Supplementary Information

Metal oxide patterns of one-dimensional nanofibers: On-demand, direct-write fabrication, and application as a novel platform for gas detection

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SUPPLEMENTARY FIGURES

Figure S1

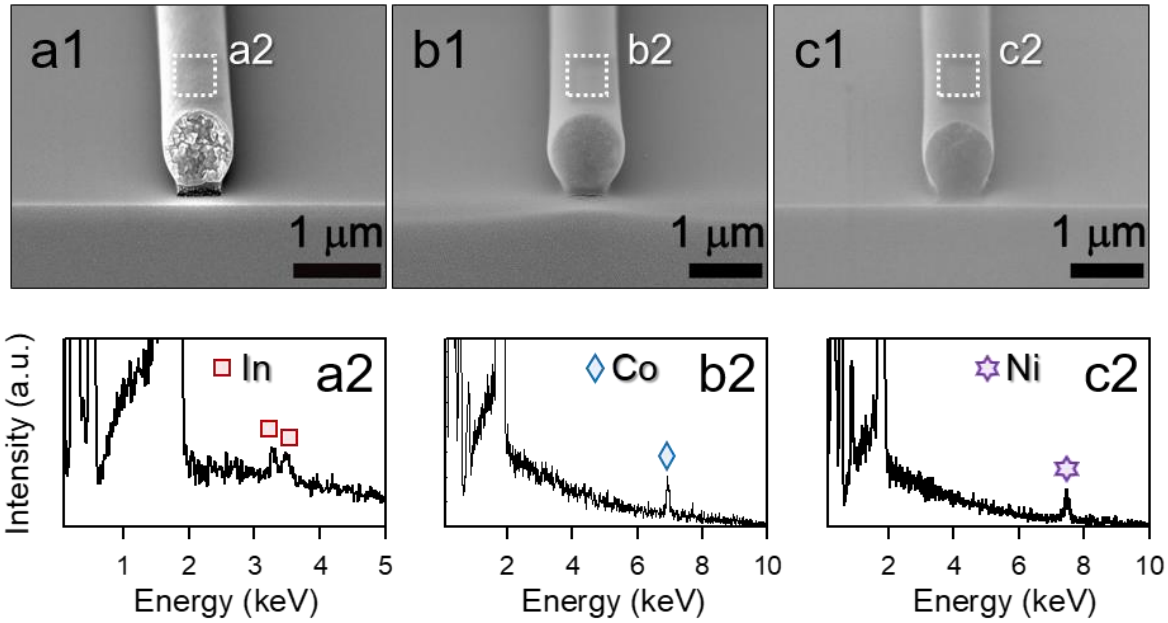

Figure S1 (a1-c1) Cross-sectional SEM images of (a1) In/PVP, (b1) Co/PVP, and (c1) Ni/PVP precursor fibers. (a2-c2) EDS analysis results for the (a2) In/PVP, (b2) Co/PVP, and (c2) Ni/PVP.

