Contribution ID: **134** Type: **Poster**

Developement of highly repeatable and recoverable phototransistors based on multi-functional oxide channels

Wednesday 20 June 2018 18:00 (20 minutes)

Visible-to-ultraviolet photodetectors are widely used in imaging, optical communication/interconnects/switches, security, and consumer optoelectronics. In contrast to conventional resistive-type photodetectors, thin-film transistor-based photodetectors (phototransistors) enable easier control of the responsivity and selectivity, which would allow increased amplification of lower detection signals. Much research has been carried out to fabricate CdS-based thin-film transistor (TFT) devices as an alternative to a-Si. However, the versatile fundamental properties of CdS, such as its direct visible band gap, high refraction index, relatively low work function, and good chemical thermal stability, continue to make it appealing for electronic and optoelectronic applications. However, the innovative improvement of CdS-based phototransistors, due to their potential for highly repeatable and recoverable photo-sensing, has rarely been reported.
Alternatively, oxide semiconductors are considered to be the most feasible semiconducting materials for transparent/flexible optoelectronic devices. The photo-response of oxide-based photo-TFTs is largely attributed to the photo-excitation of subgap states, such as ionized oxygen vacancies, and the subsequent liberation of electrons. However, the photo-excitation of ionized oxygen vacancies in oxide-based photo-TFTs is accompanied by lattice relaxation, which subsequently results in a persistent photocurrent. Unfortunately, this usually leads to long recovery times for oxide-based photo-TFTs, as compared to those of typical II-VI semiconductors.
In this work, the channel layers of chalcogenide CdS phototransistors were composed of multi-stacked constituent layers with significantly different physical properties. These were designed to produce high photo-sensing performance by combining the various characteristics of individual layers. Our proposed channel structure is based on multi-layers consisting of Al2O3, CdS, and ZnO, etc.

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Session Classification: Poster Session Wednesday

Track Classification: Electronic Materials & Processing