# Supplementary Information:

# Synthesis and Characterization of p-n Homojunction-Containing Zinc Oxide Nanowires

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## 1. XRD and Raman spectroscopy characterization of p-n containing ZnO nanowires

Fig. S1(a) shows XRD patterns of ZnO p-n junction-containing nanowire arrays grown on indium-tin-oxide (ITO) -coated glass, c-sapphire and silicon substrates. Except for the (006) peak from the substrate of *c*-sapphire, only one sharp peak at 34.5$^{o}$ is detected, corresponding to hexagonal wurtzite (002). This single, highly intense diffraction peak indicates that the as-grown ZnO NWs are highly crystalline, and suggests that they have a

preferential growth direction. This is confirmed by SEM and STEM analysis discussed in the main text.

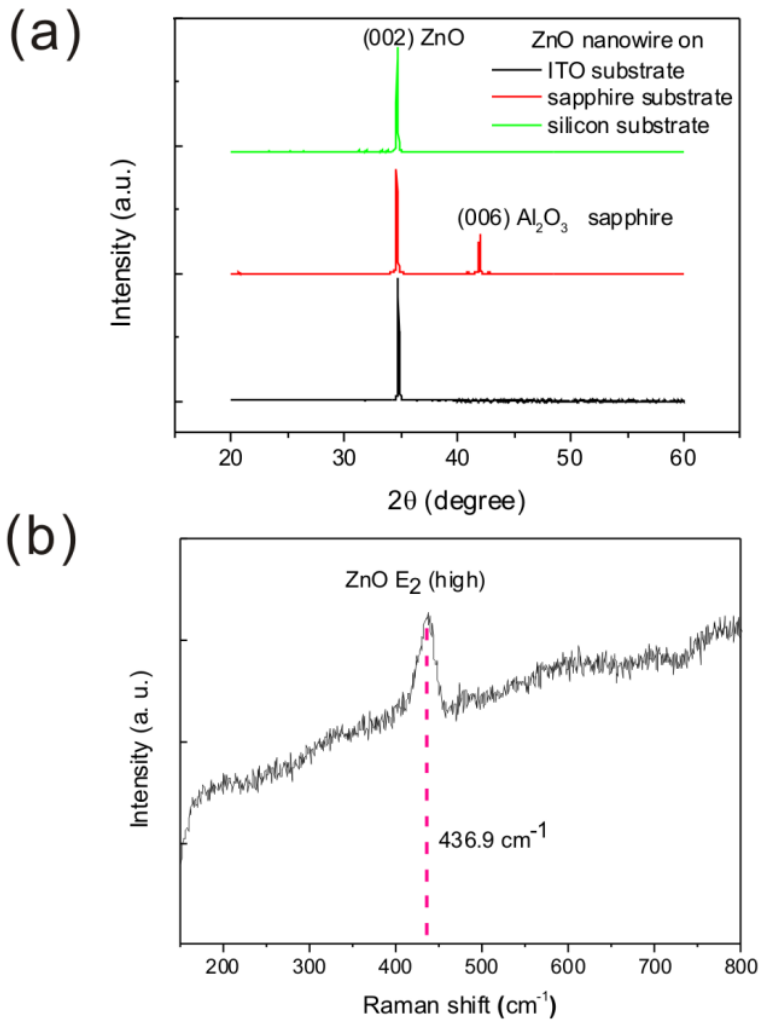


**Fig. S1** (a) XRD patterns of as-synthesized ZnO p-n junction nanowires on ITO-coated glass, sapphire, and (001) silicon substrates. (b) Raman spectrum of as-synthesized ZnO p-n junction nanowire arrays on an ITO-coated glass substrate.

To further characterize the nanowire arrays we utilized Raman spectroscopy. This is a non-destructive characterization method which can be used to study the vibrational properties of ZnO nanowires.[1-4] The wurtzite type of ZnO NW belongs to C46v (P63mc)

space group, with two formula units per primitive cell, where all atoms occupy C3v sites. Group theory predicts that it has eight optical phonon modes including $A_1+2B_1+E_1+2E_2$.[5] $B_1$ is silent, while $2E_2$ are Raman active, and $A_1+E_1$ are both Raman and infrared active. The $E_2$ modes have two frequencies, $E_2$ (high) and $E_2$ (low) which are associated with the oxygen and zinc sublattices respectively. Fig. S1(b) illustrates a Raman spectrum of as-synthesized ZnO p-n junction nanowire arrays on an ITO-coated glass substrate. Only one dominant peak centred at 436.9 $cm^{-1}$ is observed, which is attributed to $E_2$ (high) mode. This is different from the other reported Raman spectra of non-ordered ZnO nanowires,[4] where the peaks at ~380 $cm^{-1}$ ($A_1$ (TO) mode) and 570—580 $cm^{-1}$ ($E_1$ (LO) mode) commonly show up. We attribute this to the fact that Raman modes are strongly dependent on the polarization direction of the excitation laser light and the crystallographic orientation of nanowires.[6] In our Raman measurement, the incident laser light was perpendicular to the substrate, parallel to the c-axis of nanowires. In this case, Raman selection rules dictate that only the $E_2$ mode can be excited, as observed. This is in agreement with the results of XRD, SEM, and STEM investigation. Compared with non-doped ZnO NWs, the Raman spectra of the lithium doped p-n junction-containing ZnO NWs are identical. (Data from non-doped wires not shown in this paper.)

