Supplementary Information

Weight and Surface Area Estimations of TiO_2-NT/(Zn,Sn)Pd-ND and P25

(1) Weight of TiO_2-NT/(Zn,Sn)Pd-ND (1 cm^2 sample)

$$= \frac{\text{total weight with Ti substrate} - \text{weight of Ti substrate}}{\text{large sample size (total area)}} = \frac{0.5773 - 0.5655}{9.6} = 10^{-3}\ \text{g}$$

(2) TiO_2 NT inner diameter $d \sim 190$ nm, outer diameter $D \sim 250$ nm, height $H \sim 500$ nm

Inner surface area of each TiO_2 NT $= 2\pi\left(\frac{d}{2}\right) \times H = 3.0 \times 10^{-9}\ \text{cm}^2$

Outer surface area of each TiO_2 NT $= 2\pi\left(\frac{D}{2}\right) \times H = 3.9 \times 10^{-9}\ \text{cm}^2$

Number density of TiO_2 NTs $\sim \frac{14}{1.1 \times 10^6}\ \text{NT/nm}^2 = 1.3 \times 10^9\ \text{NT/cm}^2$

Total surface area of TiO_2 NTs (1 cm^2 sample) $= \left(6.9 \times 10^{-9}\right) \times \left(1.3 \times 10^9\right) = 9.0\ \text{cm}^2$

(3) Size of P25 NPs $S \sim 25$ nm, gravity density $G \sim 4.0$ g/cm^3

Surface area of each P25 NP $= 4\pi\left(\frac{S}{2}\right)^2 = 4\pi\left(\frac{25}{2}\right)^2 = 2.0 \times 10^{-11}\ \text{cm}^2$

Weight of each P25 NP $= \frac{4\pi}{3}\left(\frac{S}{2}\right)^3 \times G = \frac{4\pi}{3}\left(\frac{25}{2}\right)^3 \times 4.0 = 3.3 \times 10^{-17}\ \text{g}$

Number of P25 NPs (10^{-3} g sample) $= \frac{10^{-3}}{3.3 \times 10^{-17}} = 3.0 \times 10^{13}$

Total surface area of P25 NPs (10^{-3} g sample) $= \left(2.0 \times 10^{-11}\right) \times \left(3.0 \times 10^{13}\right) = 6.0 \times 10^2\ \text{cm}^2$

Bonding Configuration and Composition Analyses of TiO_2-NT/(Zn,Sn)Pd-ND

Table S1. XPS binding energies and full widths at half maximum (FWHMs) of Pd_{3d}, Sn_{3d}, Zn_{2p} and Ti_{2p} peaks and the compositions of (Zn,Sn)Pd NDs on TiO_2 NTs.

Peak	Binding Energy (eV)		FWHM (eV)		Area	R.S.F.†	Area/ R.S.F.	Content (at.%)	Content (at.%)*
	Reference	Present	Reference	Present					
Pd 3d5/2	335.5 [1]	335.6	1.25 [2]	1.15	72457	1182.677	61.27	72.21	81.30
Pd 3d3/2	340.8 [3]	340.9	1.10 [4]	1.20					
Sn 3d5/2	485.1 [5]	485.3	1.00 [6]	1.10	1234	1716.800	0.72	0.85	0.95
Sn 3d3/2	493.5 [6]	493.7	1.80 [8]	1.80					
Sn 3d5/2-SnO2	487.1 [7]	487.1	1.40 [6]	1.40	3752	1716.800	2.19	2.58	
Sn 3d3/2-SnO2	495.5 [6]	495.5	1.45 [8]	1.50					
Zn 2p3/2	1022.0 [9]	1022.1	2.00 [9]	2.00	11445	855.945	13.37	15.76	17.74
Zn 2p1/2	1045.1 [9]	1045.1	1.95 [9]	2.05					
Ti 2p3/2-TiO2	459.3 [10]	459.3	1.20 [11]	1.20	3093	423.679	7.30	8.60	
Ti 2p1/2-TiO2	465.1 [10]	465.1	1.20 [12]	1.50					

† Relative sensitivity factor; * contents without considerations of SnO_2 and TiO_2. Note: Auger spectrum of Zn LMM present in the XPS $Sn_{3d3/2}$ spectrum in Figure 4 is considered during bonding configuration analyses and excluded from the composition analyses of Sn.

Growth Orientation Examinations of (Zn,Sn)Pd NDs

From the standard interplanar spacing (*d*) and angles of fcc Pd (JCPDS No. 46-1043) listed in Supplemental **Table S2**, and the standard SAD pattern of fcc Pd (zone axis $[\bar{1}01]$) plotted in Supplemental **Figure S1**, the growth orientations of (Zn,Sn)Pd NDs in different regions of **Figure 4** were determined as given in Supplemental **Figure S2** as:

R1: measured d_{111} = 0.224 nm, angle to primary arm = 70° → growth direction: $[1\bar{1}1]$;

R2: measured d_{111} = 0.224 nm, angle to branch = 70°; measured d_{101} = 0.260 nm, angle to branch = 35° → growth direction: $[1\bar{1}1]$;

R3: measured d_{101} = 0.260 nm, angle to primary arm = 35° → growth direction: [111];

R4: measured d_{010} = 0.390 nm, angle to branch = 55° → growth direction: [111].

