Strategic Precursor Engineering and Continuous-Flow Synthesis of High-Quality PbS Quantum Dots for Enhanced Near-Infrared Photodetection

Ling-Hsuan Chung[1,2], Kai-Chun Hsu[1], Mu-Huai Fang[1,#]

[1]Research Center for Applied Sciences, Academia Sinica, Taipei 115201, Taiwan (R.O.C).
[2] Department of Engineering and System Science, National Tsing Hua University, Hsinchu 300044, Taiwan (R.O.C).

This study investigates the development of cost-effective and sustainable sulfur sources, such as sulfur powder, for the synthesis of PbS quantum dots. Initial investigations demonstrated that conventional lead oxide precursor systems, when utilizing sulfur powder or alternative green sulfur sources such as dodecanethiol and thioacetamide, failed to produce nanocrystals with well-defined excitonic features [1]. This structural deficiency led to poor optoelectronic performance in graphene-QD composite devices, which exhibited negligible photoresponse and failed to provide meaningful signals during characterization, indicating that the material quality was insufficient for practical applications. To address these challenges, we optimized the precursor coordination environment by transitioning from lead oxide to lead chloride [2]. This modification successfully induced strong excitonic absorption, confirming that the precursor chemistry is fundamental to the electronic structure of PbS QDs. To further ensure reproducibility and precise material control, a flow chemistry system was implemented. This approach leverages enhanced mass and heat transfer to achieve superior control over the reaction environment. The primary objective of this research is to evaluate the excitonic quality, colloidal stability, and reaction kinetics of the resulting nanocrystals [3]. Furthermore, the performance of these QDs in near-infrared photodetectors is analyzed to establish a robust experimental framework for low-cost, high-performance optoelectronic sensing technologies.

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corresponding author: fangmuhuai@gate.sinica.edu.tw