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Supporting Information

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Fabrication of Field-Effect Transistors and Functional Nanogenerators using Hydrothermally Grown ZnO Nanowires

C. Opoku*[a], A. S. Dahiya[a], F. Cayrel[a], G. Poulin-Vittrant[b], D. Alquier[a], N. Camara[a]

[a] Université François Rabelais de Tours, CNRS, GREMAN UMR 7347, 16 rue Pierre et Marie Curie, 37071 TOURS Cedex2, France.
[b] Université François Rabelais de Tours, INSA-CVL, CNRS, GREMAN UMR 7347, 3 rue de la Chocolaterie, CS 23410, 41034 BLOIS, France

S1. Scanning electron microscope images of the resulting ZnO nanowire growth on a Au coated Si substrate

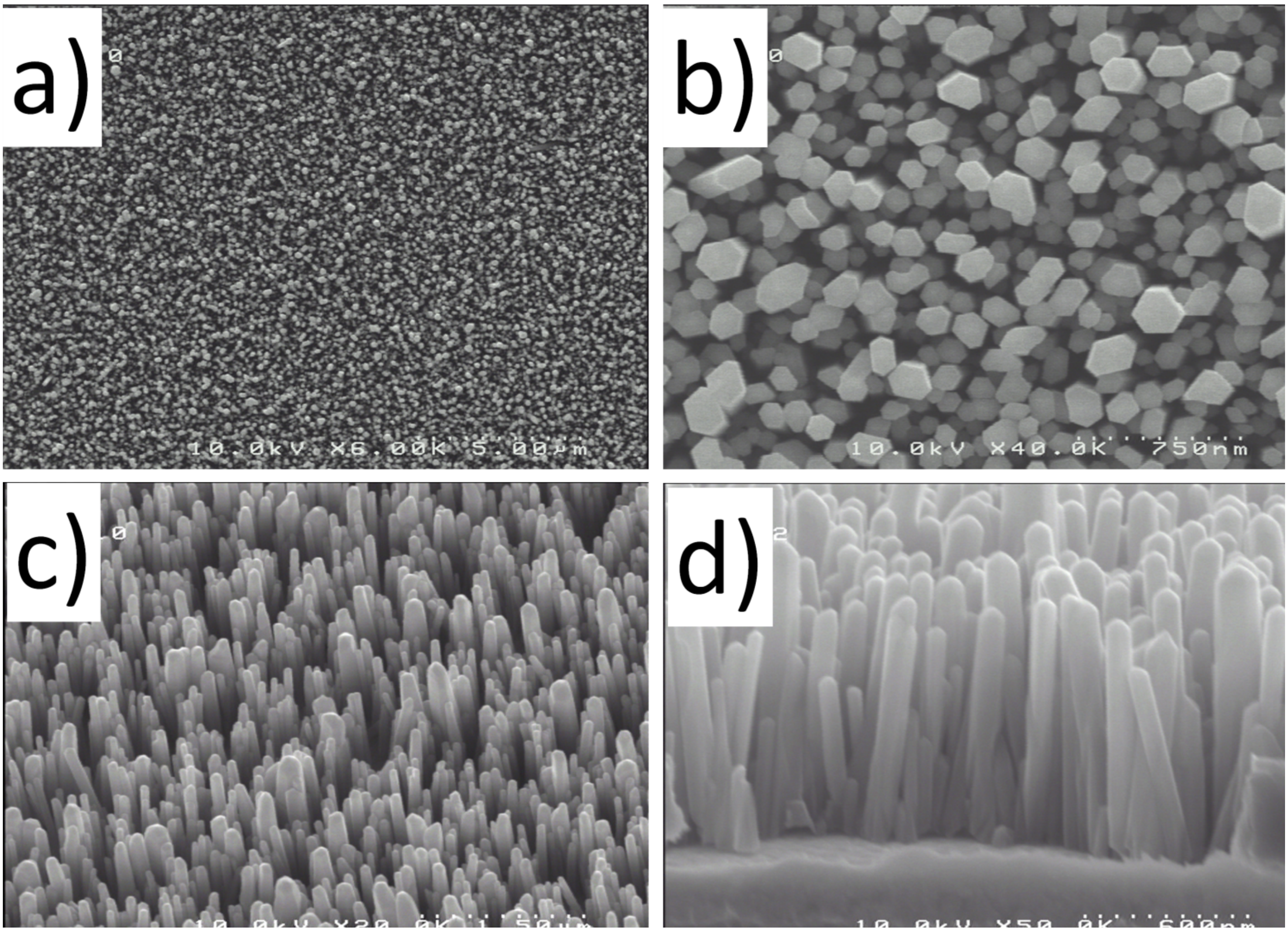


Figure S1 A collection of Scanning electron microscope images of as-grown ZnO NW arrays on Au coated Si substrates. a-b) top-view images at various magnifications, c) SEM image at ~30ºC tilt, d) cross-sectional image of the ZnO NWs.

