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ZnSe nanowire photodetector prepared on oxidized silicon substrate by molecular-beam epitaxy

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ZnSe-based II-VI wide direct bandgap materials have received increased attention in recent years owing to their promising optoelectronic applications. For example, it has been shown that ZnSe can be used as the material of light emitters. ZnSe-based light emitting diodes (LEDs) emitting in the blue, green, orange spectra regions have all been reported [1-3]. ZnSe-based white light LEDs have also been demonstrated [4]. Furthermore, room temperature, continuous-wave (CWs) operation of ZnSe-based semiconductor laser diodes with a lifetime longer than 400 hours has also been fabricated successfully [5]. With a wide direct bandgap, ZnSe can also be used as the materials of ultraviolet (UV) photodetectors [6]. It is known that UV photodetectors are important devices that can be used in space communications, ozone layer monitoring and flame detection.

In recent years, one-dimensional (1D) nanowires (NWs) have attracted much attention due to their potential applications in nano-electronics and nano-optoelectronics. In this paper, we report the growth of ZnSe nanowires on oxidized Si(100) substrate by MBE and the fabrication of ZnSe nanowire photodetectors. Physical, electrical and optical properties of the fabricated photodetectors will also be discussed.

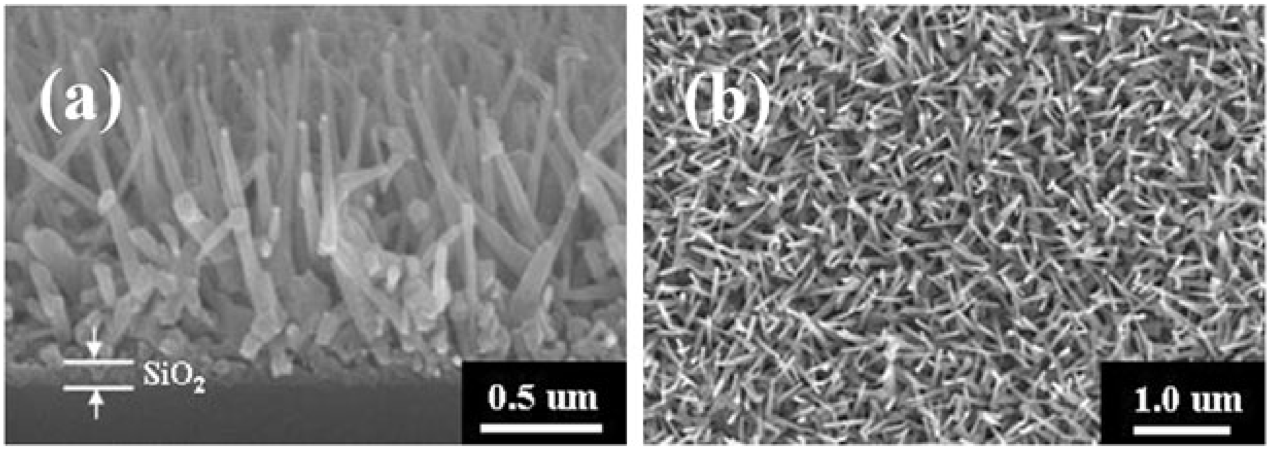

Figure 1 Cross-sectional and Top-view SEM micrograph of the ZnSe nanowires.

Figures 1(a) and 1(b) show cross-sectional and top-view FESEM images of the ZnSe nanowires prepared on oxidized Si substrate. It can be seen clearly that high density tapering ZnSe nanowires were grown on the insulating SiO$_2$ layer. It was also found that average length, average diameter and density of the ZnSe nanowires were 1.2 μm, 48 nm and 1.04×10^7 cm^{-2}, respectively. Similar selective growth has been reported by Hsu et al. [7, 8]. As a result, we designed the interdigitated shadow mask with a finger width of 400 μm wide and a finger length of 600 μm. The spacing between the neighboring fingers was kept at 30 μm. Figure 2 shows temperature dependent PL spectra of the ZnSe nanowires. At 20K, the PL peak intensity was strong with a peak located at 467 nm and a full-width-half-maximum (FWHM) of about 29 nm. It also found that PL peak position shifted to 468 and 473 nm, respectively, while peak FWHM increased to 29.8 and 30.5 nm, respectively, as we increased the temperature to 30K and 50K. As we increased the temperature, PL intensity will be quenched due to phonon induced non-radiative recombination.

