Supporting Information for:

High-performance Hydrogen gas sensor using ultrathin polypyrrole-coated CNT nanohybrids

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Comparison data

Table S1. Comparison data of conventional hydrogen gas sensors

Type of sensor	M[1]	T (°C)[2]	T (s)[3]	Ref.
Pd-Ni hydrogen sponge	100 ppm*	Room	1	S1
Pd-NP–graphene nano-composite	0.1 – 1 %	–	–	S2
Pd/SnO_2 films	0.02 – 1 %	200	< 300	S3
SnO_2 nanobelt	0.2 %	25	36	S4
Pd-functionalized FBAR	0.3 – 2 %	Room	40	S5
Pt/Al_2O_3 thick film	25 ppm	28 – 100	>45	S6
AAO nanowells	0.05% (500 ppm)	Room	120 (0.2 %)	S7
Thin Pd film	200 – 1500 ppm	20 – 80	180 (50 ℃) 60 (85 ℃)	S8
Nanoporous Nb_2O_5	0.06 – 1 %	22 – 100	88 (1 %)	S9
Germanium nano-cluster films	0.63 – 5 %	25	< 600	S10
Pt-decorated bead-like tin oxide nanowires	1 – 6 %	200	< 60	S11
Pd/Ni composite film	1 – 4 %	23	240-300 (4 %)	S12
ZnO/In_2O_3 core/shell-NanoRods	5 to 500 ppm	Room	< 300	S13
A sub-10 nm width in Pd thin films	10 ppm	Room	a few seconds	S14
Pd^0-loaded SnO_2 electrospun nanofibers	20 ppb	Room	4 – 13	S15
Co-doped SnO_2	40 ppm	–	–	S16
Au-GaN-Pt MSM sensor	50 ppm	25-90	150	S17
$Pd-WO_3$ thick Films	50 ppm	220	< 240 (50 ppm)	S18
CdO thin films	50 ppm	100	180 – 240	S19
Pd-doped, PEG-400-added SnO_2 thin film	50 ppm	225	35	S20
$PdeSiO_2$ thin-film mixture	100 ppm	25	525	S21
$B-Ga_2O_3$ thin film	100 ppm	400	–	S22
A leaf-like carbon nanotube/ nickel (CNT/Ni) composite film modified with Pd NPs)	200 ppm	Room	312	S23
TiO_2 thin films	300 ppm	300	130 –150 (800°C)	S24
Pd NPs/ ZnO nanorod arrays	500 ppm	Room	184 (Room temp.)	S25
NiO thin films	1000 ppm	175	153	S26
Pd-functionalized WO_3-NWs	1000 ppm	300	86	S27
$BaTiO_3$-based PTC thermistor	100 ppm	124	–	S28
TiO_2–SnO_2 nanomaterials	50 ppm	250-350	63 (250 °C)	S29
Pd− Ag mesowires	0.3 %	Room	–	S30
CNTs with Pd NPs	30 ppm	Room	65 (1 %)	S31
Pd-functionalized multi-layer graphene nanoribbon betworks	40 ppm	Room	21	S32
Ceramic suspensions	100 ppm	280	–	S33
Nanoporous carbon-supported Pd sensor	250 ppm	23	90 (2 %)	S34
Pd nanoparticle-decorated SnO_2 nanowire	2500 ppm	100	240	S35
Au NP-doped TiO_2 semiconductor thin films	8.5 ppm	300	9.6	S36
Au- and Pt-NP-functionalized tungsten oxide nanoneedles	100 ppm	100 – 300	120 – 480	S37
ZnO-modified SnO_2 nanorod	10 ppm	350	–	S38
Urchin-like CuO particles	300 ppb	200	305 (500 ppm, 150 °C)	S39

Pt–SnO_2/RGO nanostructure	0.5 %	50	2 – 6	S40
Pd/Ni alloys	0.08 %	Room	0.05 (2 %)	S41
Self-assembled Pd nanospheres	0.3 %	Room	–	S42
Single Pd nanowire	5 ppm	Room	150 (0.5 %)	S43
Combination of electropolymerization between Pd and polyphenol at microgap electrode arrays	1 %	–	–	S44
Single Pd nanowires	5 ppm	20	500	S45
Pd nanotube arrays	100 ppm (1.3)	Room	400 (100 ppm)	S46
Networks of ultrasmall Pd/Cr nanowires	1 %	Room	10 – 100	S47
Pd/TiO_2 nanofibrous membranes	0.3 %	Room	–	S48
Pt-Ni NPs on nitrogen-doped CNTs	0.06 %	60	–	S49
Graphene/polyaniline nanocomposite	0.06 %	24	< 180	S50
Pt-polyaniline nanofibers	1 %	–	< 600	S51
SnO_2 nanowire	10 ppm	Room – 900	< 250	S52
ZnO nanowires grown on the AlGaN/GaN heterostructure	5 %	Room	500	S53
V_2Pd-decorated as-grown VO_2 nanowire	10 sccm	35	420	S54
Pd nanotubes	500 ppm	Room	< 20	S55
Pd nanoarrays	0.3 %	–	70 (3 %)	S56
Pd-coated rough Si nanowires	5 ppm	Room	3 (2 %)	S57
Pd-coated nanomechanical beam resonator	0.02 %	–	5	S58
Highly ordered Pd nanodot patterns	0.1 %	Room	7	S59
Pd-decorated porous In_2O_3	0.05 %	25	28	S60
Platinum nanowire	10 ppm	Room	1000 – 2000	S61
Palladium nanowires	10 %	Room	2	S62
Ultrasmall Pd/Cr nanowires	3 %	Room	–	S63
Pd-contacted few-layer graphene	100 ppm	Room	30	S64
Palladium nanowire	1 ppm	21	360	S65
Pd nanotubes	100 ppm	Room	400	S66
Pd nanoparticles/Polypyrrole/CNT nanohybrids	1 ppm	Room	1	This work

1. Minimum detectable level
2. Temperature (^oC)
3. Real-time response time (s)
* ppm: parts per million

Sensing mechanism of Pd NPs

Generally, the sensing mechanism of Pd NPs to hydrogen gas can be explained by the well-known dissolution and dissociation of hydrogen molecules into atomic hydrogen at the Pd NPs, leading to the decrease of the work function of Pd NPs. Therefore, the electron can be easily transferred to the CPPy skin-coated CNT nanohybrids.[S67,S68]

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