S2. x-ray diffraction and high resolution transmission electron microscope data for pristine hydrothermal ZnO nanowires on a Au coated Si substrate

In Figure S2, we show representative x-ray diffraction data and high resolution transmission electron microscope image of as-grown hydrothermal ZnO nanowires on a Au coated Si substrate. Fig. S2a reveals three dominant peaks centred at 2θ = 34.4°, 72.5° and 125.2°, corresponding to the (0002), (0004) and (0006) planes of a highly crystalline c-axis orientated wurtzite ZnO. Peaks appearing at 38.4°, 69.1, 81.6 and 116.5 can be attributed to the Au, Ti and Si (100) substrate. Figure S2b shows the high resolution transmission electron microscope data for a representative hydrothermal ZnO NW. From this data, it can be seen that highly crystalline ZnO NW materials were obtained. The inset show the selected area electron diffraction pattern, revealing ZnO NW growth direction to be that of [0002] wurtzite ZnO.

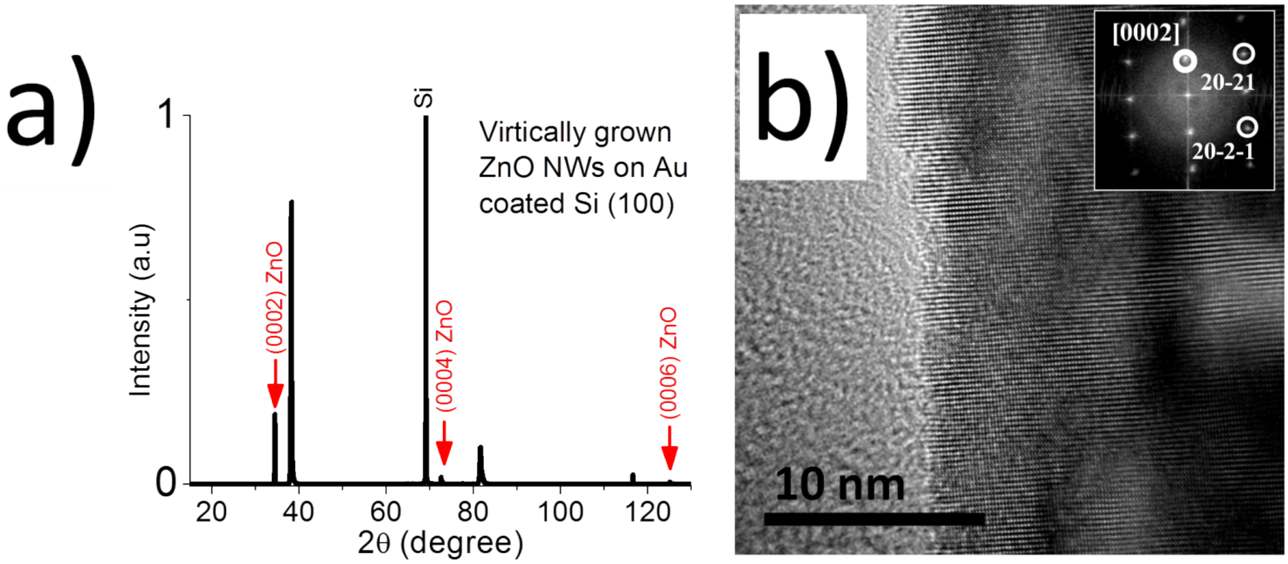
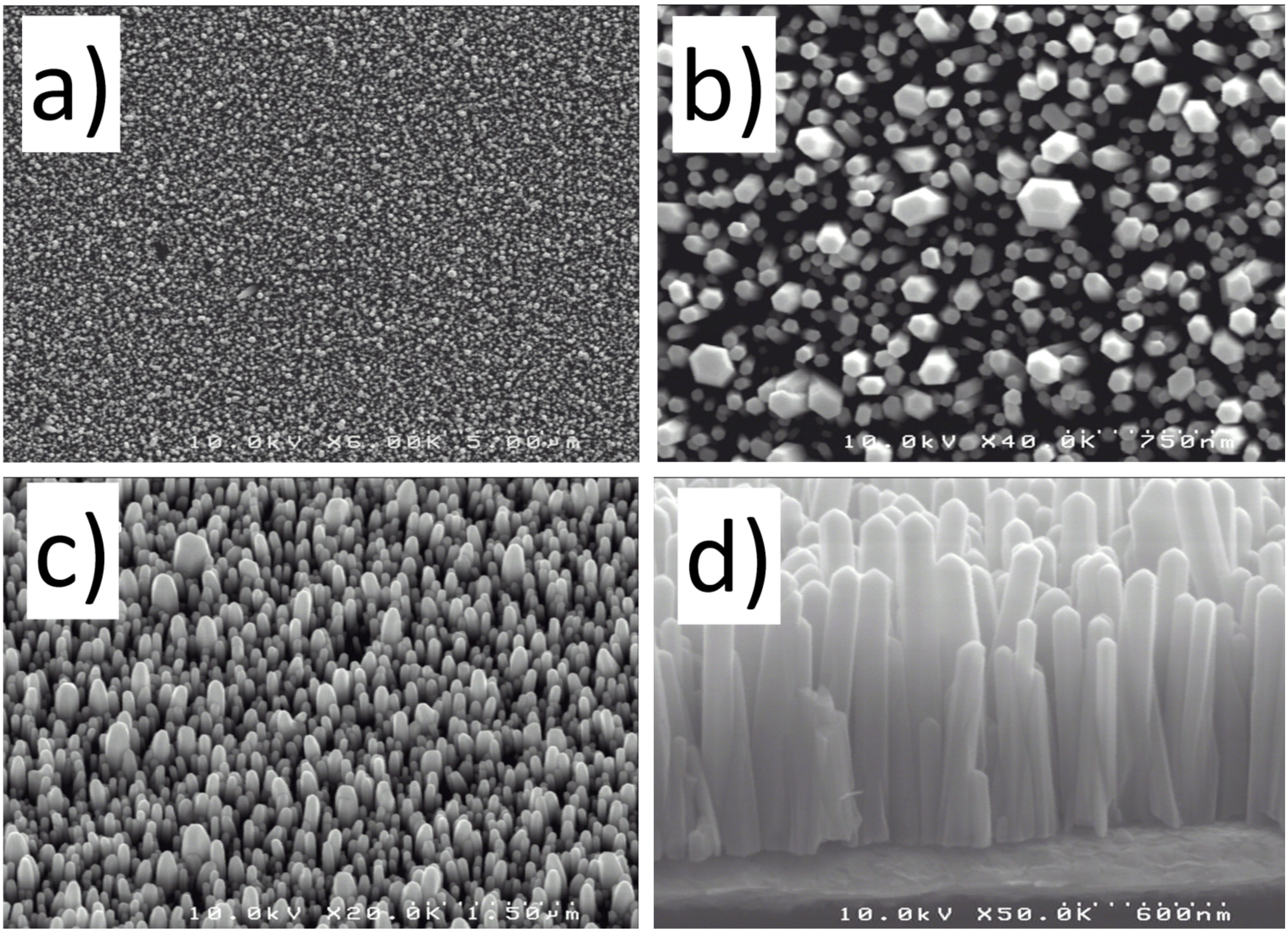


Figure S2 a) x-ray diffraction data and b) high resolution transmission electron microscope image of a representative ZnO NW on Au coated Si substrates.

S3. High resolution transmission electron microscope data of the thermally modified hydrothermal ZnO nanowires on Au coated Si substrates



S3 A collection of Scanning electron microscope images of the ZnO NWs on Au coated Si substrates after 450^{o}C thermal annealing in ambient air. a-b) top-view images at various magnifications, c) SEM image at ~30^{o}C tilt, d) cross-sectional view of the ZnO NWs

S4. X-ray diffraction data for the thermally modified vertically oriented hydrothermal ZnO nanowires on a Au coated Si substrate

Figure S4 shows the x-ray diffraction data for ZnO NW arrays after thermal annealing (450ºC in ambient air for 30min). From this data, it can be seen that the ZnO NWs are well oriented even after thermal treatment. The peaks appearing at 2θ = 34.4º, 72.5º and 125.2º are consistent with the (0002), (0004) and (0006) planes of c-axis orientated wurtzite ZnO, similar to the data for pristine ZnO NW arrays. Additional peaks at 2θ = 38.4º, 69.1 º, 81.6º and 116.5º were successfully assigned to the Au, Ti and the Si (100) substrate. These findings confirms that the thermal treatment had very little influence on the nanowire morphology.

