PQS2D Special Topic – MOCVD Latest News

Hang Chi

Department of Physics, University of Ottawa

PQS2D Research Collaboration Meeting

Online

Wednesday, October 21, 2026

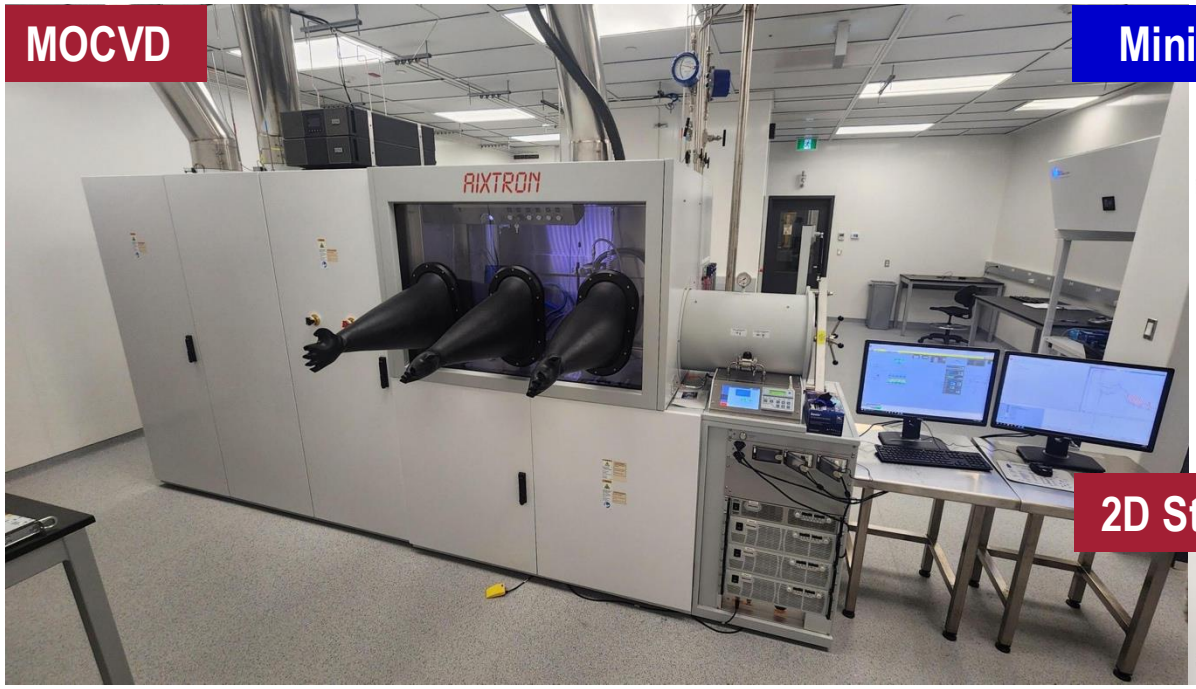
creatematerials.org

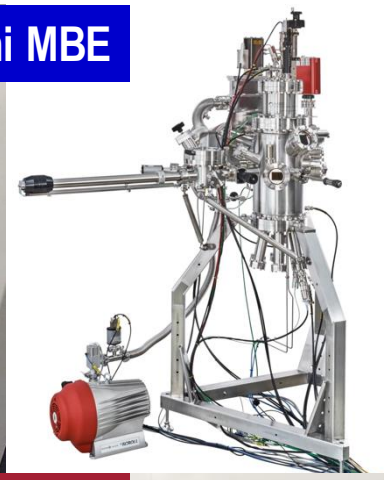
CANADA RESEARCH CHAIRS
CHAIRES DE RECHERCHE DU CANADA
NSERC CRSNG
New Frontiers in Research Fund
Fonds Nouvelles frontières en recherche
Acceleration Consortium
INNOVATION Canada Foundation for Innovation Fondation canadienne pour l'innovation
Ontario Research Fund
Digital Research Alliance of Canada
Alliance de recherche numérique du Canada

Overview

- 2D Quantum Materials (2DQM) Facility
- Capabilities
- PQS2D

2dqm.uottawa.ca







AIXTRON CCS 3 × 2" MOCVD + **ONWAY 2D Station** + MBE-K Mini MBE

FORGE-QM (CFI 2027 bid) for MBEs + ARPES + OptiCool (THz, MultiD Spectroscopy)