## 2. Electrical transport measurements of Li-doped ZnO nanowires (without p-n junctions)

Li-doped ZnO NWs were synthesized by growing only the first p-type section of ZnO NWs (without the n-type section). Simple two-terminal devices were fabricated in the same way as described in the main text, and measured first without an applied gate

voltage. The resulting symmetric response at low bias is shown in Fig. S2. To confirm the p-type conductivity of the Li-doped ZnO NWs, we fabricated back gate field-effect transistor (FET) using the same Li-doped ZnO NWs. Fig. S3 Shows typical gate-dependent $I_{ds}$-$V_{ds}$ characteristics of the Li-doped ZnO NWs, where the conductance increases under negative $V_g$ and decreases under positive $V_g$, characteristic of a p-type semiconductor, and consistent with the recently reported data of Li-doped ZnO by Hong's group. [7]

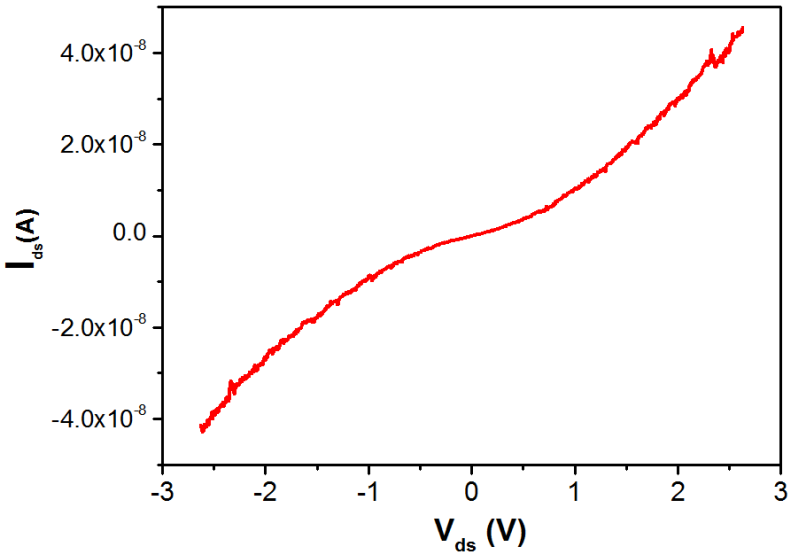


**Fig. S2** Current-Voltage curve of Li-doped ZnO NWs with zero gate voltage at low bias, showing a symmetric response.

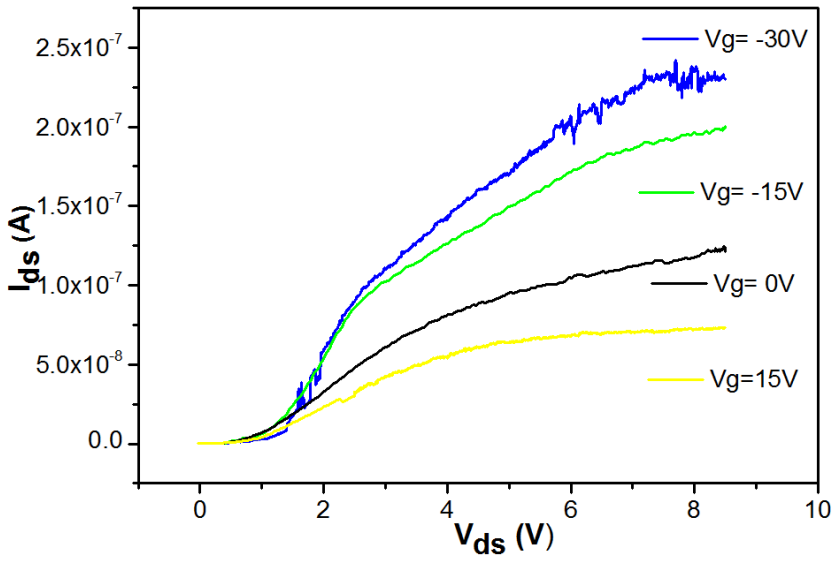


**Fig. S3** Gate-dependent current-voltage curves of Li-doped ZnO NWs.

## References:

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