Electronic Supplementary Information

Fabrication of ZnO Nanowires Array with Nanodiamond as Reductant

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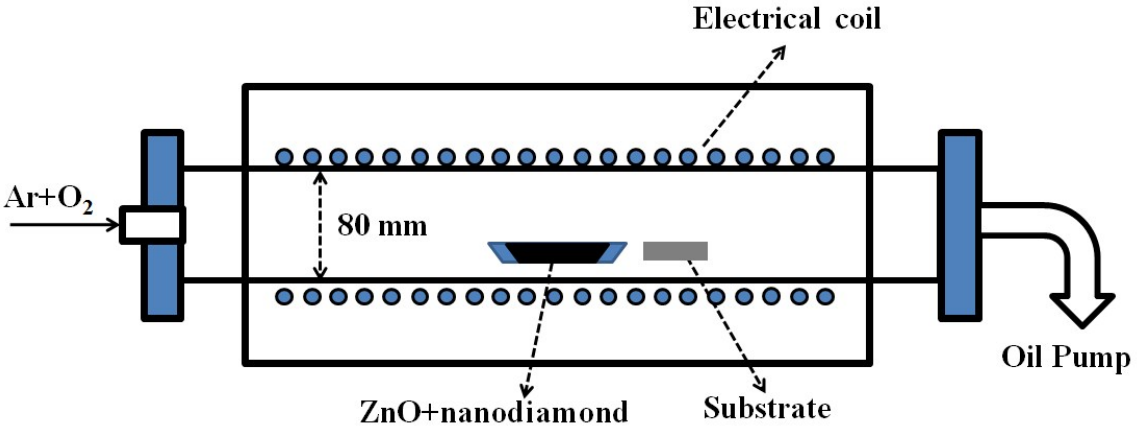

Fig. S1. The schematic illustration of the chemical vapor deposition set-up for ZnO nanowire growth

(the mass of ZnO and diamond in this experiment were 0.21g, and 0.07g, respectively.)

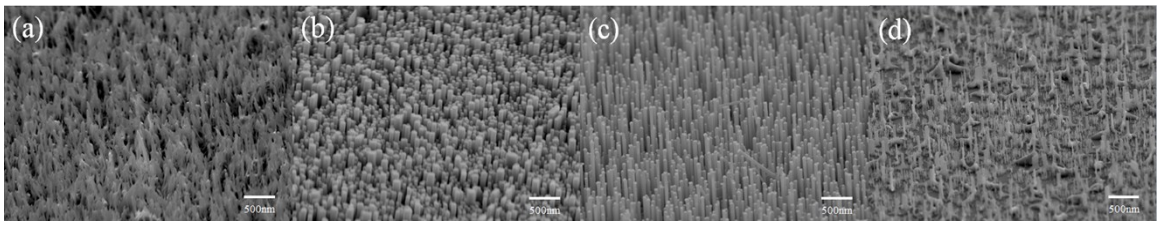

Fig. S2. SEM images of obtained ZnO nanorods in 960 °C reaction with different reactants (a) ZnO+graphite, (b)ZnO+100nm nanodiamond, (c)ZnO+10nm nanodiamond, and (d) SEM image of obtained ZnO nanorods in 600°C reaction with ZnO+10nm nanodiamond without Au catalyst.