Figure S2

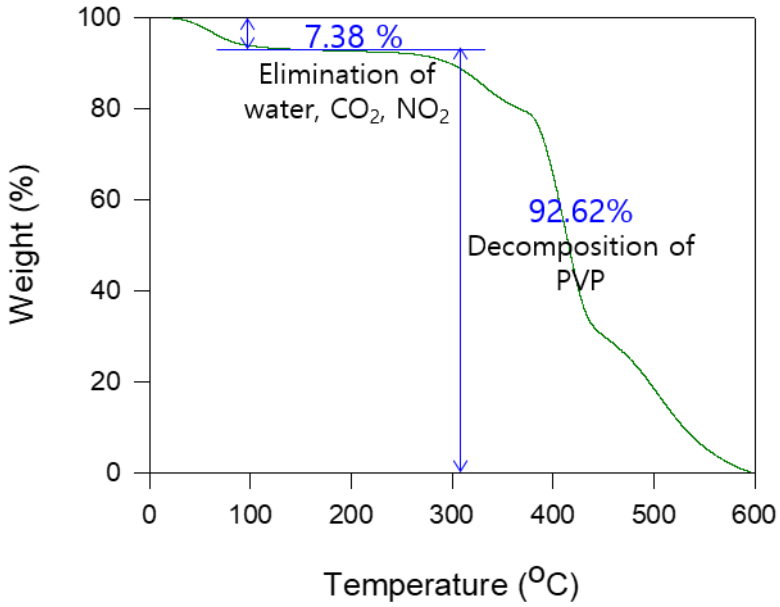

Figure S2 Thermal gravimetric analysis (TGA) of PVP (M_w=1,300,000).

Figure S3

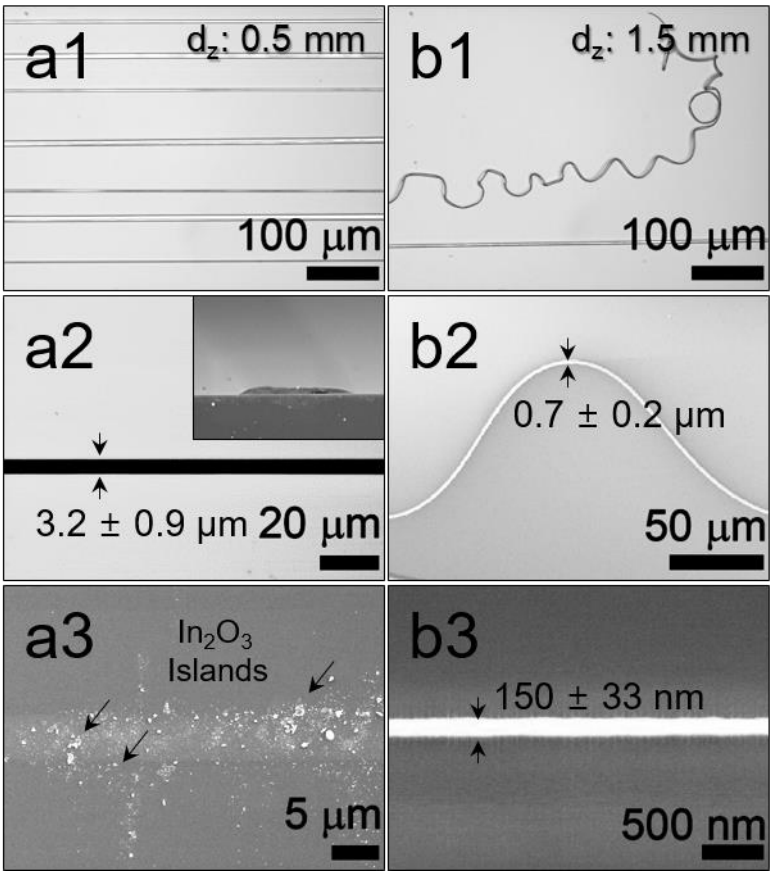

Figure S3 (a1,b1) Optical and (a2,b2) SEM images of In/PVP arrays fabricated at the d_z of (a1,a2) 0.5 and (b1,b2) 1.5 mm. (a3,b3) SEM images of In_2O_3 after heat treatment of the corresponding In/PVP at 600 °C for 5 h (number of measurement for determining the width of nanofiber: 10).

