Supplementary Material (ESI) for Journal of Materials Chemistry

Ultrasensitive metal-insulator-semiconductor UV photodetectors based on the ZnO/SiO_2 core-shell nanowires

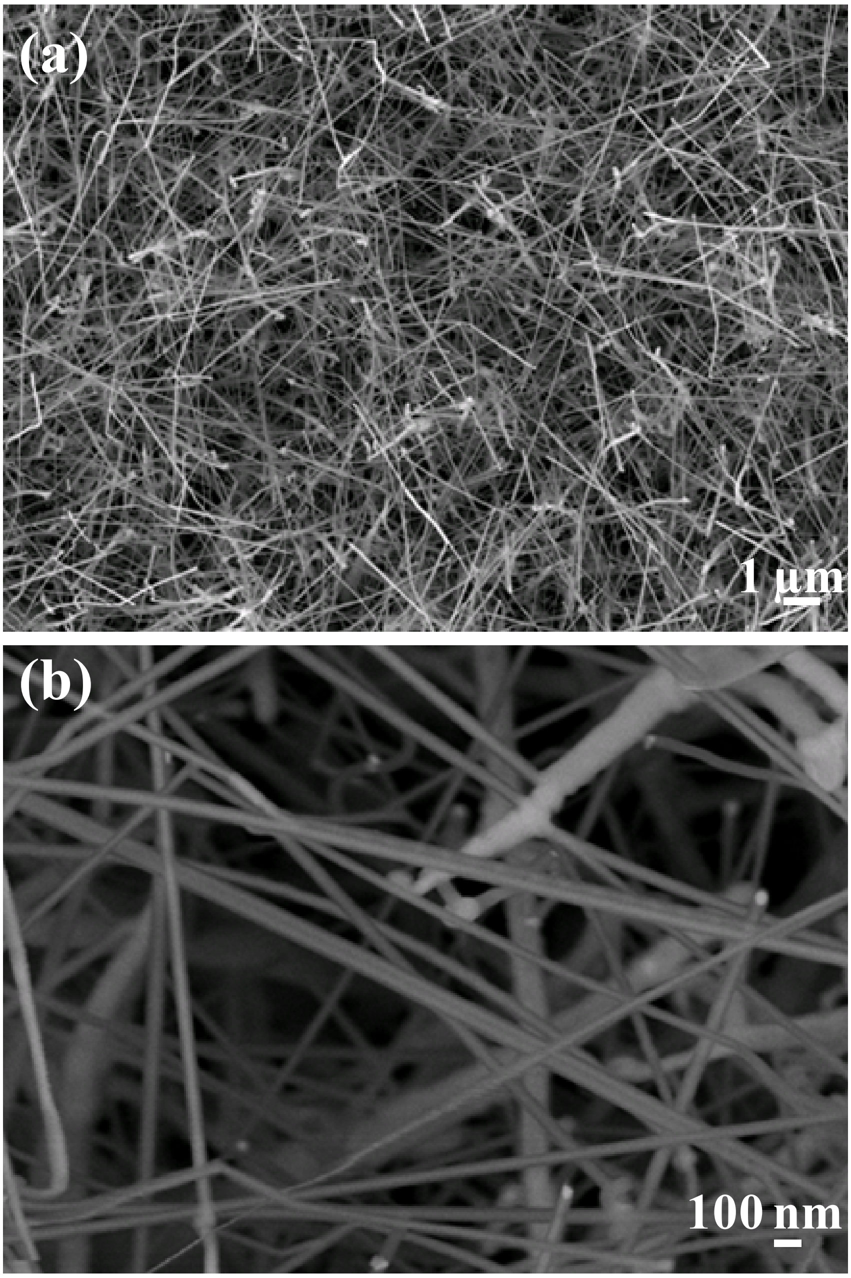
*Manekkathodi Afsal, Chiu-Yen Wang, Li-Wei Chu, Hao Ouyang and Lih-Juann Chen**

Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan, 30013, R.O.C

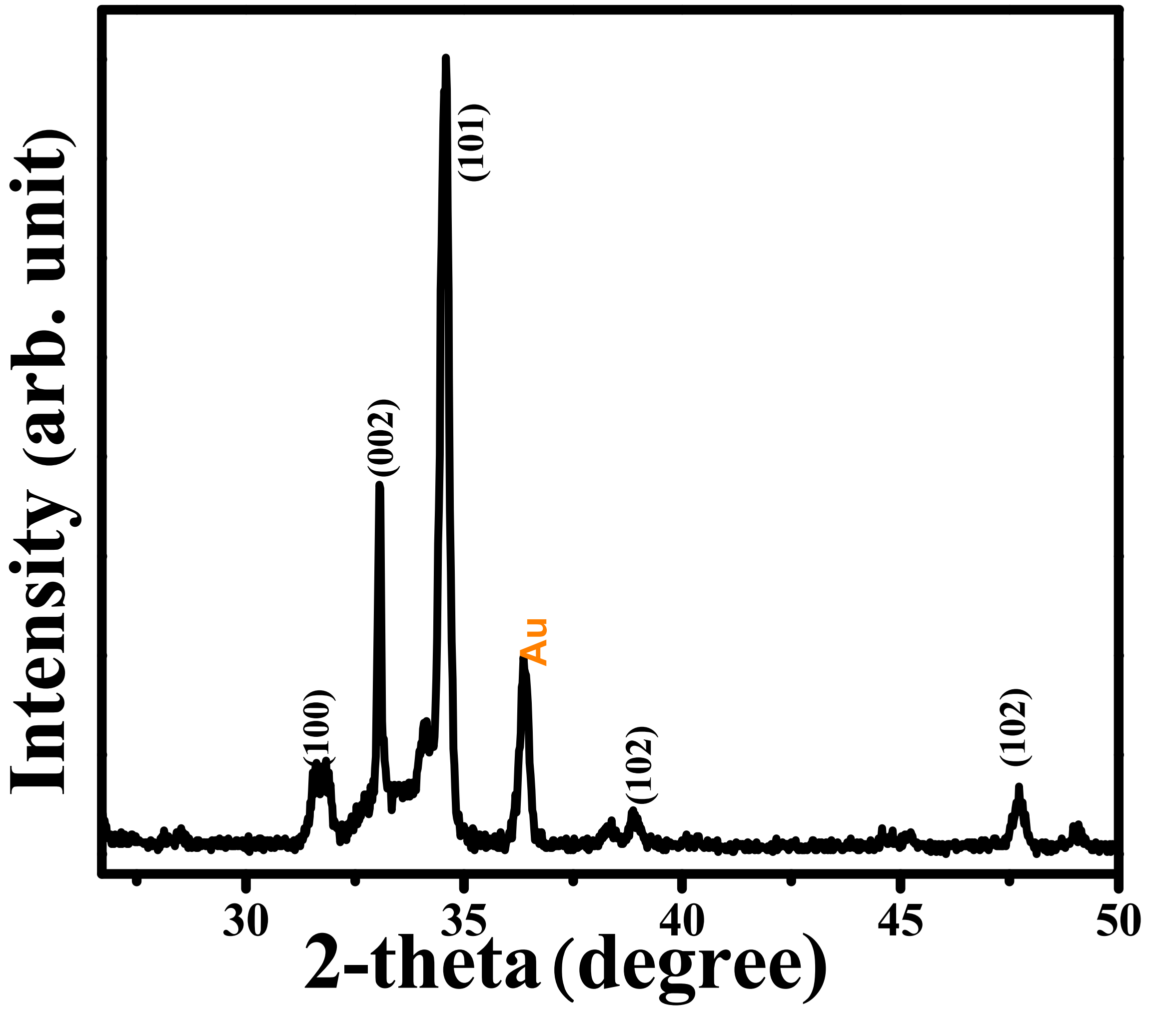
Corresponding author: E-mail: ljchen@mx.nthu.edu.tw

