Electronic Supplementary Material (ESI) for RSC Advances.
This journal is © The Royal Society of Chemistry 2015

Electronic Supplementary Information

In the case of a nondegenerate n-doped semiconductor, the Boltzmann approximation for the concentration of electrons (n) reads:

$$n = N_c exp(\frac{E_F - E_C}{K_B T}) , \quad (1)$$

Where Nc is the effective density of states in the conduction band, Ec and EF are the conduction band energy level and the Fermi energy level, K_B is Boltzmann constant and T is the temperature. If the effective donors concentration C_D is significantly higher than the intrinsic carriers concentrations n_i, the concentration of electrons n can be used to estimate C_D by using the following approximation:

$$C_D \stackrel{\text{def}}{=} N_D^+ - N_A^- \approx n \quad (2)$$

Where the effective donors concentration C_D is defined as the difference between the ionized concentration of donors N_D^+ and the ionized concentration of acceptors N_A^-. When the n-doped semiconductor surface is electrically connected to the tip through a back contact, the V_{CPD} can be written as:

$$V_{CPD} = \frac{\phi_{tip} - \chi + (E_F - E_C)}{q} \quad (3)$$

Where x is the electron affinity of the semiconductor. Analogous expressions can be derived for a p-doped semiconducting surface. In equation (3) the band bending termφ_B is not explicitly included and its effect on the electrical conductivity of the surface is taken into account by including it in the bulk. By combining equations (1-3), V_{CPD} images probed by SKPM can be mapped into the effective donors concentration C_D, which actually corresponds to the effective doping profile:

$$C_D \approx N_C exp(\frac{qV_{CPD} - \emptyset_{tip} + \chi}{K_B T}) \quad (4)$$

$V_{CPD'}$ between Au and tip could be calculated as below

$$V_{CPD'} = \frac{\emptyset_{tip} - \emptyset_{Au}}{q} , \quad (5)$$

Combined formula (4, 5), V_{CPD} could be writhed as

$$V_{CPD} = \frac{(\emptyset_{Au} + qV_{CPD'}) - \emptyset_{sample}}{q} , \quad (6)$$

Here, work function of Au is 5.1 eV, electron affinity of ZnO is 4.5 eV, effective density of states in the conduction band N_C is 3.7×10^{18}, Boltzmann constant K_B is 8.6×10^{15}eV/K, and temperature T is 300K. The carrier density of ZnO nanowire could be calculated, as shown Fig S1. The Fig S1 shows that the carrier density of small terminal is lower. The carrier density decrease along axle of ZnO nanowire, which consistent with trend of surface potential.

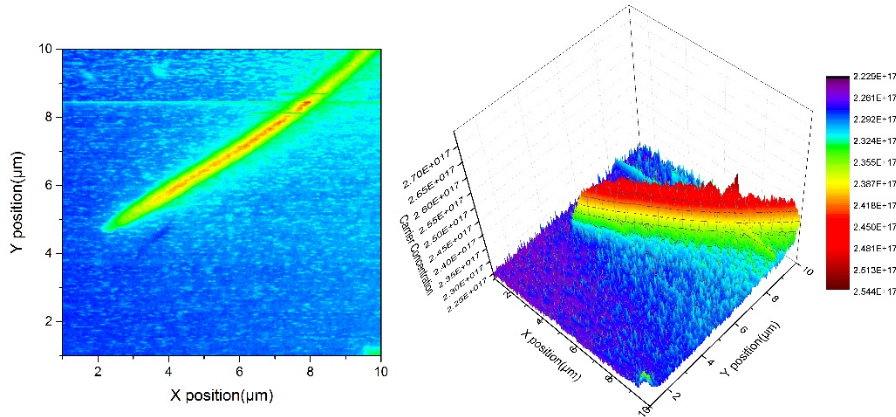

Fig S1 carrier density of ZnO nanowire

The carrier density of ZnO nanowire increase after UV illumination with 0-140 min, as shown in Fig S2. The carrier density of ZnO with 300nm diameter increase from 2.45×10^{17} to 2.68×10^{17} after UV illumination. The carrier density reach to saturation, after 40 min illumination. At the beginning, numerous electron-hole pair were generated by UV illumination. The hole attracted by surface oxygen ion. Therefor the electron density increase drastically. Meanwhile, the surface potential decrease due to increasing electron density. The recombination of electron-hole pair increase due to carrier density increase. The carrier density reach equilibrium when photo-generation equal to recombination.

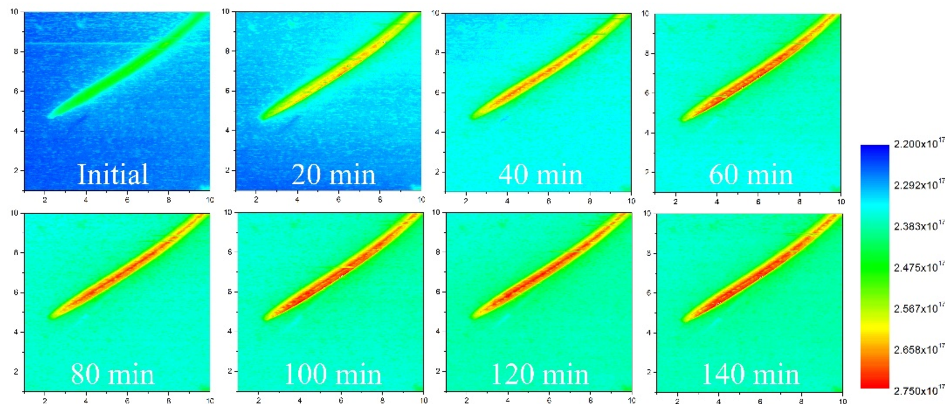

Fig S2 carrier density of ZnO nanowire under UV illumination with 0-140min