Figure S4

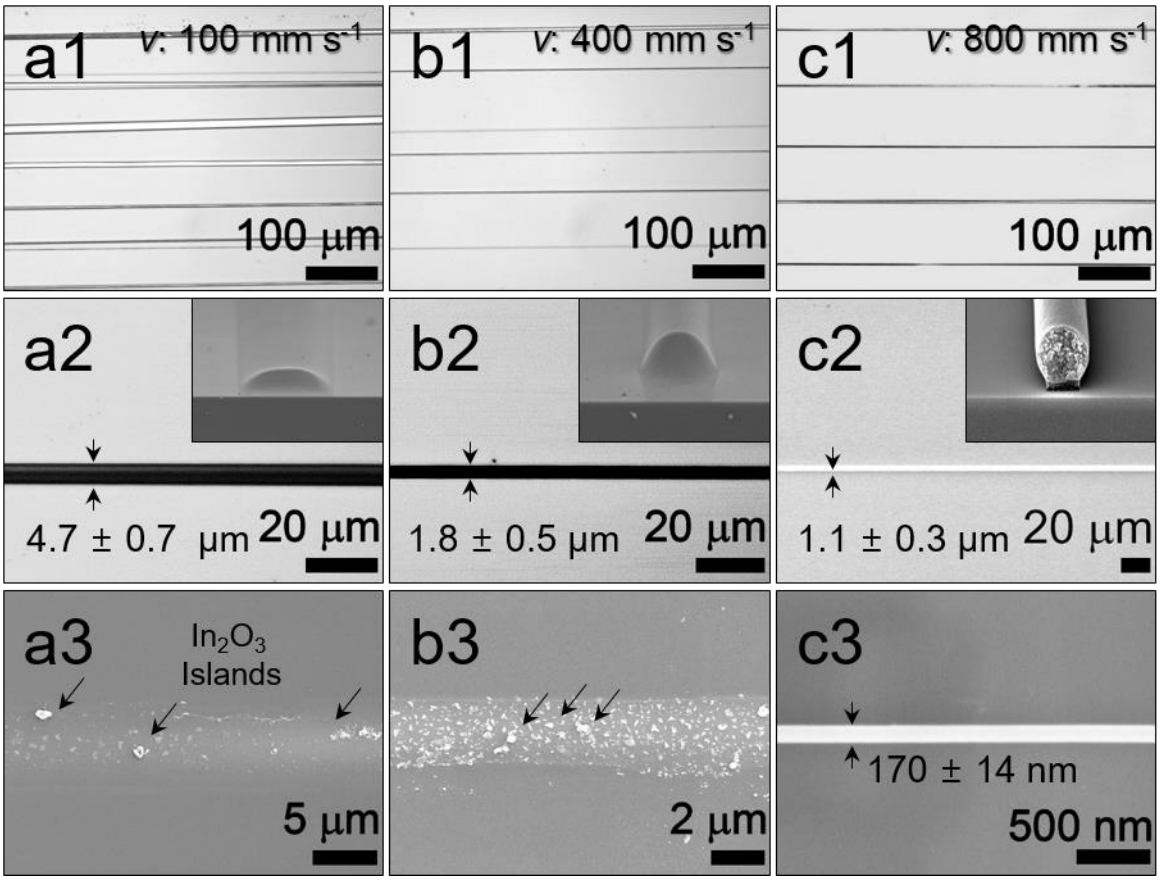

Figure S4 (a1-c1) Optical and (a2-c2) SEM images of In/PVP arrays at the *v* of (a1,a2) 100, (b1,b2) 400, and (c1,c2) 800 mm s^{-1}. (a3-c3) SEM images of In_2O_3 after heat treatment of the corresponding In/PVP at 600 °C for 5 h (number of measurement for determining the width of nanofiber: 10).