Table S2. Standard interplanar spacing (*d*) and angles of fcc Pd (JCPDS No. 46-1043).

Plane	{100}	{110}	{111}
d (nm)	0.3890	0.2751	0.2246
{100}	90.0°		
{110}	45.0°	60.0°	
{111}	54.7°	35.3°	70.5°

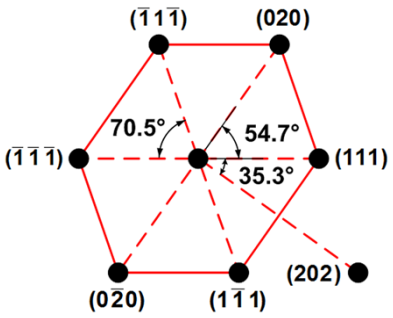

Figure S1. Standard SAD pattern of fcc Pd (zone axis [$\bar{1}01$]).

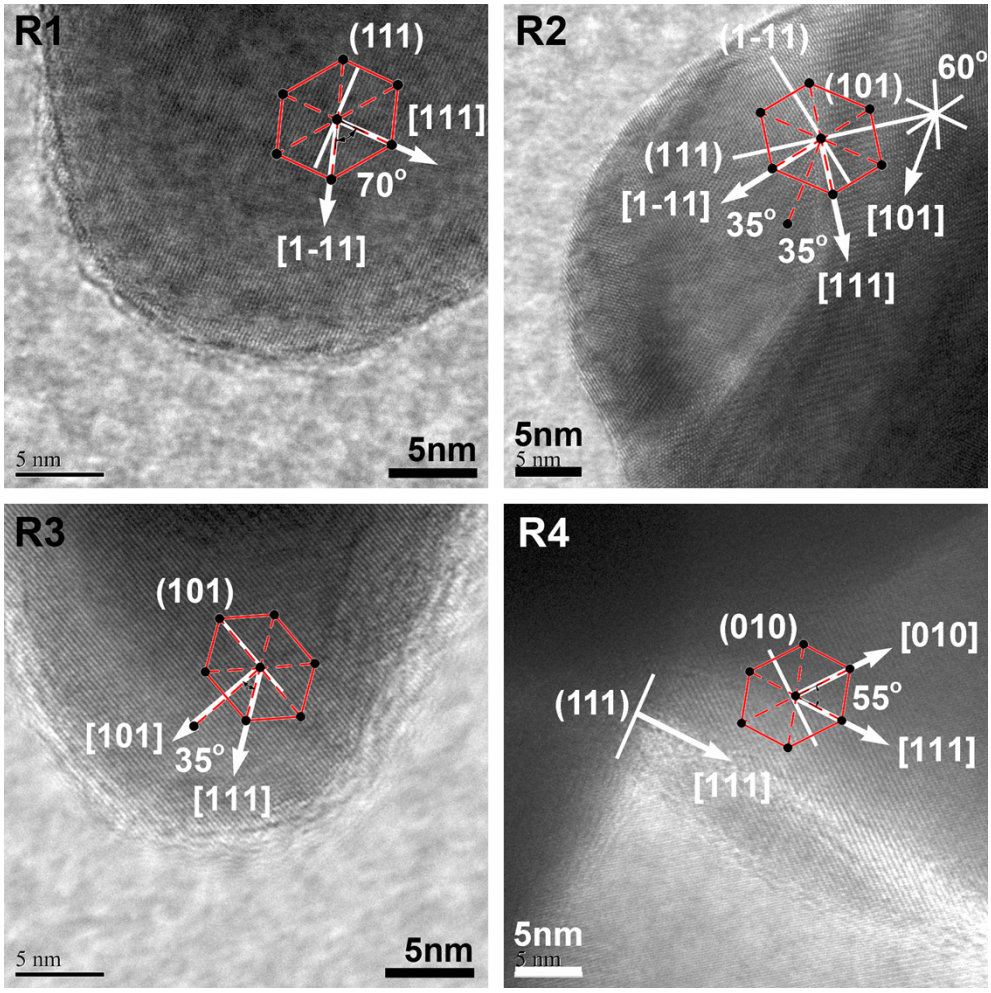

Figure S2. High-resolution TEM images and corresponding standard SAD patterns (zone axis [$\bar{1}01$]) showing the growth orientations of (Zn,Sn)Pd NDs in different regions of Figure 4 (R1, R2, R3, R4) all along <111> direction group.

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