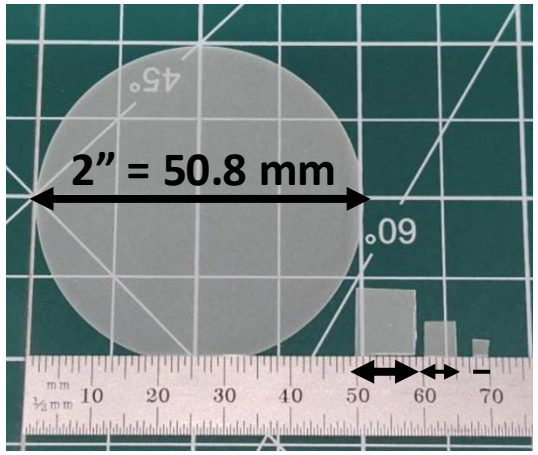
Graphene

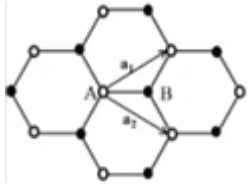
Substrate: 2" MSE Sapphire

T_{ANNEAL} (°C): 1400, 10 minutes

T_{GROWTH} (°C): 1400, 130 seconds

CH_4 with H_2 carrier gas





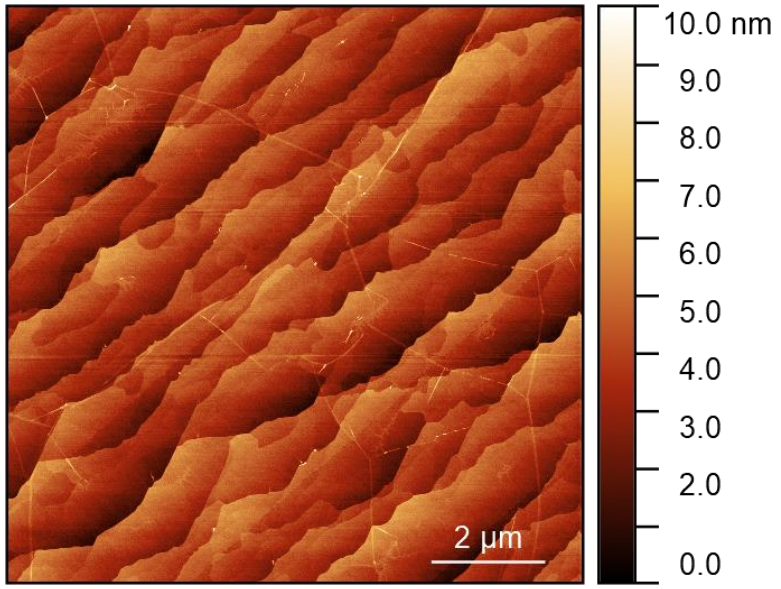
Graphene Crystal Structure

Crystal system: 2H

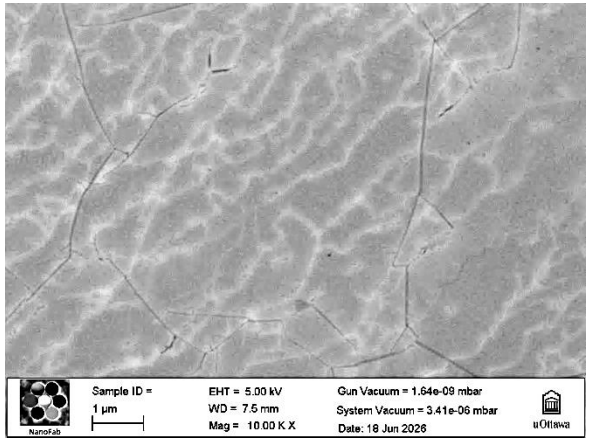
Space group: P6/mmm

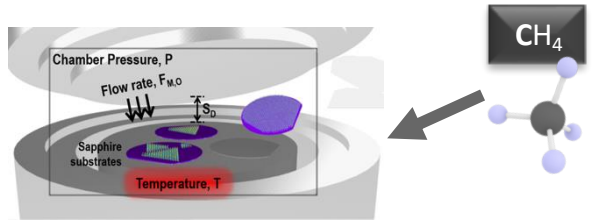
$a_1 = a_2 = 0.246$ nm

Atomic Force Microscopy (AFM)