Figure S5

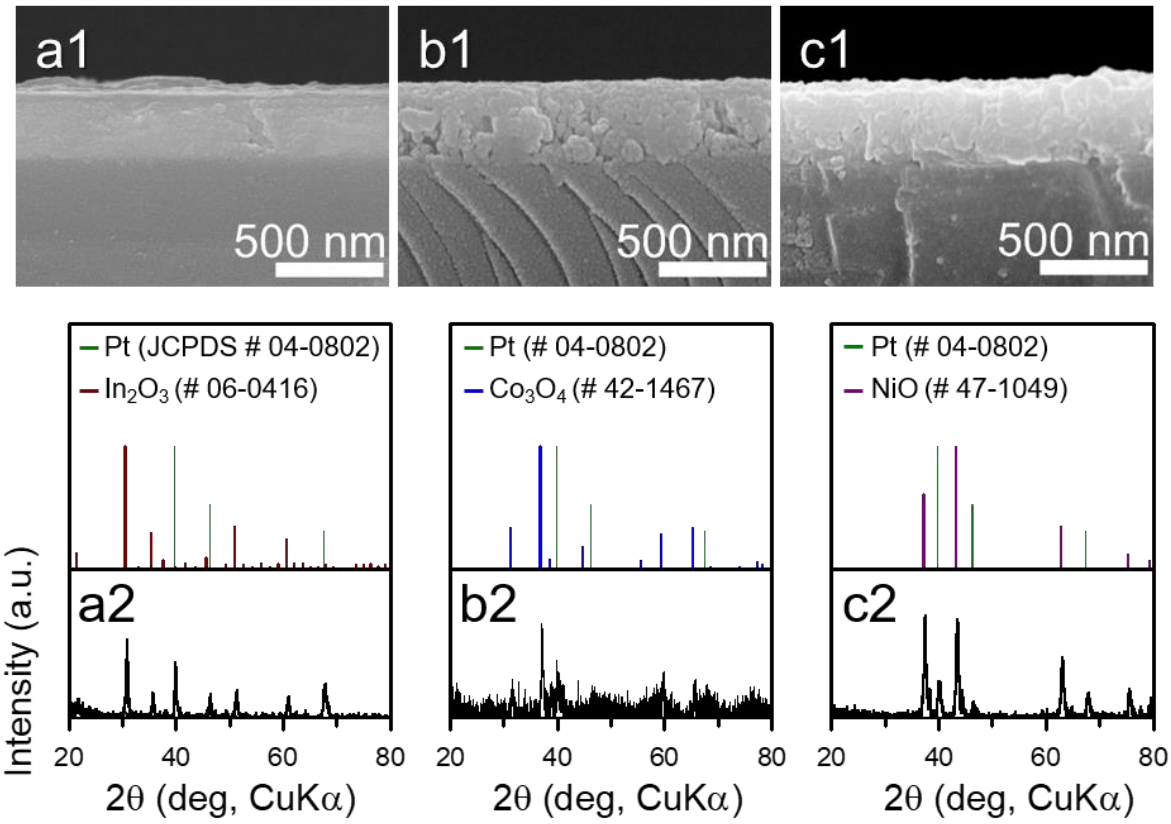

Figure S5 (a1-c1) SEM images of (a1) In_2O_3-F, (b1) Co_3O_4-F, and (c1) NiO-F sensors. (a2-c2) XRD patterns of the corresponding thin film sensors.

