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# High Quality Ultraviolet Photodetector Based on Ternary $ZnSe_{1-x}Te_x$ Nanotips Grown by MBE

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## 1. Introduction

The ternary $ZnSe_{1-x}Te_x$ semiconductor systems, with the capability of being made both p-type and n-type more easily [1], has been the theme of intensive research, including bulk [1-3] and epitaxial ones [4-6] reported previously. It is proposed that the adjustment in Te concentration could affect their optical properties. From this point of view, it is generally found that the ternary compound semiconductors system provide the advantage of changing the optoelectronic properties by tuning the stoichiometry of the three elements, so as for ternary compound semiconductor nanowires, which could be exploited for architectures like 1D radial [7] and axial [8] heterostructures. Our ternary ZnSeTe nanotips, which are of great importance for blue-green light emission nanodevices, could even make the ZnSe-based heterostructure nanowires system available.

## 2. Experimental

All of the samples were grown by a Riber 32P solid source MBE system in our experiments. The source materials applied in the MBE system were elemental Zn (6N), Se (6N) and Te (6N). Using vapor-liquid-solid (VLS) mechanism, the substrate was thermally oxidized to form a $SiO_2$ film after being cleaned by RCA process, followed by a 2-nm-thick Au film sputtered onto the oxidized surface. To form Au nano-particles, the substrate was then transferred into the preparation chamber and annealed at 300°C for 5 min.

Subsequently, the substrate was loaded into the growth chamber to grow the ternary $ZnSe_{0.95}Te_{0.05}$ nanotips at 320°C for 1 hour. With careful calibration and precise control of growth parameters, we can successfully grow high quality ternary $ZnSe_{0.95}Te_{0.05}$ nanotips on oxidized Si(100) substrate.

For the fabrication of the ZnSeTe nanotip photodetector, a patterned 100-nm-thick Au film was then thermally evaporated onto the $ZnSe_{0.95}Te_{0.05}$ nanotips through an interdigitated shadow mask, serving as the electrodes. The current-voltage (I-V) curve and current-time (I-T) characteristic with a fixed bias voltage of the nanotip photodetector were then investigated in the dark and under UV illumination.

## 3. Results and discussion

Figure 1(a) shows cross-sectional FESEM image of the tapered $ZnSe_{0.95}Te_{0.05}$ nanotips prepared on Si (100) substrate. It is found that their average length and diameter were 0.9 μm and 60 nm, respectively. A high-magnification top-view image of the nanotips is also shown in figure 1(b).

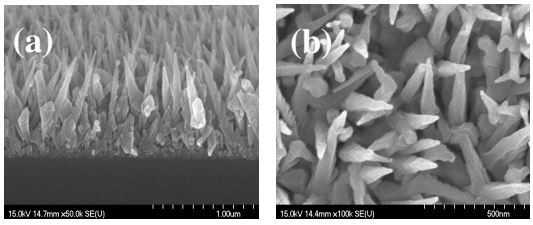


Fig. 1 (a) Cross-sectional and (b) high-magnification top-view FESEM images of the tapered $ZnSe_{0.95}Te_{0.05}$ nanotips grown on Si(100) substrate.

TEM image of a single $ZnSe_{0.95}Te_{0.05}$ nanotip is shown in figure 2 and the inset displays selected-area electron diffraction (SAED) pattern. It was found that the $ZnSe_{0.95}Te_{0.05}$ nanotip was single crystalline structure.

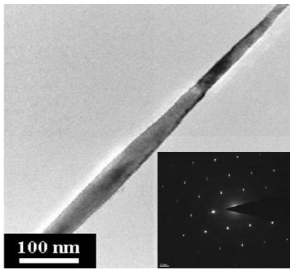


Fig. 2 Bright-field TEM image of a single $ZnSe_{0.95}Te_{0.05}$ nanotip. Inset in figure 2 shows the corresponding SAED pattern.

Figure 3 shows the XRD pattern of the $ZnSe_{0.95}Te_{0.05}$ nanotips. The peaks are indexed to (111), (220), and (311) diffractions of cubic zinc-blende ZnSe crystals, respectively. Besides, there also exist some other weak peaks, like (103),

(100), (101), (200), and (112) diffractions, which are indexed to those of hexagonal wurtzite ZnTe crystals.