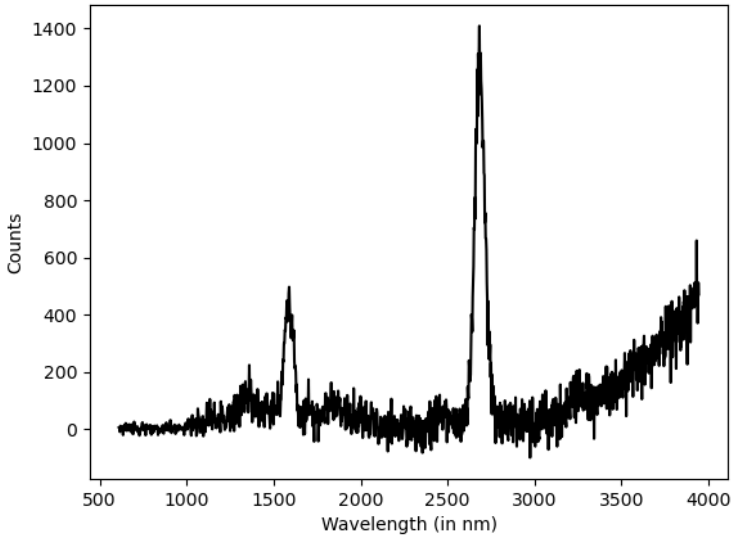


Scanning Electron Microscopy (SEM)





Raman Spectroscopy



Recipe: Mishra, N. *et al.* Wafer-Scale Synthesis of Graphene on Sapphire: Toward Fab-Compatible Graphene. *Small* **15**, 1904906 (2019).