Figure S6

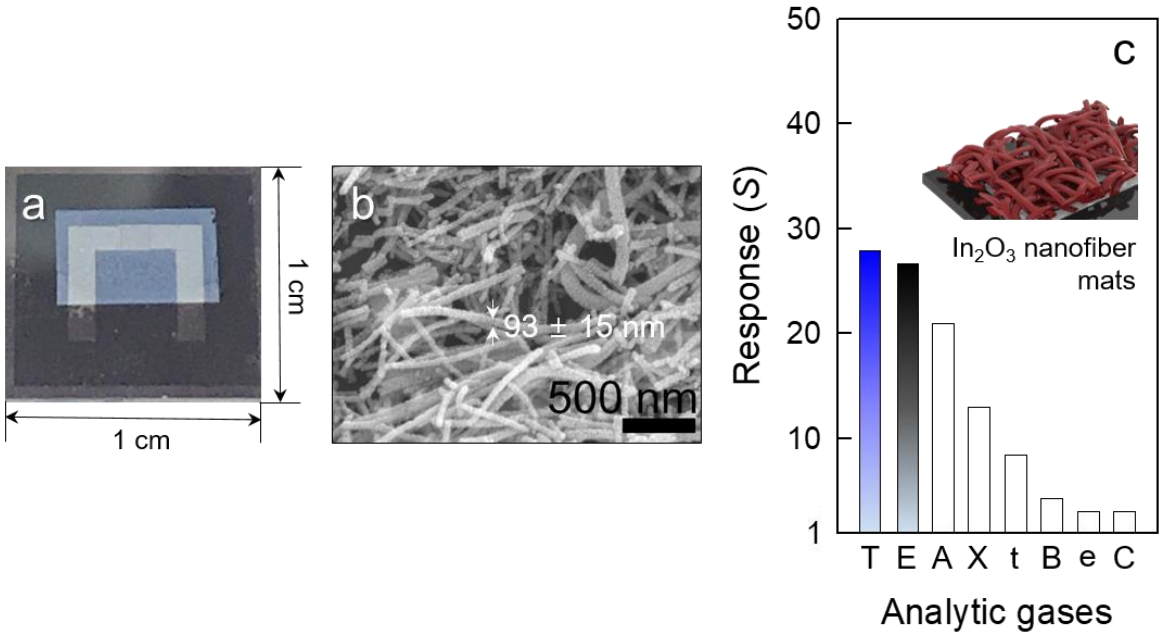

Figure S6 (a) Optical and (b) SEM images of In_2O_3 nanofiber mats sensor fabricated by c-ES (number of measurement for determining the width of nanofiber: 10). (c) Gas responses of In_2O_3 nanofiber mats sensor to 5 ppm of TMA (T), ethanol (E), ammonia (A), *p*-xylene (X), toluene (t), benzene (B), ethylene (e) and CO (C) at 350 °C.

Figure S7

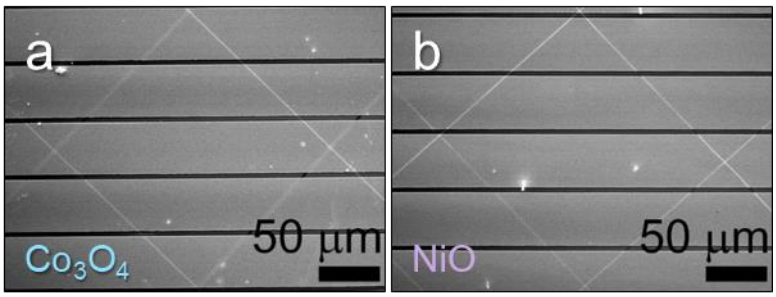

Figure S7 (a,b) SEM images of (a) Co_3O_4-P, and (b) NiO-P sensors.

