Atomic-Level Customization of 4 in. Transition Metal Dichalcogenide Multilayer Alloys for Industrial Applications

Despite many encouraging properties of transition metal dichalcogenides (TMDs), a central challenge in the realm of industrial applications based on TMD materials is to connect the large-scale synthesis and reproducible production of highly crystalline TMD materials. Here, the primary aim is to resolve simultaneously the two inversely related issues through the synthesis of MoS2(1-x) Se2x ternary alloys with customizable bichalcogen atomic (S and Se) ratio via atomic-level substitution combined with a solution-based large-area compatible approach. The relative concentration of bichalcogen atoms in the 2D alloy can be effectively modulated by altering the selenization temperature, resulting in 4 in. scale production of MoS1.62 Se0.38, MoS1.37 Se0.63, MoS1.15 Se0.85, and MoS0.46 Se1.54 alloys, as well as MoS2 and MoSe2. Comprehensive spectroscopic evaluations for vertical and lateral homogeneity in terms of heteroatom distribution in the large-scale 2D TMD alloys are implemented. Se-stimulated strain effects and a detailed mechanism for the Se substitution in the MoS2 crystal are further explored. Finally, the capability of the 2D alloy for industrial application in nanophotonic devices and hydrogen evolution reaction (HER) catalysts is validated. Substantial enhancements in the optoelectronic and HER performances of the 2D ternary alloy compared with those of its binary counterparts, including pure-phase MoS2 and MoSe2, are unambiguously achieved.

General information
Publication status: Published
Organisations: Department of Energy Conversion and Storage, Korea Research Institute of Chemical Technology, Yonsei University, Korea Basic Science Institute, Ulsan National Institute of Science and Technology
Corresponding author: Lim, J.
Number of pages: 14
Publication date: 2019
Peer-reviewed: Yes

Publication information
Journal: Advanced Materials
Volume: 31
Issue number: 29
Article number: e1901405
Ratings:
Web of Science (2019): Indexed yes
Original language: English
Keywords: 2D ternary alloys, Hydrogen evolution reaction, Photodetectors, Transition metal dichalcogenides
DOI: 10.1002/adma.201901405
Source: FindIt
Source-ID: 2448783140
Research output: Contribution to journal » Journal article – Annual report year: 2019 » Research » peer-review