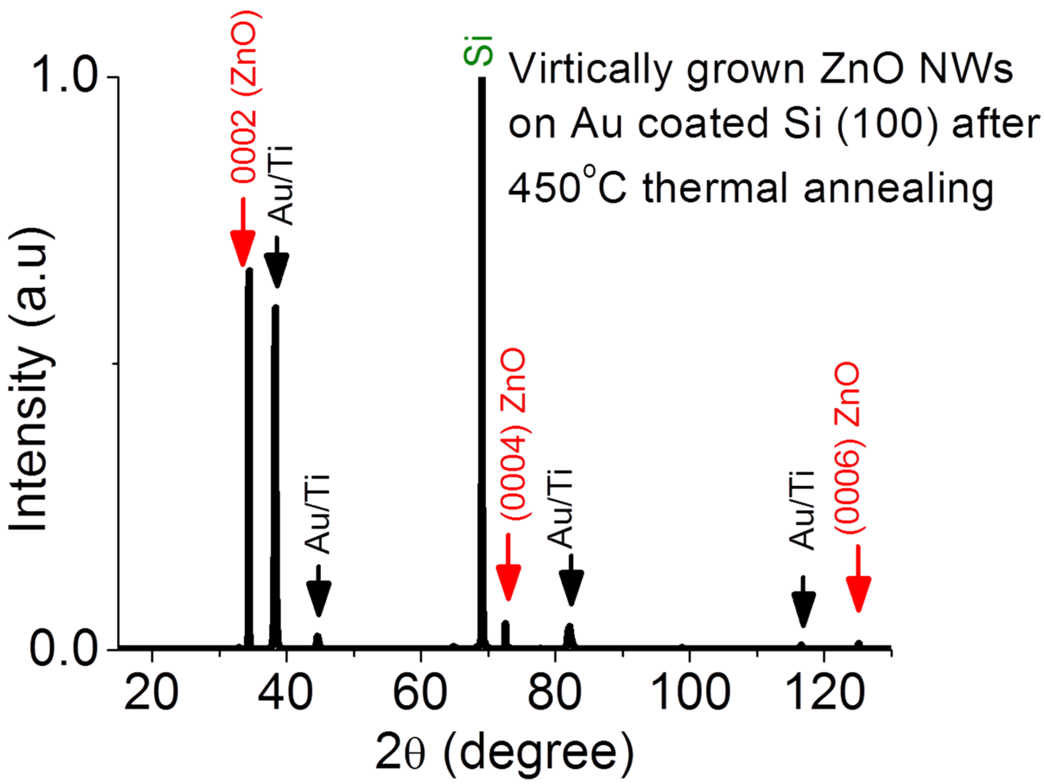


Figure S4 a) x-ray diffraction data for ZnO NW arrays on a Au coated Si substrate after 450ºC thermal annealing under ambient air conditions.

S5. Transfer and output characteristics for single nanowire transistors based on 350°C and 550°C annealed ZnO nanowires

Figure S5 shows the transfer and output scans for representative single nanowire FETs incorporating thermally modified ZnO nanowires at 350°C (a-b) and 550°C (c-d). It can be seen that the device based on 350°C annealing exhibits very weak gate modulation of less than one decade. For this device, we obtain very high off-state current (I_{off}) of around 50µA at ~-60V (V_G). The on-state current was extracted to be around 73µA (at V_G = 20V). The V_T parameter was not extractable for this device due to excessively high free carrier concentration. This behaviour of the device suggest that 350°C thermal annealing of our hydrothermally grown ZnO NWs provided insufficient free carrier suppression. The single NW device based on 550°C annealed ZnO NWs on the other hand demonstrated excellent gate modulation, markedly different from the 350°C annealed device. For this device, V_T, I_{off}, I_{on}, on/off ratio and s-s parameters were extracted to be ~ 0.36V, 22fA, 2.2µA, 10^8 and 0.54V/dec. Using the extracted V_T value, we can estimate a n_e of ~ $1.7x10^{16}/cm^3$ in this modified ZnO NW device (L = 5µm, ZnO NW diameter ~100 nm and C_{NW} of around $5.9x10^{-16}$F).