Figure S8

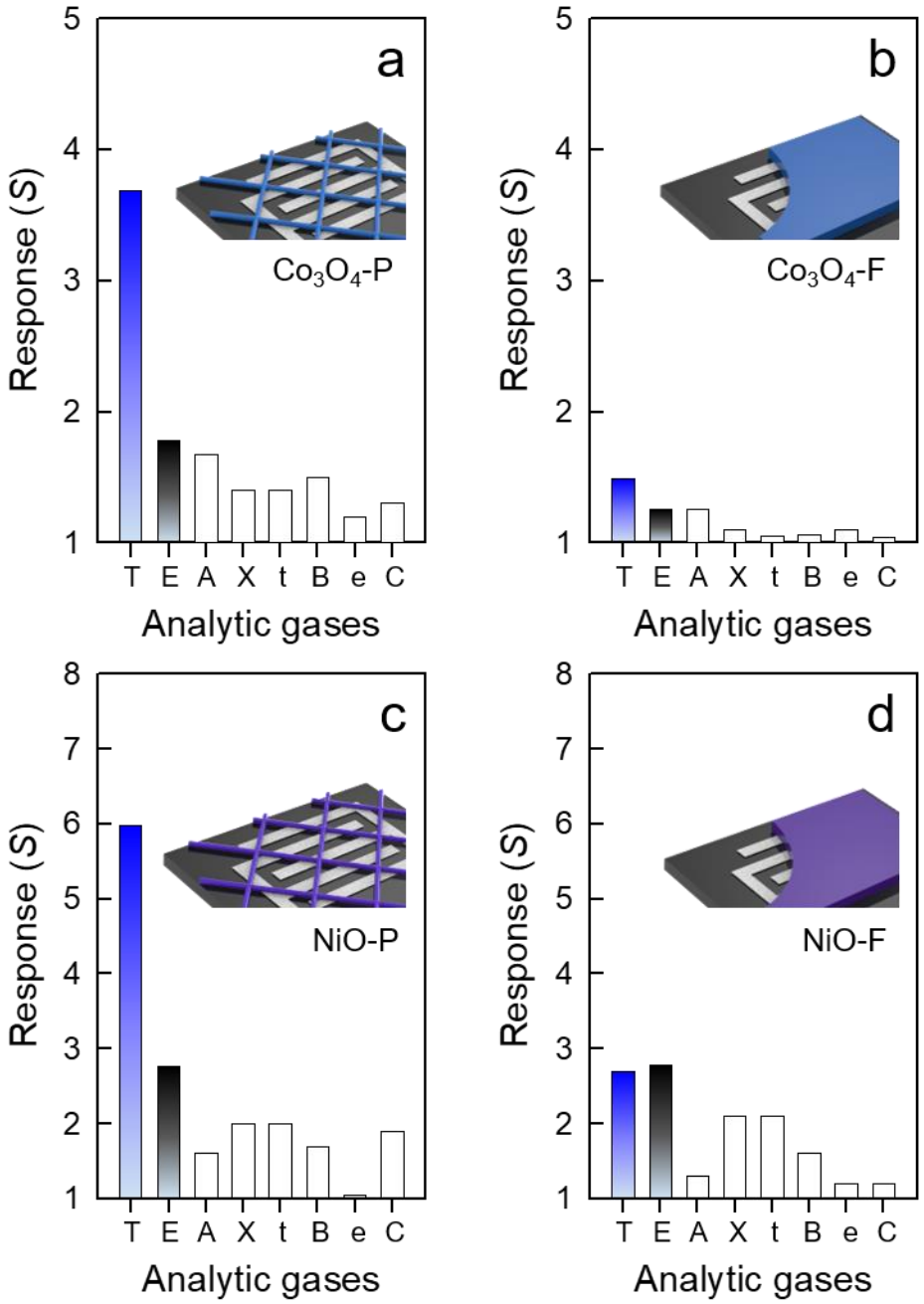

Figure S8 (a,b) Gas responses of (a) Co_3O_4-P and (b) Co_3O_4-F sensors to 5 ppm of TMA (T), ethanol (E), ammonia (A), *p*-xylene (X), toluene (t), benzene (B), ethylene (e) and CO (C) at 225 °C. (c,d) Gas responses of (c) NiO-P, and (d) NiO-F sensors to the gases at 300 °C.