WS_2

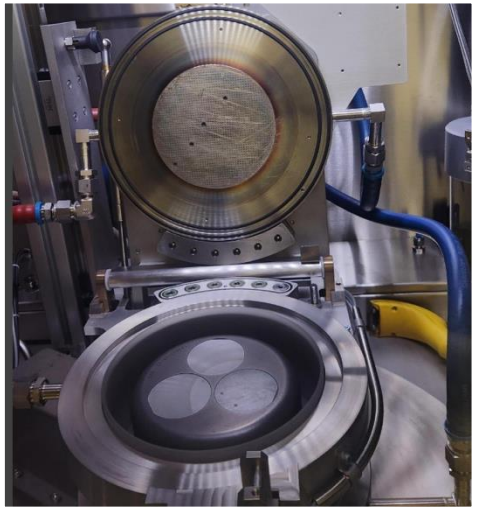
Substrate: 2" MSE Sapphire

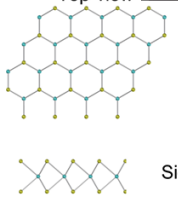
T_{ANNEAL} (°C): 1200, 10 minutes

$T_{NUCLEATION}$ (°C): 650, 15 minutes

$T_{LATERAL}$ (°C): 800, 144 minutes

$W(CO)_6$/DTBS with H_2 carrier gas





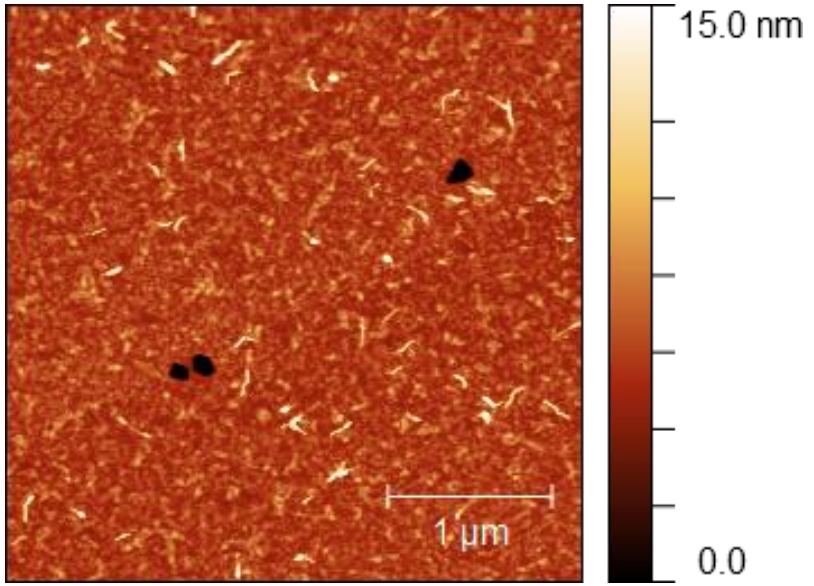
WS_2 Crystal Structure

Crystal system: 2H

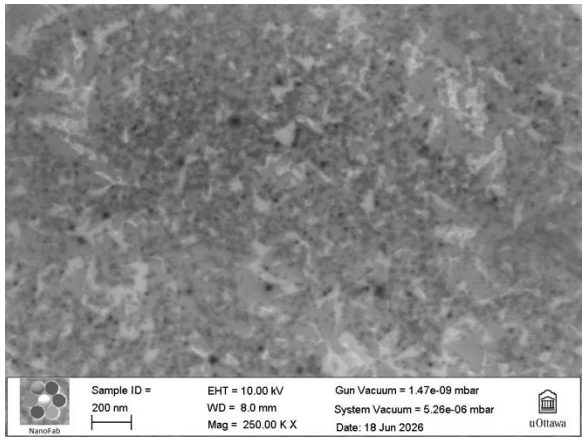
Space group: P6/mmm

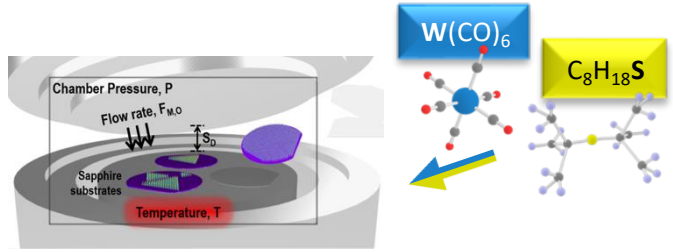
$a = b = 0.318$ nm

Atomic Force Microscopy (AFM)

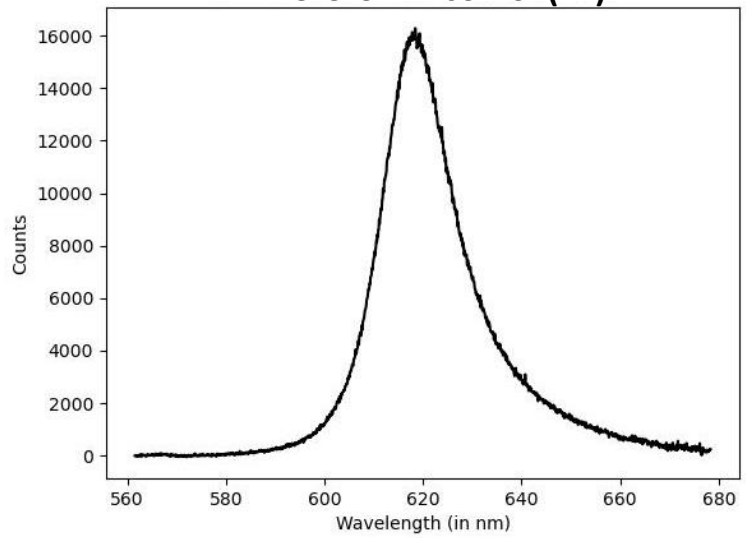


Scanning Electron Microscopy (SEM)