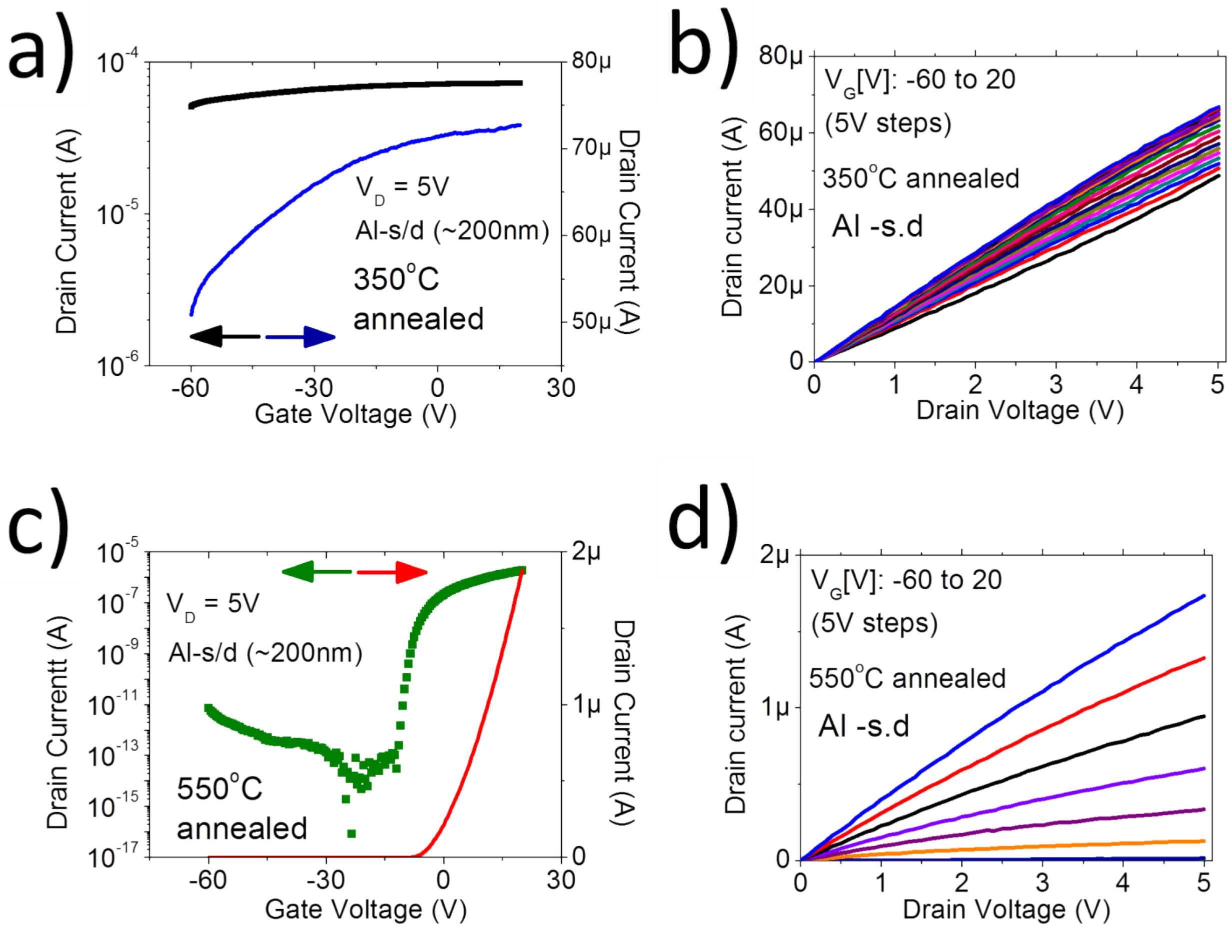


Figure S5 a-b) Transfer and output scans for the 350°C annealed single ZnO nanowire device. c-d) transfer and output scans for 550°C thermally annealed ZnO nanowire device.