

Ultrafast Electrochemical Synthesis of Defect-Free In_2Se_3 Flakes for Large-Area Optoelectronics

Hunahuan Shi

Ali Shaygan Nia, Martin R. Lohe, and Xinliang Feng
Technische Universität Dresden, Zellescher 19, Dresden, Germany
Contact@E-mail : huanhuan.shi@mailbox.tu-dresden.de

Abstract

Indium(III) selenide (In_2Se_3), an important semiconductor, has been applied in various electronics and optoelectronics owing to its thickness-dependent direct bandgap (1.3-2.8 eV) and exceptional optoelectronic properties and high stability [1]. However, the scalable production of defect-free In_2Se_3 flakes with large crystal domains remains an impediment to their practical applications. Here, a facile electrochemical strategy is presented for the ultrafast delamination (30 min) of bulk layered In_2Se_3 crystals in dimethylformamide (DMF) containing tetrahexylammonium(THA^+), resulting in high-yield (83%) production of In_2Se_3 flakes with large lateral size (up to 26 μm). The intercalation of THA^+ ions mainly creates stage-3 intercalated compounds in which every three layers of In_2Se_3 are occupied by one layer of THA molecules [2]. The subsequent exfoliation leads to a majority of trilayer In_2Se_3 nanosheets (4 nm). Owing to the excellent solution processability of exfoliated sheets (2 mg/mL in DMF), large-area (400 $\mu\text{m} \times 20 \mu\text{m}$) photodetectors are fabricated based on filtrated In_2Se_3 thin films from their stable dispersions. The fabricated devices demonstrated high responsivity ($\approx 1 \text{ mA W}^{-1}$), superfast rise (41 ms) and decay time (39 ms) and high stability to light, superior to the performances of other 2D materials such as, graphene, black phosphorus, MoS_2 , and WS_2 [3].

References

- [1] W. Ding, J. Zhu, Z. Wang, Y. Gao, D. Xiao, Y. Gu, Z. Zhang, W. Zhu, Nat. Commun. 2017, 8, 14956.
[2] C. Wang, Q. He, U. Halim, Y. Liu, E. Zhu, Z. Lin, H. Xiao, X. Duan, Z. Feng, R. Cheng, N. O. Weiss, G. Ye, Y. Huang, H. Wu, H. Cheng, I. Shakir, L. Liao, X. Chen, W. A. Goddard Iii, Y. Huang, X. Duan, Nature 2018, 555, 231.
[3] H. Shi, M. Li, A. Nia, M. Wang, S. Park, Z. Zhang, M. R. Lohe, S. Yang, X. Liang, Adv. Mater. 2020, 1907244

Figure

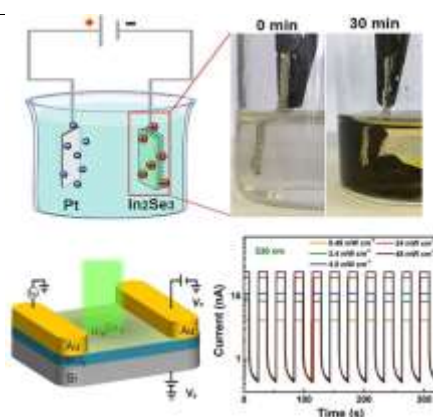


Figure 1: Schematic illustration and photographs of the electrochemical delamination of bulk In_2Se_3 (top) and schematic and photoresponse of the In_2Se_3 -based thin film photodetector (down).