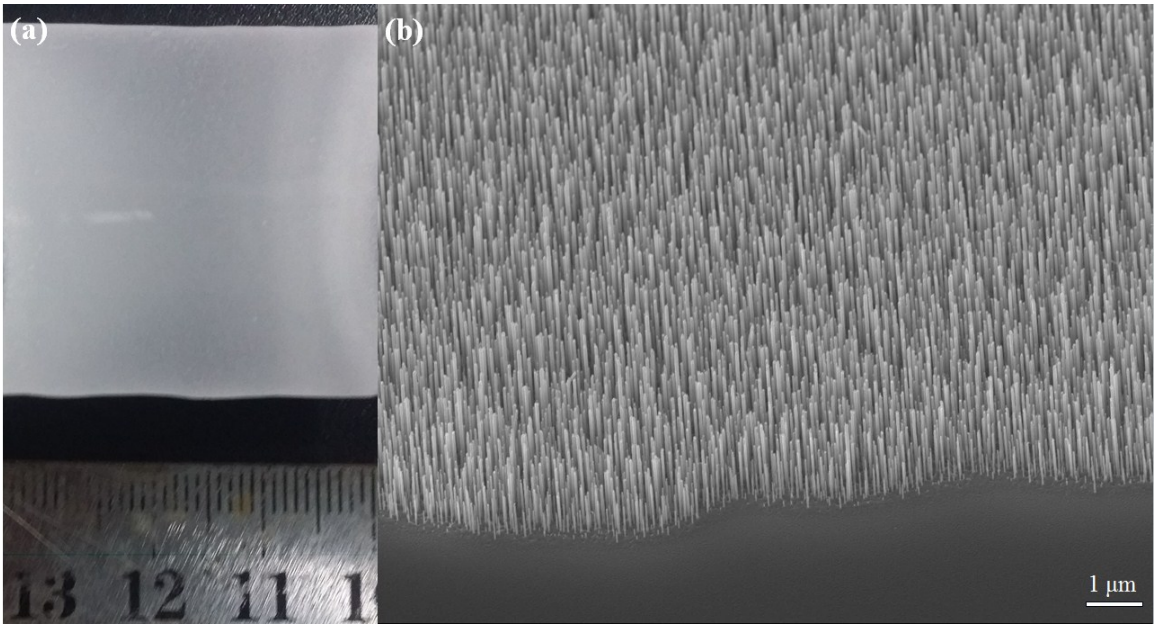

Fig. S3. The (a) optical and (b) low magnification SEM images of obtained ZnO nanorods in 600 °C reaction for 8 hours.

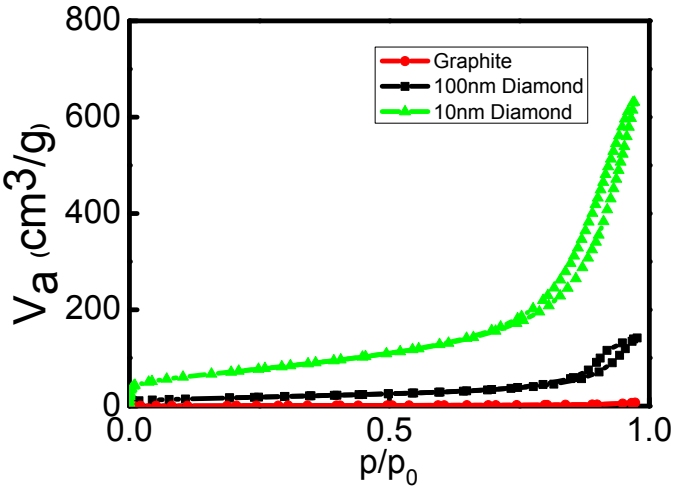

Fig. S4. The nitrogen adsorption−desorption isotherms of different allotropes of carbon

Calculation of Debye characteristic temperature of 10 nm and 100nm nanodiamond

The Debye characteristic temperature of 10 nm and 100nm nanodiamond was calculated based on X-ray diffraction intensities by the methods introduced by X.S. Lu[1].

Lu's method can be described as follows:

In the X-ray diffraction, the natural logarithm of the ratio of the calculated intensities to the observed intensities $\ln(I_{calc} / I_{obs})$ should have the linear relationship with $\sin^2\theta / \lambda^2$. The slope should be 2B. In Debye theory of specific heat, B can be expressed as

$$B = (6h^2T / Mk\Theta_D^2)[\Phi(x) + x/4]$$

Of which, $x = \Theta_D / T$.

If we assumed $G = BMkT / 6h^2$, $\Phi(x) + x/4 = Gx^2$. If we got the value of B from the X-ray diffraction data,

the G can be calculated. Then x can be determined by the graphic method. If we let $y_1 = Gx$, $y_2 = \Phi(x) + x/4$, two curves can be obtained in the coordinate graph. The intersection of the two curves is the x value. Finally, Debye characteristic temperature can be calculated with the obtained x value.

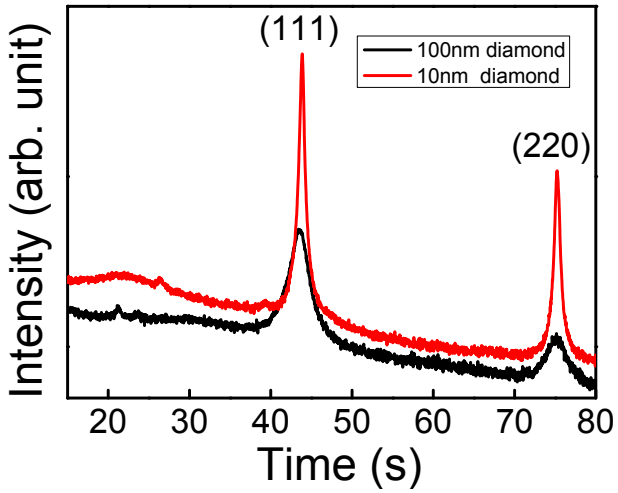

Fig. S5 The XRD diffraction pattern of 10nm diamond and 100nm diamond.