List of contents

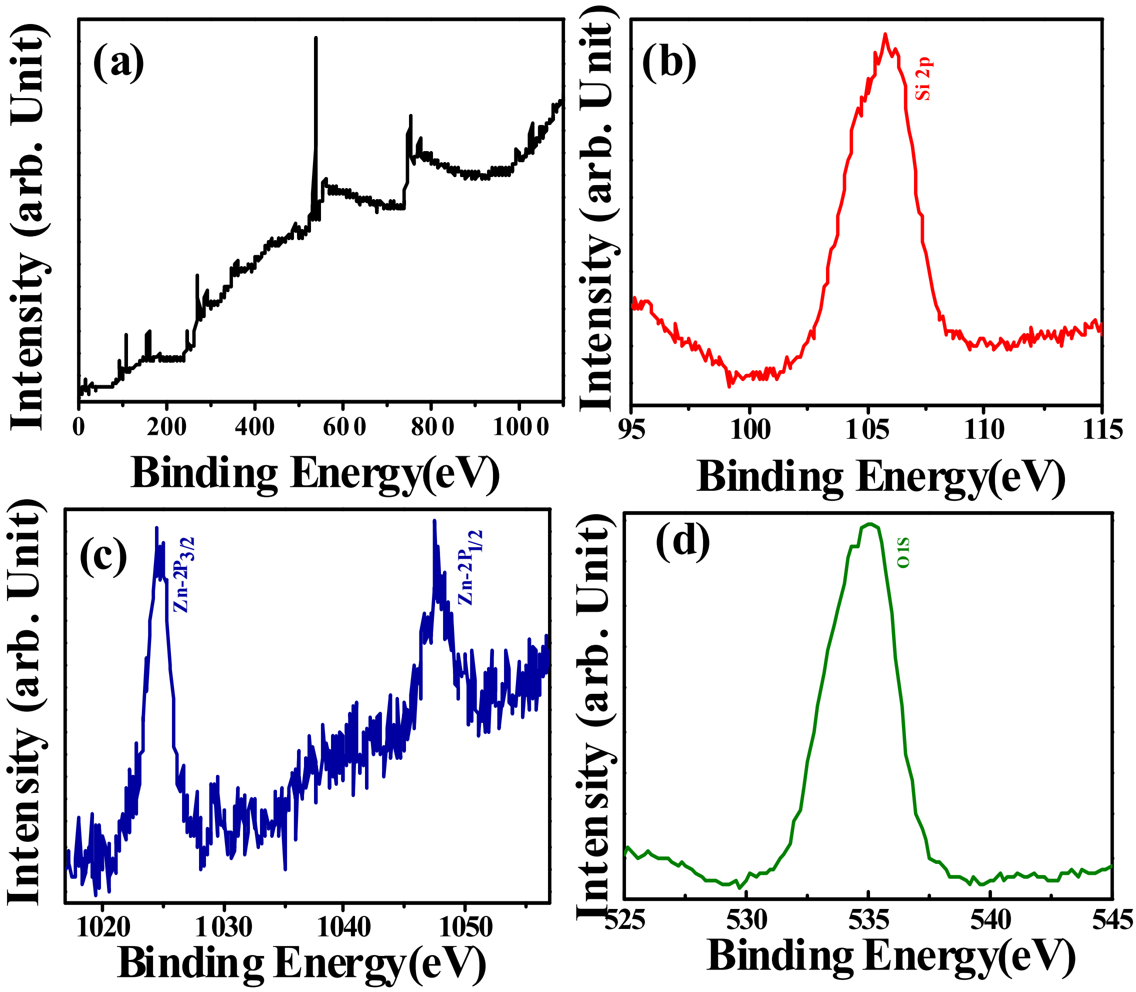
1. SEM images of ZnO/SiO_2 core-shell nanowires on the sapphire substrates.
2. X-ray diffraction measurements of ZnO/SiO_2 core-shell nanowires grown on silicon substrate
3. ESCA analysis of ZnO/SiO_2 core-shell nanowires grown on silicon substrate.
4. Photoconductive performance of ZnO nanowire based conventional MSM photodetector.