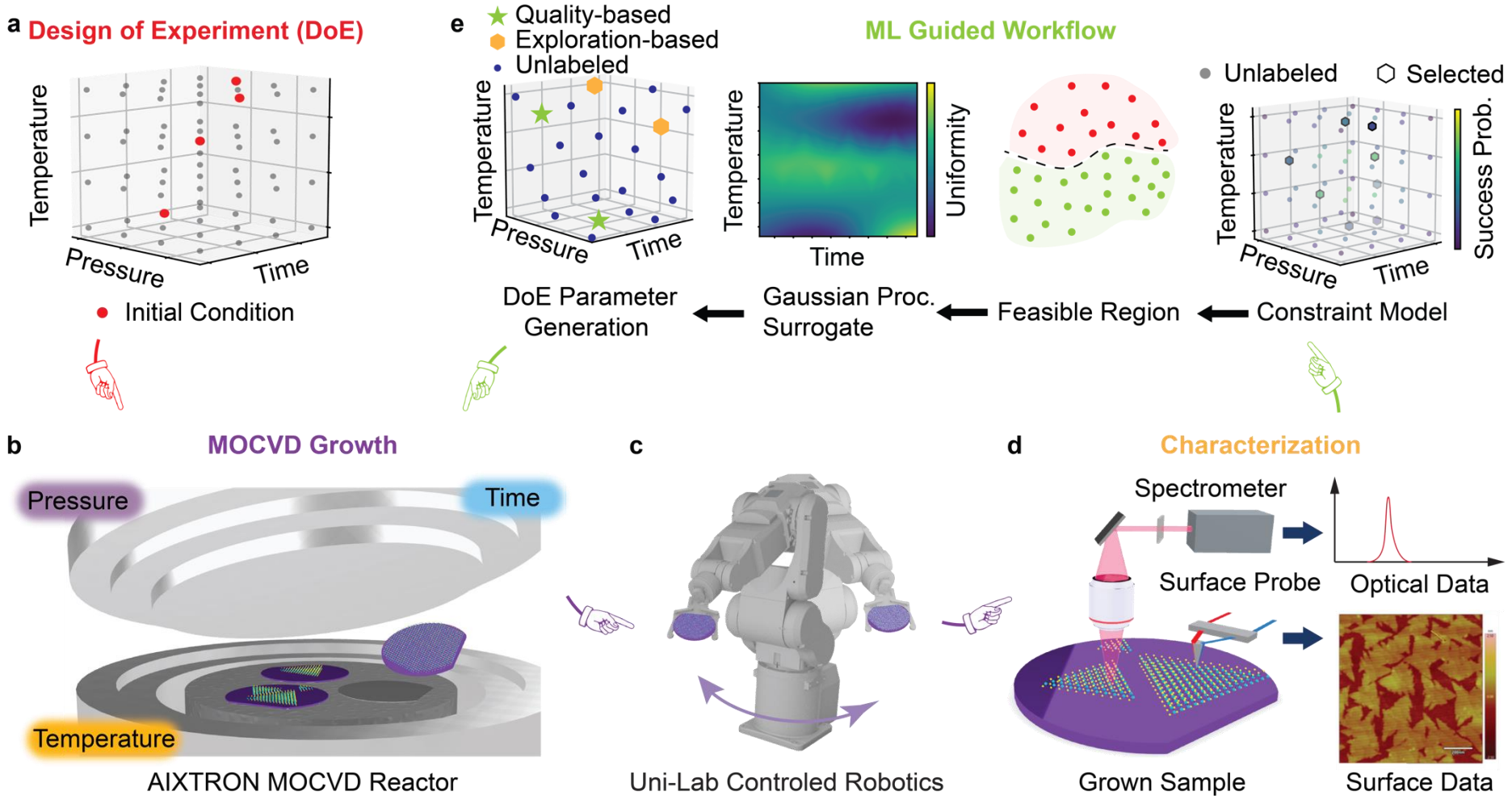


Photoluminescence (PL)



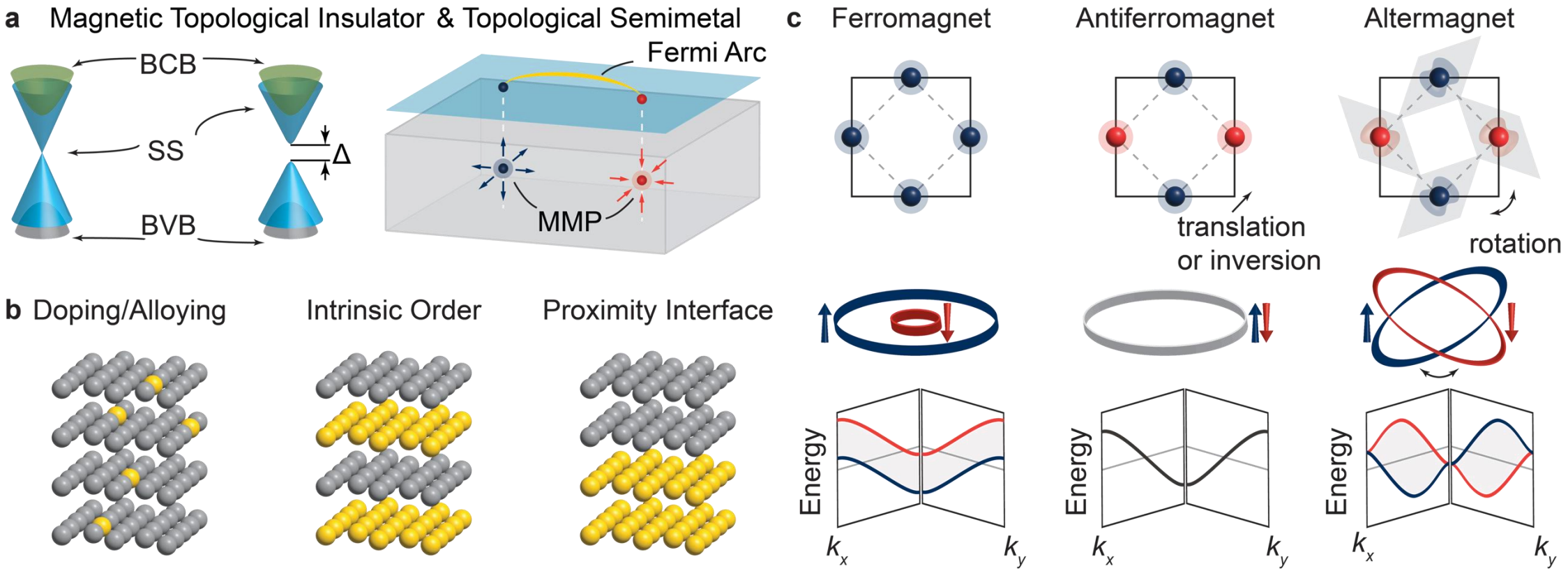
Recipe: Tang, S. *et al.* Migration-Enhanced Metal–Organic Chemical Vapor Deposition of Wafer-Scale Fully Coalesced WS_2 and WSe_2 Monolayers. *Crystal Growth & Design* **23**, 1547–1558 (2023).