Figure S9

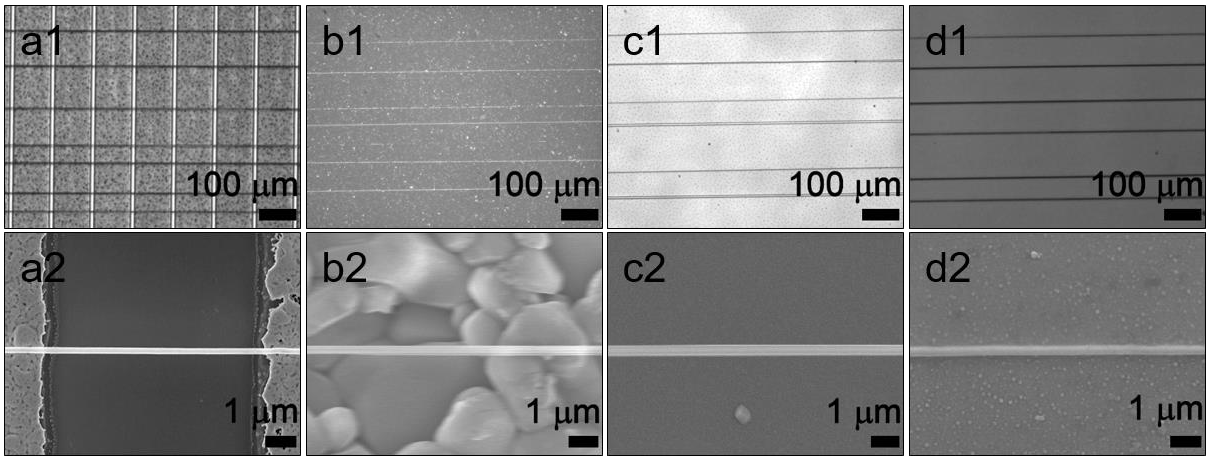

Figure S9 (a1-d1) Optical images of In/PVP arrays on various substrates; SiO_2/Si wafer with (a) Au interdigitated electrodes, (b) alumina, (c) glass, and (d) indium tin oxide (ITO) substrates. (a2-d2) SEM images of In_2O_3 nanofibers after heat treatment of the In/PVP on the substrates at 600 ^oC for 5 h.

Table S1 The compositions of solutions used in this study, and the resultant structures of precursor and metal oxides.

Solvent (g)	Polymer (wt%)	Metal salts (wt%)	Structure	
			Precursor	After heat treatment
Methanol (7)	PVP (17.4)	Indium nitrate (1.4)	Non-wetted fiber	Nanofiber
Methanol (7)	PVP (17.4)	Cobalt nitrate (1.7)	Non-wetted fiber	Nanofiber
Methanol (7)	PVP (17.4)	Nickel nitrate (1.7)	Non-wetted fiber	Nanofiber
Ethanol (7)	PVP (17.4)	Indium nitrate (1.4)	Wetted fiber	Islands
Water (7)	PVP (17.4)	Indium nitrate (1.4)	Wetted fiber	Islands
Methanol (7)	PVP (4.7)	Indium nitrate (1.4)	Wetted fiber	Islands
Methanol (7)	PVP (8.9)	Indium nitrate (1.4)	Wetted fiber	Islands
Methanol (7)	PVP (12.8)	Indium nitrate (1.4)	Wetted fiber	Islands
Methanol (7)	PVP (19.7)	Indium nitrate (1.4)	Not available	Not available
Methanol (7)	PVP (17.4)	Indium nitrate (0)	Non-wetted fiber	Not available
Methanol (7)	PVP (17.4)	Indium nitrate (0.47)	Non-wetted fiber	Islands
Methanol (7)	PVP (17.4)	Indium nitrate (0.93)	Non-wetted fiber	Islands
Methanol (7)	PVP (17.4)	Indium nitrate (1.8)	Entangled fiber	Entangled nanofiber

Table S2 The compositions of solutions for c-ES using PVP (M_w=1,300,000) and metal salts reported in the literature.[22-27]

Solvent	Metal salts	Viscosity (mPa s)	Ref.
Ethanol	Titanium(IV) isopropoxide	335	22
Ethanol	Titanium tetraisopropoxide	59	23
Ethanol	1-Tetra-n-butyl titanate	330	24
Ethanol + H_2O	Iron(III) nitrate nonahydrate, Cobalt (II) acetate tetrahydrate	117	25
Ethanol + H_2O	Indium(III) Nitrate	480	26
Ethanol + H_2O	Cerium nitrate	400	27

Table S3 TMA response (S_T) and selectivity ($S_T\ S_E^{-1}$) of the sensors using In_2O_3 nanostructures reported in the present study and the literature.[34-38]

Structure	Synthesis method	TMA conc. (ppm)	S_T	$S_T\ S_E^{-1}$	Ref.
Nanofibers pattern	NFES	5	245	7.5	This study
Thin film	E-beam deposition	5	24	1	This study
Nanofibers mats	c-ES	5	28	1	This study
Nanofibers mats	c-ES	5	15	1	34
Nanoparticles	Precipitation	5	3	0.17	35
Microrods	Hydrothermal method	50	21	1.75	36
Nanospheres	Hydrothermal method	50	5	1	37
Hollow microtubes	Solution process	50	120	1.2	38