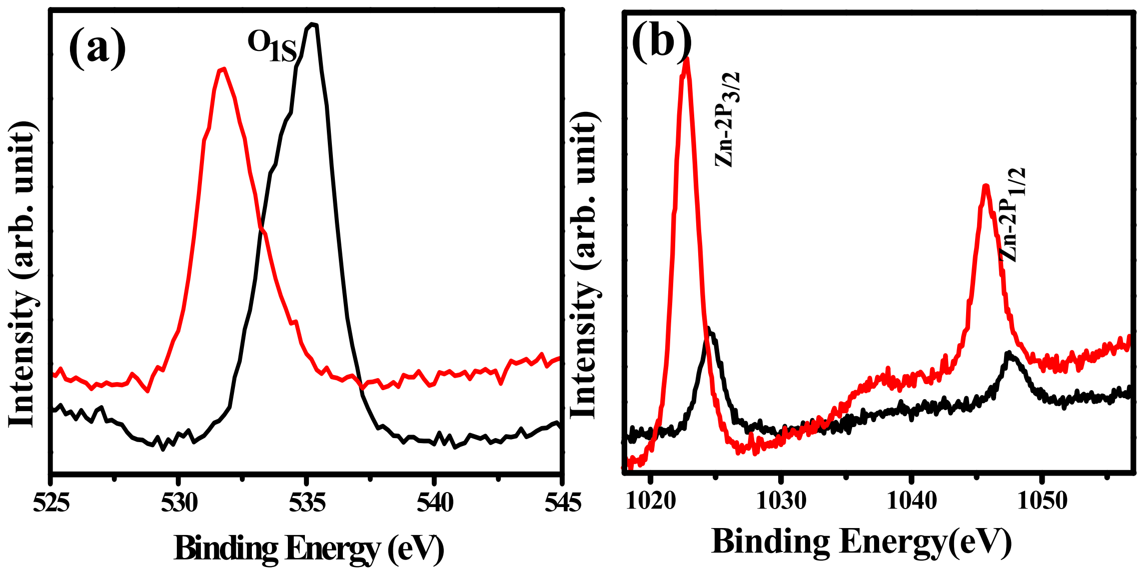
Supporting information S1: Figure shows low (a) and high (b) magnification FESEM images of the ZnO/SiO_2 core-shell nanowires grown on sapphire substrate. Here Au coated sapphire was placed near the 15 nm Au-coated silicon substrate and the experiment was carried out under the same conditions. The nanowires exhibited a high aspect ratio and decrease in the shell thickness, comparing to as grown product on the silicon substrate. It may be due to a decrease of silicate induction to the nanowire from the sapphire substrate.