Accelerated Quantum Materials Discovery



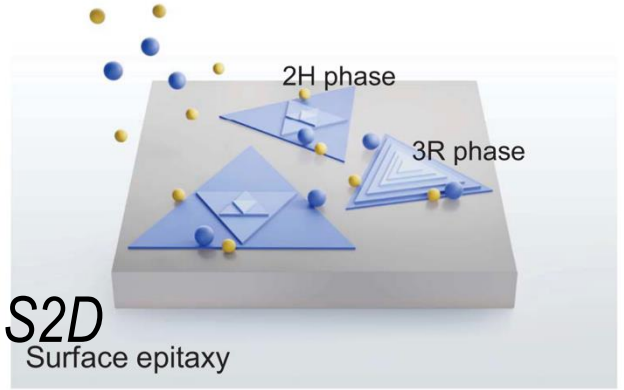
- Self-driving labs accelerating materials innovation and discovery – *AI for Materials*
- Novel semiconductor chip design using new 2D quantum matter – *Materials for AI*

2D Quantum Materials & Interfaces



Topical Reviews: *J. Phys.: Condens. Matter* **38**, 333003 (2026). *Newton* **2**, 100436 (2026).
Nat. Commun. **17**, 5350 (2026). *Rep. Prog. Phys.* **88**, 060501 (2025). *Nat. Commun.* **14**, 3222 (2023). *Phys. Rev. Lett.* **131**, 027001 (2023).

PQS2D Plan?



10.1126/science.ado6038

- **Films/Heterostructures:** graphene, BN, $(Mo,W)(S,Se)_2$

  Anisotropic thermal transport and surface acoustic wave | *moiré PQS2D*

- **Metallization:** low contact resistance with semimetal Bi/Sb
- **<u>Rhombohedral</u>:** TMDC (*Science* '24), rBN (*Nature* '24), graphene (*Nature* '24)
- SOC (**Te**), magnetic (**Cr**), *superconducting* (Nb) <u>sensing + communication + computing</u>

					year 1				year 2				year 3				year 4				year 5			
Thrust	Objectives		Milestone/deliverable	Progress indicator	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
T3. Large-area high-purity 2D materials synthesis and device integration	3A. Large-area high-purity 2D materials synthesis		Demonstrate wafer scale TMD growth	Single crystal domain size																				
			Demonstrate control over defects	Number of defects per square																				
			Demonstrate heterostructure growth	Single crystal domain size																				
	3B. Wafer-scale integration of 2D materials into electrical devices	3B.1: Develop innovative techniques for	Demonstrate uniform transfer of TMD on SiO2/Si wafer	Surface roughness																				
				Process yield																				
		3B.2: Improve and scale up device fabrication techniques	Demonstrate electrical contacts with low contact resistance	Contact resistance																				
			Demonstrate patterning into quantum dots	Yield of QD structures																				
			Demonstrate transferred heterostructures	Surface roughness																				