The X-ray diffraction results were shown in table S1.

Table S1. The raw data and calculation results

hkl		Θ/° C	f	$\|F\|^2$	J	P	I_{calc}	I_{obs}	$\ln(I_{calc}/I_{obs})$
111	10nm	43.398	3.125	312.5	8.178	8	20425	3587	0.755
	100nm	43.822	3.125	312.5	8.178	8	20425	50674	-0.395
220	10nm	75.090	2.028	263.2	2.815	12	8891.5	537	1.219
	100nm	75.228	2.028	263.2	2.815	12	8891.5	9512	-0.293

(1) X-ray atomic scattering factor f (to sinθ/λ Å^{-1}), can be calculated after looking up the table[2] .

(2) The structure factor is calculated by the following equation[2],

$$|F|^2 = FF^* = \left|\sum_m f_m \exp\left[-2\pi i r_m \text{ o} G\right]\right| \quad |F|^2$$

For diamond cell, m=8, there are 8 atoms in the unit cell. The position coordinates are 000, $\frac{1}{2}\frac{1}{2}0$, $0\frac{1}{2}\frac{1}{2}$, $\frac{1}{2}0\frac{1}{2}$, $\frac{1}{4}\frac{1}{4}\frac{1}{4}$, $\frac{3}{4}\frac{3}{4}\frac{1}{4}$, $\frac{1}{4}\frac{3}{4}\frac{3}{4}$, $\frac{3}{4}\frac{1}{4}\frac{3}{4}$. Therefore, the calculation results should be $\left|F_{(111)}\right|^2 = 32 f_{(111)}^2$, $\left|F_{(220)}\right|^2 = 64 f_{(220)}^2$.

(3) The expression of the angular factor J is

$$J = (1+\cos^2 2\theta_B)/(\sin^2\theta_B \bullet \cos\theta_B)$$

The value can be calculated by above equation as well as looking up the table[1].

(4) The multiplicity factor P can be found in the table through the crystal surface index (hkl).

(5) The calculation intensities I_{calc}^2 can be calculated as

$$I_{calc} = KN_0^2 VFF^*$$

In which, K is a scaling factor; $N_0^2 V$ is the number of unit cells that can produce diffraction.

The calculated values of the above quantities are shown in table S1.

From the linear relationship between $\ln(I_{calc} / I_{obs})$ and $\sin^2\theta / \lambda^2$, B can be calculated. Then, G can be calculated with the constant parameters (atom mass 1.66053×10^{-24} g, $k = 1.38062\times10^{-23} J\cdot K$ $h = 6.62620\times10^{-34} J\cdot s$). After G was obtained, x can be determined by the graphic method. As we know $\Theta_D = x\cdot T$, the Debye characteristic temperature can be calculated.

Table S2. The Debye temperature of nanodiamond and graphite

Average diameter	B/nm^2	T/℃	G	x	Θ_D/K
10nm	0.03698	20	0.95868	1.002	304
100nm	0.008219	20	0.213	2.166	646

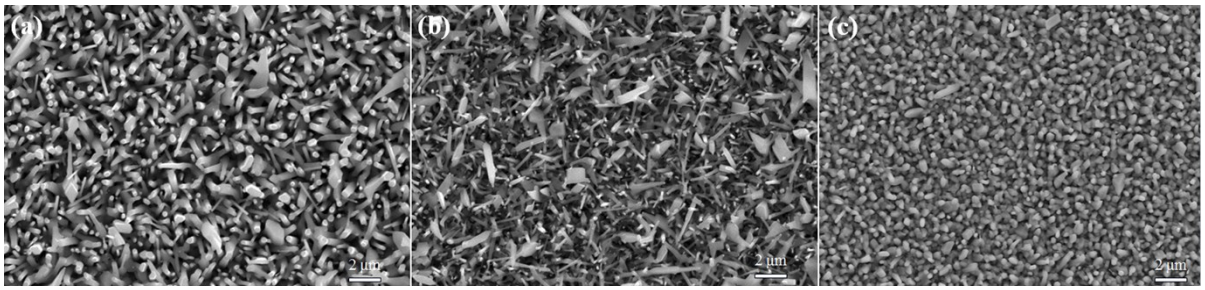

Fig. S6 The SEM images of ZnO nanostructures obtained in (a)Si, (b)SiO_2, and (c)FTO substrates

REFERENCES

1. P. W. Chen, S. R. Yun, F. L. Huang, Y. S. Ding and Q. Chen, *Chinese J of High Pressure Phys*, 2001, **15**, 32-38.
2. B. D. Cullity and J. W. Weymouth, *Elements of x-ray diffraction*, Addison-Wesley Pub. Co.