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II-VI Based Inorganic-Organic Hybrid Quantum Structures with High Degree of Structural Ordering, Long-Term Stability, and Novel Properties

Yong Zhang

Electrical and Computer Engineering Department, University of North Carolina at Charlotte, 9201 University City Blvd., Charlotte, NC 28223, USA.

*Corresponding Author: Yong Zhang. Email: yong.zhang@uncc.edu.

Translational symmetry ensures phase coherency of a physical process among different units of a crystal, and thus produces collective quantum effects beyond the sum of the units. Any significant physical and/or chemical fluctuation, which typically exists in a semiconductor alloy or self-assembled or artificially grown nanostructure array, would hinder our ability to study and use the collective behavior relying on this coherency. Man-made structures remain as one of the central interests since semiconductor superlattices were proposed by Esaki and Tsu in 1970. Unfortunately, man-made structures with both genuine long- and short-range order are rare. Here a new family of inorganic-organic hybrid quantum structures provides us a unique opportunity to explore coherency quantum phenomena in man-made structures. These self-assembled hybrid structures are ultra-thin slabs or atomic chains of II-VI semiconductors interconnected or coordinated by small organic molecules, exhibiting very high degree of structural perfectness comparable to a typical binary semiconductor, as manifested in a very small XRD and Raman linewidth. They exhibit several extraordinary properties, for instance, exceedingly strong excitonic absorption, large exciton binding energies, and zero thermal expansion. By varying either the inorganic or organic component, one can tune the coupling between the inorganic units to achieve quasi-1-D, quasi-2-D, and 3-D super-structures with tailored material properties for different basic research interests and potential applications (e.g., room temperature exciton-polariton condensation, high efficiency UV emission and detection, p-type transparent conducting material). Furthermore, some hybrid structures, such as β-ZnTe(en)0.5, have been found to retain the same structural perfectness after being stored under ambient condition over a decade, despite others show varying degrees of structural degradation. This finding indicates that the long-term stability of the material depends on both the intrinsic effect, the strength of chemical bonding, and the extrinsic effect, such as the presence of defects in the initial structure.

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References

1. Huang, X. Y., Li, J., Zhang, Y., Mascarenhas, A. (2003). From 1D chain to 3D network: Tuning hybrid II-VI nanostructures and their optical properties. *Journal of the American Chemical Society, 125*, 7049.
2. Fluegel, B., Zhang, Y., Mascarenhas, A., Huang, X., Li, J. (2004). Electronic properties of hybrid organic-inorganic semiconductors. *Physical Review B, 70,* 205308.

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3. Zhang, Y., Dalpian, G. M., Fluegel, B., Wei, S. H., Mascarenhas, A. et al. (2006). Novel approach to tuning the physical properties of organic-inorganic hybrid semiconductors. *Physical Review Letters, 96,* 026405.
4. Zhang, Y., Islam, Z., Ren, Y., Parilla, P. A., Ahrenkiel, S. P. et al. (2007). Zero thermal expansion in a nanostructured inorganic-organic hybrid crystal. *Physical Review Letters, 99,* 215901.