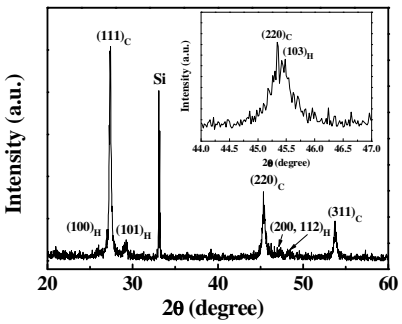


Fig. 3 XRD patterns of the $ZnSe_{0.95}Te_{0.05}$ nanotips. Inset shows the 2θ angle region (44°-47°) in an enlarged scale.

Figure 4 shows PL spectra of the $ZnSe_{0.95}Te_{0.05}$ nanotips measured at 20K. By cautious analysis, a strong PL signal at 494 nm (2.51 eV) with a full-width-half-maximum (FWHM) of about 36 nm was found.

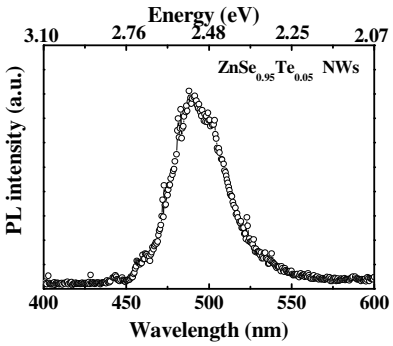


Fig. 4 PL spectra measured from the $ZnSe_{0.95}Te_{0.05}$ nanotips at 20k.

Figure 5 plots I-V characteristics of the fabricated $ZnSe_{0.95}Te_{0.05}$ nanotip photodetector in the dark and photo current at a UV illumination. The dark current was only $2.234\times10^{-8}$ A/cm$^2$ at 5V.

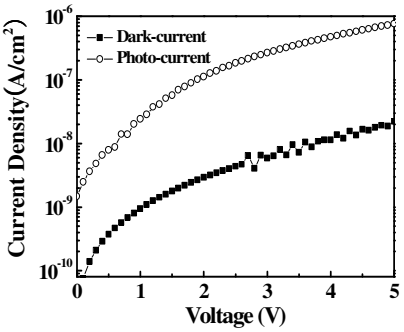


Fig. 5 I-V curves of the $ZnSe_{0.95}Te_{0.05}$ nanotip photodetector measured in dark and photo-current under the UV illumination.

Figure 6 depicts photoresponse of the $ZnSe_{0.95}Te_{0.05}$ nanotip photodetector with UV illumination under 5V bias. When the illumination was turned off, the measured current was ~$2.35\times10^{-8}$ A, whereas the current increased up to $9.1\times10^{-7}$ A under illumination. This indicates that a photocurrent-to-dark current ratio of ~40 was achieved. During turning the illumination on and off, it is found that a rapid response with stability was also achieved.

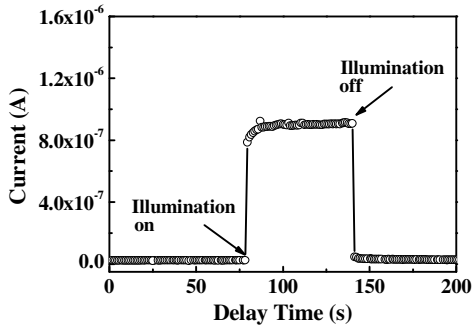


Fig. 6 Reversible switching characteristics of the $ZnSe_{0.95}Te_{0.05}$ nanotip photodetector with on-off illuminations at UV light illumination.

## 4. Conclusions

In summary, we grow high density $ZnSe_{0.95}Te_{0.05}$ nanotips successfully on oxidized Si (100) substrates by MBE. Structural data indicate that our $ZnSe_{0.95}Te_{0.05}$ nanotips were wurtzite and zinc-blende alloy structured. The peak of PL spectra arises from the $Te_n$ ($n \geqq 3$) clusters-induced emission. A $ZnSe_{1-x}Te_x$ nanotip photodetector was then fabricated successfully, and our measurements of I-V curve and photoresponse demonstrate a good photocurrent-to-dark current contrast ratio, and it is also found that a rapid response to the UV light illumination with stability was achieved.

## References


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