

Winter 2020 Colloquium

NAKAMURA LECTURE

Materials Department

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Dept. of Materials Science and
Engineering
Pennsylvania State University

Tuesday, January 28th, 2020
2:00 pm, ESB 1001



Epitaxy in 2D: The path to wafer-scale single crystal monolayers and heterostructures

The spectrum of two-dimensional (2D) materials “beyond graphene” has been continually expanding driven by the compelling properties of layered chalcogenide and related materials in monolayer and few-layer form. The layered chalcogenides include 2D transition metal dichalcogenide (TMD) monolayer films that are only a few atoms thick, topological insulator bismuth chalcogenide films that only conduct on the 2D surface, and multilayers of dissimilar chalcogenide films whose properties are dominated by 2D interfaces. The full realization of the scientific and technological potential of 2D materials, however, requires the development of atomic-level mastery over the wafer-scale synthesis of films with high crystalline quality and low defect densities.

Our research is aimed at the development of an epitaxial growth technology for layered chalcogenides similar to that which exists for III-V and other compound semiconductors, based on metalorganic chemical vapor deposition (MOCVD). Our studies have focused primarily on epitaxial growth of semiconducting TMDs including WSe_2 , MoS_2 and WS_2 and are aimed at understanding fundamentals of nucleation, epitaxy and anisotropic growth that are characteristic of van der Waals crystals. Point defects and surface steps are used to control the nucleation density and orientation of TMD domains as demonstrated for epitaxial growth on hBN and sapphire substrates, respectively, to suppress the formation of inversion domains. Monolayers of WS_2 and WSe_2 grown by MOCVD on 2” sapphire exhibit optical and transport properties approaching that of single crystal flakes exfoliated from bulk crystals. Prospects and challenges associated with the epitaxial growth of vertical and lateral TMD heterostructures will also be discussed.

Bio

Joan Redwing received her Ph.D. in Chemical Engineering from the University of Wisconsin-Madison. After working as a research engineer at Advanced Technology Materials Inc., she joined the faculty of the Department of Materials Science and Engineering at Penn State University in 2000. She currently serves as Director of the 2D Crystal Consortium, an NSF-supported Materials Innovation Platform (MIP) national user facility. Her research focuses on understanding fundamental mechanisms of crystal growth and epitaxy of electronic materials, with a particular emphasis on thin film and nanomaterial synthesis by metalorganic chemical vapor deposition. Dr. Redwing currently serves as vice president of the American Association for Crystal Growth, is an associate editor for the Journal of Crystal Growth and a regional editor for 2D Materials. She is a fellow of the Materials Research Society, the American Physical Society and the American Association for the Advancement of Science and is a senior member of IEEE. She is an author or co-author on over 270 publications in refereed journals and holds 8 U.S. patents.

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