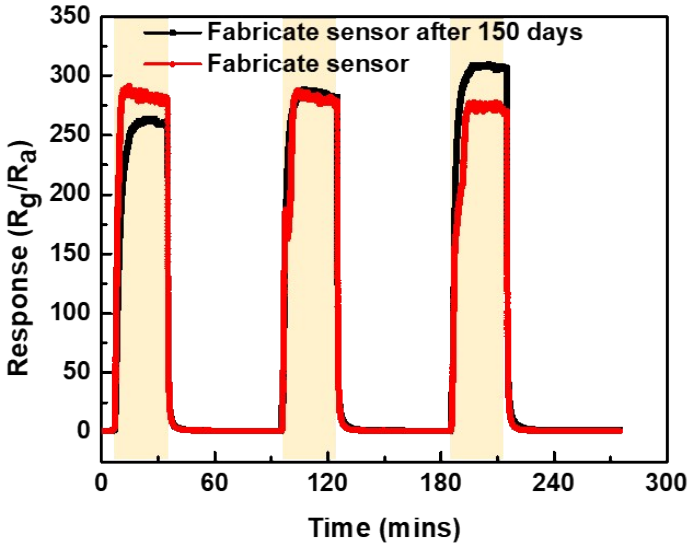

Figure S10 long term stability N-GD–SnO_2 sensor after 150 days at 150°C towards 100 ppb NO_2.

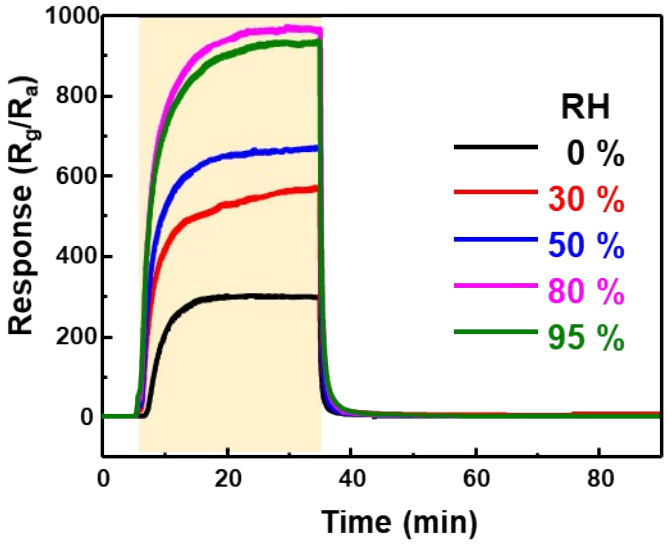

Figure S11 (a) Gas response of N-GD–SnO_2 sensor toward 100 ppb NO_2 as a function of relative humidity from 0 to 95 %.

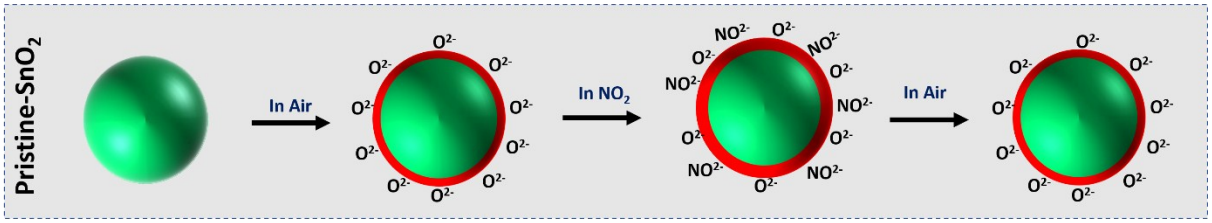

Figure S12 gas sensing mechanism of pristine SnO_2.

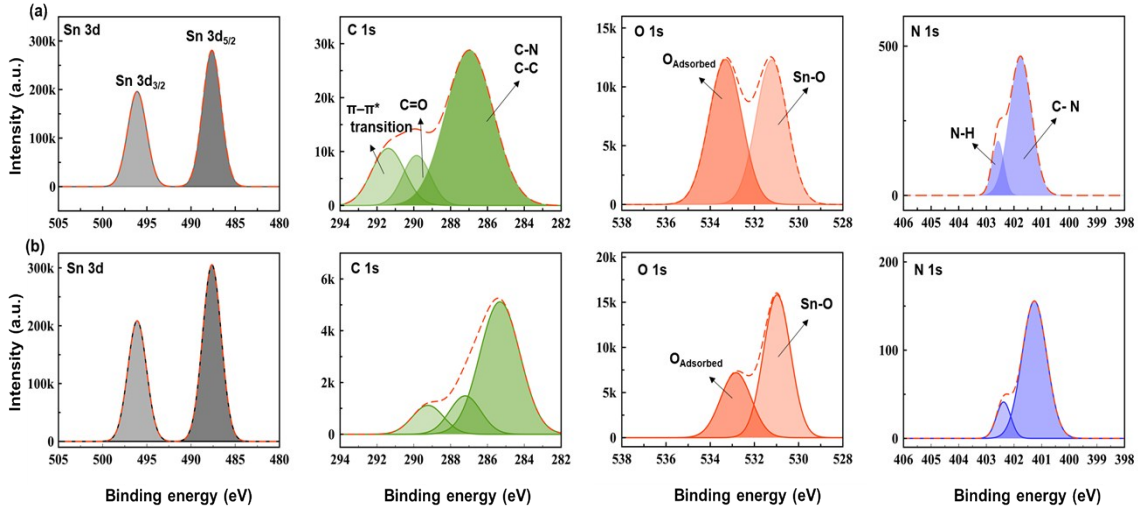

Figure S13 XPS spectra of N-GDs-SnO_2 (a) before and (b) after NO_2 exposure at room temperature.