Indium Selenide: A van der Waals Semiconductor for Catalysis and Optoelectronics

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ABSTRACT

The presence of a band gap, absent in graphene, is crucial for achieving a high ON/OFF ratio in nanodevices. Consequently, semiconductors with interlayer van der Waals bonds have recently attracted the interest of scientific community. Furthermore, a direct band gap also allows the use of materials in optoelectronics. Among van der Waals semiconductors, β-indium selenide (β-InSe) promises superb impact onnanoelectronics, due to its ambient stability, flexibility and high mobility of charge carriers and a band-gap energy matching with visible [1]. Moreover, the possibility to grow β-InSe bulk single crystals by Bridgman-Stockbarger technique enables scalability for large-scale production.

The band structure of β-InSe was measured by angle-resolved photoemission spectroscopy and reproduced by density functional theory [2]. Electronic band structure shows robustness against surface oxidation. The ambient stability of bulk crystals was further secured by monitoring the behavior of the efficiency of field-effect transistors (FETs) with an active channel of InSe [3] in a timescale extended up to several months, complemented by vibrational experiments [3]. Atomically thin layers were achieved byliquid-phase exfoliation (LPE) [4]. InSe nanosheets were proposed aselectrocatalysts for HER [4] and for photodetectors in the visible and NIR (<900 nm) [5].

The catalytic activity of InSenanosheetsis enhanced by the presence of Se vacancies and edge sites, with induce the formation of a self-assembed In2O3/InSe heterostructure [6], with superior catalytic activity, similarly to the parental compound GaSe. Our results pave the way for InSe-based technological applications in catalysis and optoelectronics.

Keywords—2D materials; indium selenide; liquid-phase exfoliation; hydrogen evolution reaction

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Songül Duman is a professor at Erzurum Technical University in Turkey since 2016. She graduated first in class at the Physics Department, Atatürk University in 1997. She received M.Sc. degree and Ph.D. degree on Solid State Physics at Atatürk University in 2001 and 2006, respectively. Her research interests include semiconductor devices, layered crystal growth, semiconductor characterization, 2D-layered materials, thin films and solar-cells. She has co-authored more than 60 peer-reviewed journal papers and h-index of 19 as of October 2020. These papers have been cited for about 1000 times.