Department of Materials Science and Engineering Seminar Series 2025

Area-Selective Growth of Two-Dimensional Transition Metal Dichalcogenides

Li Haobo

Date and time: 28th November 2025 (Friday) 2 pm - 4 pm

Venue: EA-06-04 Seminar Room

Abstract

Two-dimensional transition metal dichalcogenides (TMDs), particularly molybdenum disulfide (MoS_2), are promising for next-generation electronics owing to their tunable bandgaps, strong electrostatic control, and atomic thickness. However, scalable synthesis with spatial precision remains challenging, especially for lithography-free, bottom-up patterning. This thesis develops electron-beam–assisted strategies for area-selective growth of MoS_2 through substrate surface modification. Two approaches are demonstrated: (1) selective CVD growth on electron-irradiated SiO_2/Si using MoO_3 and sulfur precursors, and (2) preferential sulfurization of ALD-grown MoO_x films irradiated before sulfurization. Both achieve strong spatial selectivity and pattern fidelity across diverse geometries. Comprehensive characterization reveals that electron irradiation induces surface charging, oxygen vacancies, and structural rearrangements that enhance MoS_2 conversion and interfacial adhesion, while excessive doses lead to carbon-induced suppression. The underlying mechanism links oxygen-vacancy formation and Si-O network modification to area-selective growth. This lithography-free route enables clean, controllable patterning

without resists or etching. The findings advance fundamental understanding of irradiation-induced surface modification and establish a promising framework for direct patterned synthesis of 2D materials, paving the way for direct patterning techniques compatible with 2D materials, which minimize contamination, and reduce complexity in the fabrication process.

Biography

Li Haobo received his bachelor's degree in Materials Science & Engineering from Northwestern Polytechnical University, and master's degree in Materials Science & Engineering from Carnegie Mellon University. Haobo is currently a PhD candidate in the Department of Materials Science and Engineering under the supervision of Prof. Silvija Gradečak. His research focuses on the area-selective synthesis of 2D transition metal dichalcogenides and related mechanisms.

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