IUMRS-ICA 2017

Symposium A2: Compound Semiconductors and Wide Bandgap Materials for Electronic and Optical Devices

Titled: **Synthesis and optical characterization of II-VI and III-VI wide bandgap sulfide compounds for UV-visible optoelectronics application**

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ABSTRACT

In this presentation, I would demonstrate single crystal growth and optical characterization of II-VI oxygen-incorporated ZnS [i.e. $ZnS_{(1-x)}O_x$ series, x=0, 0.06, 0.12] and III-VI Ga_2S_3 compounds by using chemical vapor transport (CVT) method. The $ZnS_{(1-x)}O_x$ compounds are environment friendly wide-band-gap semiconductors available for light-emitting devices and solar cell use. The series materials have considerable potential to be applied in visible to ultraviolet (UV) region with the flexibility of color palette emissions. High resolution transmission electron microscopy (HRTEM), X-ray diffraction (XRD), thermoreflectance (TR) and photoluminescence (PL) measurements are implemented to evaluate their structure and optical property. Through the study the structure of the oxygen-incorporated ZnS is crystallized in majorly zinc-blende phase and a little bit wurtzite structure. The lattice constants of the major cubic phase have been determined to be a = 5.43Å (ZnS), 5.41Å ($ZnS_{0.94}O_{0.06}$) and 5.39Å ($ZnS_{0.88}O_{0.12}$), respectively. Three band-edge excitonic transitions from ~3.7 to 3.9 eV are simultaneously detected by TR for the undoped ZnS, $ZnS_{0.94}O_{0.06}$ and $ZnS_{0.88}O_{0.12}$. With the oxygen content is increased, the band-edge transition energies of the $ZnS_{(1-x)}O_x$ series compounds are decreased. The defect emissions in the $ZnS_{(1-x)}O_x$ series also show higher energy values than those of pure ZnO to show blue and purple colors lights. It amends the drawback of ZnO that only emits the defect emissions with energies lower than green color owing to the lower bandgap. With adjusting the oxygen content, the $ZnS_{(1-x)}O_x$ can be a series of color-palette luminescence matters that applied for fluorescent display or light-emitting device. For the study of the III-VI Ga_2S_3 compound, we demonstrate the experimental band-edge structure and excitonic transitions of monoclinic digallium trisulfide using PL, TR, and optical absorption measurements at low and room temperatures. According to the experimental results, three band-edge transitions of E_A=3.052 eV, E_B=3.240 eV, and E_C=3.328 eV are respectively determined and they are proven to construct the main band-edge structure of Ga_2S_3. Distinctly optical-anisotropic behaviors by orientation- and polarization-dependent TR measurements are clearly observed. The results indicated that the three band-edge transitions are coming from different origins. Low-temperature PL results show defect emissions, bound-exciton and free-exciton luminescences in the radiation spectra of Ga_2S_3. The below-band-edge transitions are

respectively characterized. On the basis of experimental analyses, the optical property of near-band-edge structure and excitonic transitions in the monoclinic Ga_2S_3 crystal is hence realized.

Brief CV

Dr. Ching-Hwa Ho is now a distinguished professor in the Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology. Professor Ho joined in the faculty members of National Taiwan University of Science and Technology in 2009. He had ever been served as a professor and chairperson of Department of Materials Science and Engineering and Graduate Institute of Optoelectronic Engineering in National Dong Hwa University from 2006 to 2009. His research interest focuses on crystal growth, 2D semiconductors, energy compounds, optical characterization of semiconductors, modulation spectroscopy and semiconductor measurement techniques. He is now an editorial board member in Scientific Reports, and also serves for three other international journals. He have authored and co-authored more than 150 scientific journals in his related research field.

List of selected publications:

1. C. H. Ho, Z. Z. Liu, and M. H. Lin, *Nanotechnology* **28**, 235203 (2017).
2. C. H. Ho, Y. H. Chen, Y. K. Kuo, and C. W. Liu, *Chem. Commun.* **53**, 3741 (2017).
3. D. Zhou, Y. Zhou, C. Pu, X. Chen, P. Lu, X. Wang, C. An, Y. Zhou, F. Miao, C. H. Ho, J. Sun, Z. Yang, D. Xing, *npj Quantum Mater.* **2**, 19 (2017).
4. C. H. Ho and J. X. Li, *Adv. Optical Mater.* **5**, 16008 (2017).
5. C. H. Chan, M. H. Lin, L. C. Chao, K. Y. Lee, L. C. Tien, and C. H. Ho, *J. Phys. Chem. C* **120**, 21983 (2016).
6. C. H. Ho, and M. H. Lin, *RSC Adv.* **6**, 81053 (2016).
7. D. Ovchinnikov, F. Gargiulo, A. Allain, D. J. Pasquier, D. Dumcenco, C. H. Ho, O. V. Yazyev, A. Kis, *Nature Commun.* **7**, 12391 (2016).
8. C. H. Ho, *2D Mater.* **3**, 025019 (2016).
9. C. H. Ho and Y. J. Chu, *Adv. Optical Mater.* **3**, 1750 (2015).
10. Y. C. Lin, H. P. Komsa, C. H. Yeh, T. Björkman, Z. Y. Liang, C. H. Ho, Y. S. Huang, P. W. Chiu, A. V. Krasheninnikov, and K. Suenaga, *ACS Nano* **9**, 11249 (2015).