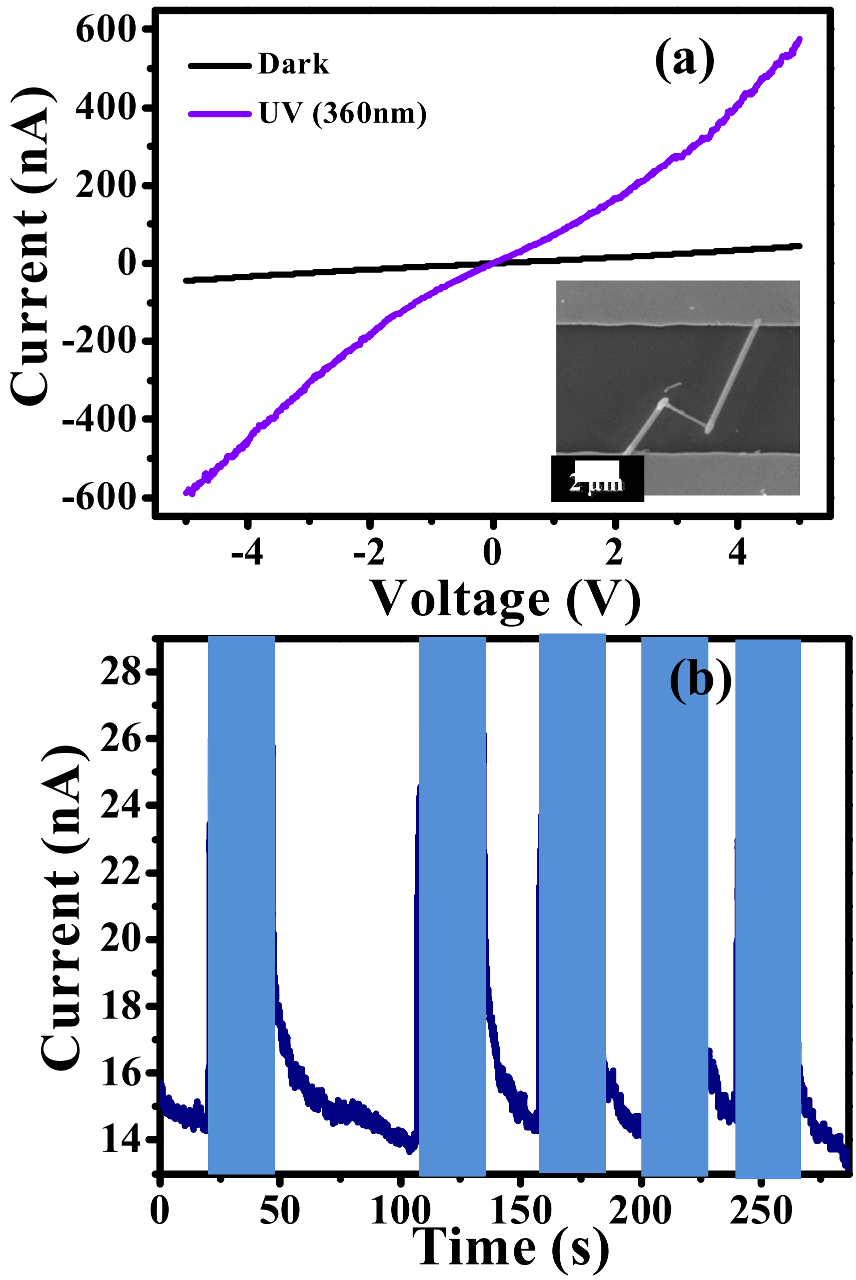
Supporting information S2: The X-ray diffraction pattern of ZnO/SiO_2 core-shell nanowires grown on silicon substrate. The predominant peaks in the spectrum can be attributed to the ZnO hexagonal wurtzite structure. It is observed a considerable enhancement for the peaks at $2\theta \sim 31.18^{\circ}$, $2\theta \sim 33.13^{\circ}$ and $2\theta \sim 34.44^{\circ}$ indicating core ZnO has growth direction along [0001] direction. Apart from the ZnO peaks, the additional peak, observed at $2\theta \sim 36.46^{\circ}$, is perceived from the gold layer used as catalyst.



