Layered metal thio (seleno) phosphates for broad-band optoelectronics

Kalyan Jyoti Sarkar
Zdenek Sofer
Department of Inorganic Chemistry, University of Chemistry and Technology Prague, Technická 5, 166 28 Prague 6, Czech Republic
sarkark@vscht.cz

A large number of promising two-dimensional (2D) semiconductor materials, represented by black phosphorus (0.3 eV), transition metal dichalcogenide (TMDCs) (<2 eV), and hexagonal boron nitride (6 eV), have been extensively studied in optoelectronic devices. However, the spectrum of large-band gap materials remains very narrow, limiting the application for broadband optoelectronic devices. The broad family of metal thio and selenophosphates with large tunable band gaps (1.5-3.5eV), which can be adjusted by varying the metal cation and the anion during the synthesis, can bridge the gap of intermediate band gaps (1.5-4 eV) between TMDCs to hBN [1]. We present the synthesis and fabrication of high-performance broadband photodetector based on multilayered $CuInP_2Se_6$ and $CuInP_2S_6$. Both samples were prepared by the CVT method. The samples were thoroughly characterized by in-depth microscopic (SEM, HRTEM, AFM) and spectroscopic (Raman, PL) techniques. We have calculated the electronic band structure and density of states of both samples. Fabricated devices were irradiated with different wavelengths (300-1100 nm) of light, showing outstanding responsivity with low dark current and a high on/off ratio. Time-resolved photocurrent measurements were also performed, which exhibit a fast response time. We also have designed photodetectors using multiscale modeling to explore the device's performance. By using semiconductor module for theoretically modeled devices, the terminal current across the device with respective wavelength was calculated and compared with the experimental results.

References

[1] Susner et al. Adv.Mater.2017, 29, 160285