Supporting information for: Na-doped *p*-type ZnO microwires

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1. Growth method descriptions of the Na-doped ZnO microwires

1.1 Growth method of the Na-doped ZnO microwires

In these experiments, *p*-type ZnO microwires were grown by a catalyst-free, vapor-liquid-solid process from the direct reaction of zinc metal vapor with water vapor in a quartz tube furnace. In a typical synthesis process, 1 g of metal zinc powder, 0.5 g carbon powder and 0.2 g NaCl were mixed; then the mixture powder was loaded into an alumina crucible covered with a 200 mesh iron screen. The whole assembly was placed in a tube furnace and put into a quartz tube of 3 cm in diameter. After that, the quartz tube was heated to 950°C with a 300 sccm flow of argon. The gas flowed through a boiling water flask and the water vapor is carried into the quartz tube under atmospheric pressure. After one-hour of growth, the gas flow was switched to argon followed by cooling to room temperature. After the growth, high-density ZnO microwires were observed on the side of the iron screen facing the source vapor.

1.2 SEM image of the Na-doped ZnO microwires

Figure S1 SEM image of the Na-doped ZnO microwires

Figure S2 Diameter distribution of the Na Doped ZnO microwire

1.3 EDX line scans spectra

Figure S3 a) a typical TEM image of an individual Na doped ZnO microwire. b) EDX line scan. c) EDX spectra to show the composition. d) The distribution of the Na in the wire corresponding to the Fig. S3 b. The concentration of the Na is around 1%.

1.4 XRD curve of Na-doped ZnO microwires

Figure S4 XRD curve of the Na-doped ZnO microwires

2. Undoped ZnO microwire synthesis and characterizations

The method is similar to the synthesis of the Na-doped ZnO. 1 g of metal zinc powder, 2 g carbon powder; then the mixture powder was loaded into an alumina crucible covered with a 200 mesh iron screen.

2.1 TEM images and the EDX spectra of the undoped ZnO microwires

Figure S5 Structural characterizations of an undoped ZnO microwire. a) TEM image; b) SAED patterns; c) High-resolution TEM; and. (d) EDX spectra.

2.2 Temperature-dependent PL spectra of the undoped ZnO microwires

Figure S6 Temperature-dependent PL spectra of the undoped ZnO microwires measured from 9 to 300 K.

2.3 FET characterizations of the undoped ZnO microwires

Figure S7 a) I_{DS} - V_{DS} plots of the n-type ZnO NW transistor at different back-gate voltages. b) The corresponding I_{DS} - V_{GS} plot at $V_{DS} = 10$ V.

3. Full citation for ref. 1d

(d) Willander, M.; Nur, O.; Zhao, Q. X.; Yang, L. L.; Lorenz, M.; Cao, B. Q.; Pérez, J. Z.; Czekalla, C.; Zimmermann, G.; Grundmann, M.; Bakin, A.; Behrends, A.; Al-Suleiman, M.; El-Shaer, A.; Mofor, A.; Postels, B.; Waag, A.; Boukos, N.; Travlos, A.; Kwack, H. S.; Guinard, J.; Dang, D. L. S. *Nanotechnology* **2009**, 20, 332001

4. Additional notes on Na acceptors:

The N_A value in equation (1) is an estimated value based on the Na dopant concentration (1%).

There were early reports on Na deep levels with binding energy over 0.8 eV.^{1,2} In our research, we cannot completely exclude the formation of these deep levels. However, the p-type conduction evidenced in the FET devices strongly suggests the presence of relatively shallow Na acceptor states, which provide holes for the channel conduction.

Reference:

1. Zwingel, D.; Gärtner, F. *Solid State Commun.* **1974**, *14*, 45-49.
2. Schirmer, O. F.; Zwingel, D. *Solid State Commun.* **1970**, *8*, 1559-1563.