Supporting Information

Size-dependent surface effects on the photoluminescence in ZnO nanorods

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Fabrication of single nanorod field effect transistor (FET)

Heavily doped Si wafers (p-type, < 0.005 Ω·cm) with a 300 nm-thick SiO_2 layer were used as the substrate. Electrode patterns with gap size of 2 μm were predefined by photolithography and metal electrodes consisting of Ti (2 nm)/ Au (60 nm) were formed on the substrate by e-beam evaporation and lift-off processes. The as-grown ZnO nanorods were dispersed in ethanol solution with ultrasonic agitation and are randomly transferred to the substrate. Standard global back-gate geometry was used to apply the gate voltage. Sometimes rapid thermal annealing is necessary to obtain good contact. Fig. S1 shows the SEM image of the FET.

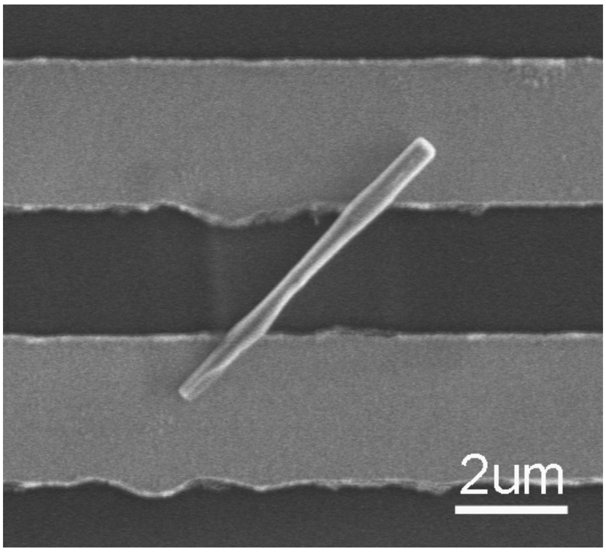

Fig. S1 SEM image of single nanorod FET

I-V characterization of FET

I-V characteristics are obtained with a probe station using Agilent E5207B electrometer. Fig. S2 shows the transfer characteristics of the FET, revealing typical n-type feature. The nanorods show high resistivity (the source-drain current is typically ~10^{-10} A at V_{ds} = 5V). The electron concentration, n_e, for a quasi-one-dimensional system can be expressed as $n_e = V_{th}C/q\pi(d/2)^2L$, where $C = 2\pi\varepsilon_0\varepsilon_{SiO2}\ L/\ln(4h/d)$ is the nanorod capacitance [1]. In the equations, V_{th} is the threshold voltage, d is the nanorod diameter, L is the nanorod length, h is the thickness of SiO_2. From Fig. S2, V_{th} is deduced to be ~8 V at V_{DS} = 3 V. The diameter and length of the nanorod can be obtained from Fig. S1. Taking into account the deviation of diameter and length among each individual nanorod, we estimate n_e ~ mid-10^{16} cm^{-3}. This value is rather low and is comparable with that of high-quality ZnO films or bulk crystals [2]. We note that the low electron concentration does not necessarily point to low defect/impurity density, because defects or impurities act as deep donors contribute only slightly to the n-type conductivity.

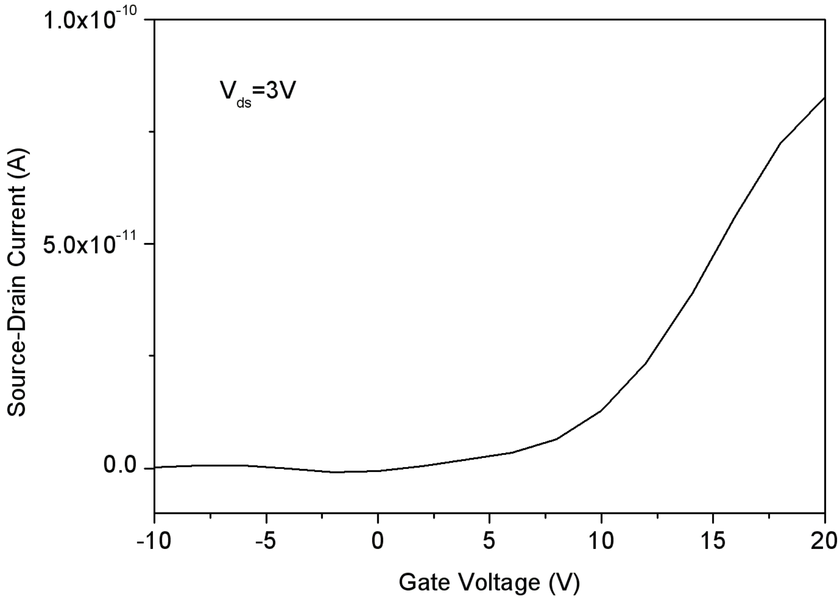

Fig. S2 Transfer characteristics of single ZnO nanorod FET

References:

[1] G. D. Yuan, W. J. Zhang, J. S. Jie, X. Fan, J. A. Zapien, Y.H. Leung, L. B. Luo, P. F. Wang, C. S. Lee, and S. T. Lee, Nano Lett. 8, 2591 (2008).

[2] A. Tsukazaki, A. Ohtomo, T. Onuma, M. Ohtani, T. Makino, M. Sumiya, K. Ohtani, S.F. Chichibu, S. Fuke, Y. Segawa, H. Ohno, H. Koinuma, M. Kawasaki, Nature Mater. 4, 42 (2005).