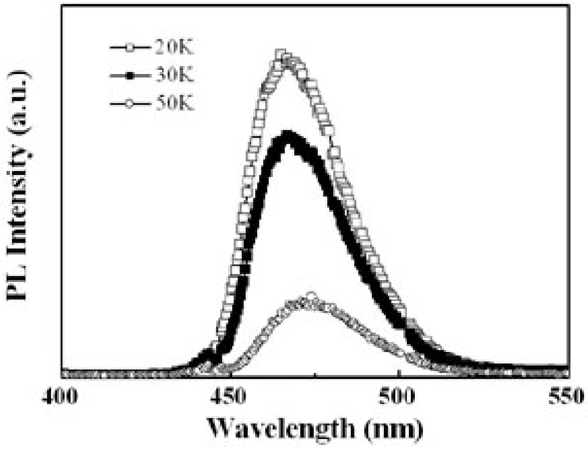

Figure 2 Temperature dependent PL spectra of the ZnSe nanowires.

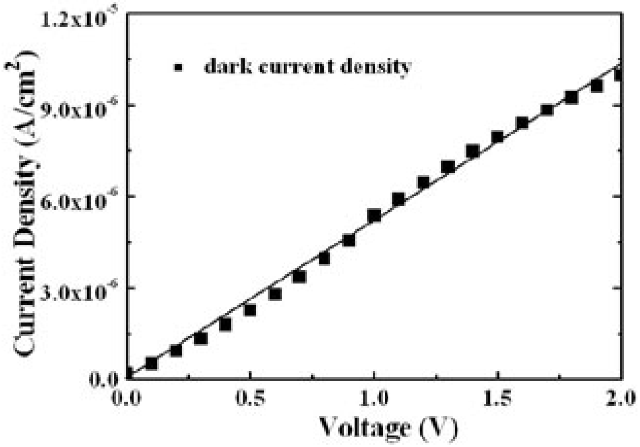

Figure 3 I-V characteristics of the sample photodetector measured in dark.

Figure 3 shows I-V characteristics of our photodetector measured in dark. It was found that measured current increased linearly with the applied bias. With 1 V applied bias, it was found that dark current density of the device was only 5.4×10^{-6} A/cm^2.

Figure 4 shows measured photo response as a function of time as we switched the UV illumination on and off. Without excitation, it was found that measured current was less than 2.9×10^{-8} A at 0.1 V. Under illumination, it was found that measured current increased to 2.7×10^{-6} A. In other words, we achieved a photocurrent to dark current contrast ratio higher than 90. It should be noted that this value is much larger than the 67.5 photocurrent to dark current contrast ratio observed from a ZnO nanowire photodetector [9].

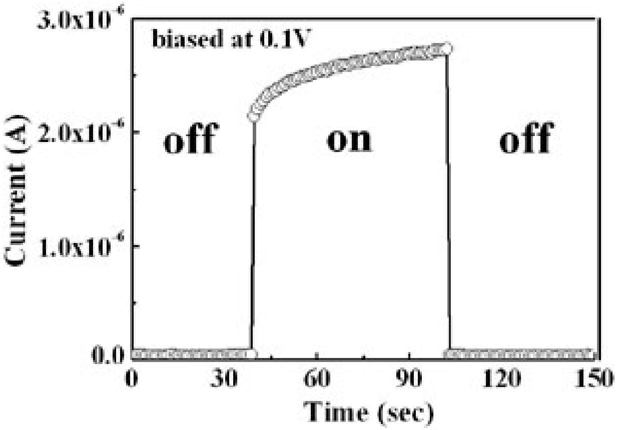

Figure 4 Measured photo-dark response as a function.

In summary, we reported the growth of ZnSe nanowires on oxidized Si substrate by MBE. UV photodetectors were then fabricated by sputtering a thick Au film through an interdigitated shadow mask onto the ZnSe nanowires. It was found that the fabricated photodetector exhibited large photocurrent to dark current contrast ratio and fast response.

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