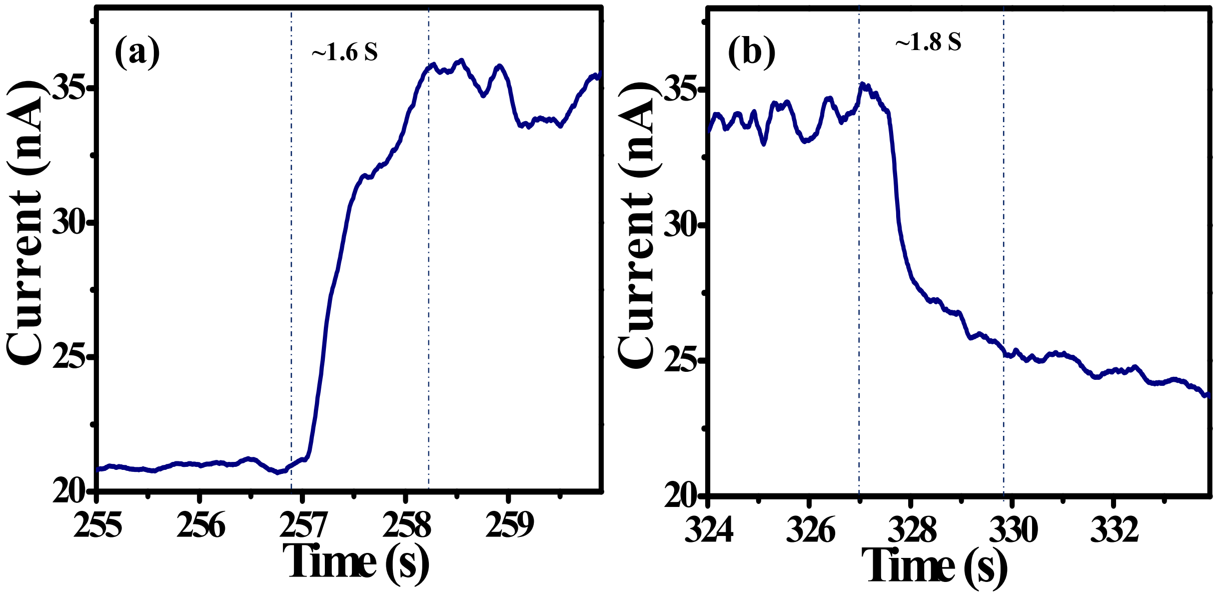
Supporting information S3: The figure shows ESCA analysis of ZnO/SiO_2 core-shell nanowires grown on silicon substrate**.** The ESCA survey spectra (Figure S3, (a)) study from as-grown nanowires, predominantly, yielded to silicon and oxygen and zinc peaks demonstrating the surface covered with composite materials containing ZnO and SiO_2. It is noted that detailed multiplex spectra collected for silicon, zinc, and oxygen ((Figure S3, (b-d)) revealed a comparative increase in the peak intensity of silicon and oxygen with the zinc which again indicate the Zn is located at the core.



Supporting information S4: The variation in the CL spectra is substantiated by XPS analyses by taking multiplex plots for (a) oxygen and (b) zinc. The figure shows the XPS spectra collected from core-shell nanowire with shell thickness of ~50 nm (red) and 10 nm (red). The ESCA analysis shows that both O1s and Zn $2P_{3/2}$ peaks exhibit shifts to higher energy for thin SiO_2 coated core-shell nanowires compared to thick shelled ZnO/SiO_2 core-shell nanowires. The shift of the O1s peak to higher energy state reveals the increase of oxygen defects in ZnO nanostructures, while, the shift of Zn $2P_{3/2}$ peak indicates that more zinc defects are bound to oxygen atoms.



Supporting information S5: ZnO nanowire based MSM photodetector. In designing the ZnO nanowire based photodetector, we have grown single crystal ZnO nanowire using chemical vapor deposition using the same furnace system and photodetector devices were fabricated with similar geometric parameters and designing techniques as ZnO/SiO_2 based MIS device. Figure S5 (a) shows *I–V* characteristic of the device with dark current and photocurrent in the range of 10^{-9} and 10^{-7} A. b) , the photoresponse plot of ZnO photodetector.



Supporting information S6: ZnO nanowire based MSM photodetector. Enlarged portions from response plot of a ZnO based MSM photodetectors demonstrating its response and recovery speeds, according to ON and OFF states of the UV light, are between 1–2 seconds