

van der Waals Epitaxy of One-dimensional II-VI Nanostructures

Alex Owen

on behalf of Ezekiel Ogle

Advisor: Haitao Zhang



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING



Outline

- Introduction
- Experimental Setup and Procedures
- Results and Discussions
- Summary and Future Work
- Acknowledgements



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING



Introduction

— Objectives

- Achieve high quality and uniform growth
- Employ CVD for heterogeneous growth
- Compare:
 - van der Waals epitaxy
 - Conventional epitaxy



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING



Introduction

— What are II-VI Materials?

II-VI Semiconductors:

Periodic Table of the Elements

IA																																0																	
1																																	2																
H																																	He																
3		IIA																4																		5		6		7		8		9		10			
Li																		Be																		B		C		N		O		F		Ne			
11																		11																		13		14		15		16		17		18			
Na																		Mg																		Al		Si		P		S		Cl		Ar			
		IIIB		IVB		VB		VIB		VIIB		VII		IB		IIB																																	
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54														
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe														
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	104	105	106	107	108	109	110	111	112	113																			
Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	Fr	Ra	+Ac	Rf	Ha	Sg	Ns	Hs	Mt	110	111	112	113																			



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING



— Applications of II-VI Nanostructures

II-VI Nanostructures applications

- Photovoltaic conversion
- Light emission
- Photo detection
- High-energy radiation detection



UNC CHARLOTTE

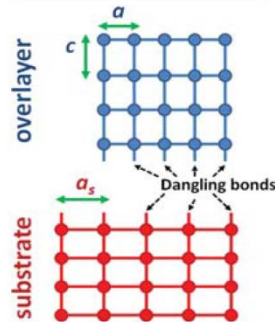
The WILLIAM STATES LEE COLLEGE of ENGINEERING



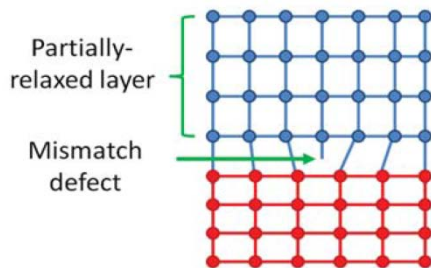
— Epitaxial Growth: van der Waals vs. Conventional

Conventional Epitaxy

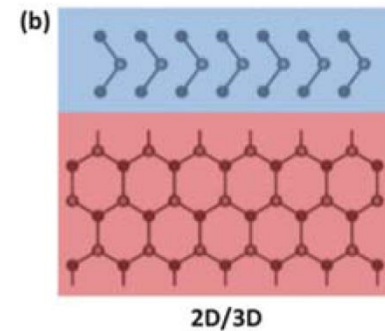
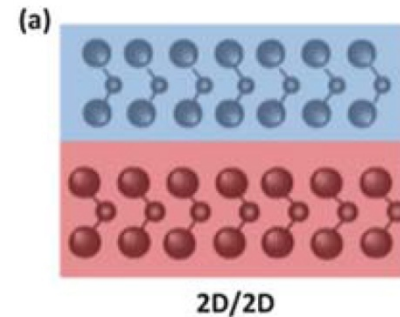
(a) Freestanding form



(c) Mismatch Defect in heteroepitaxy



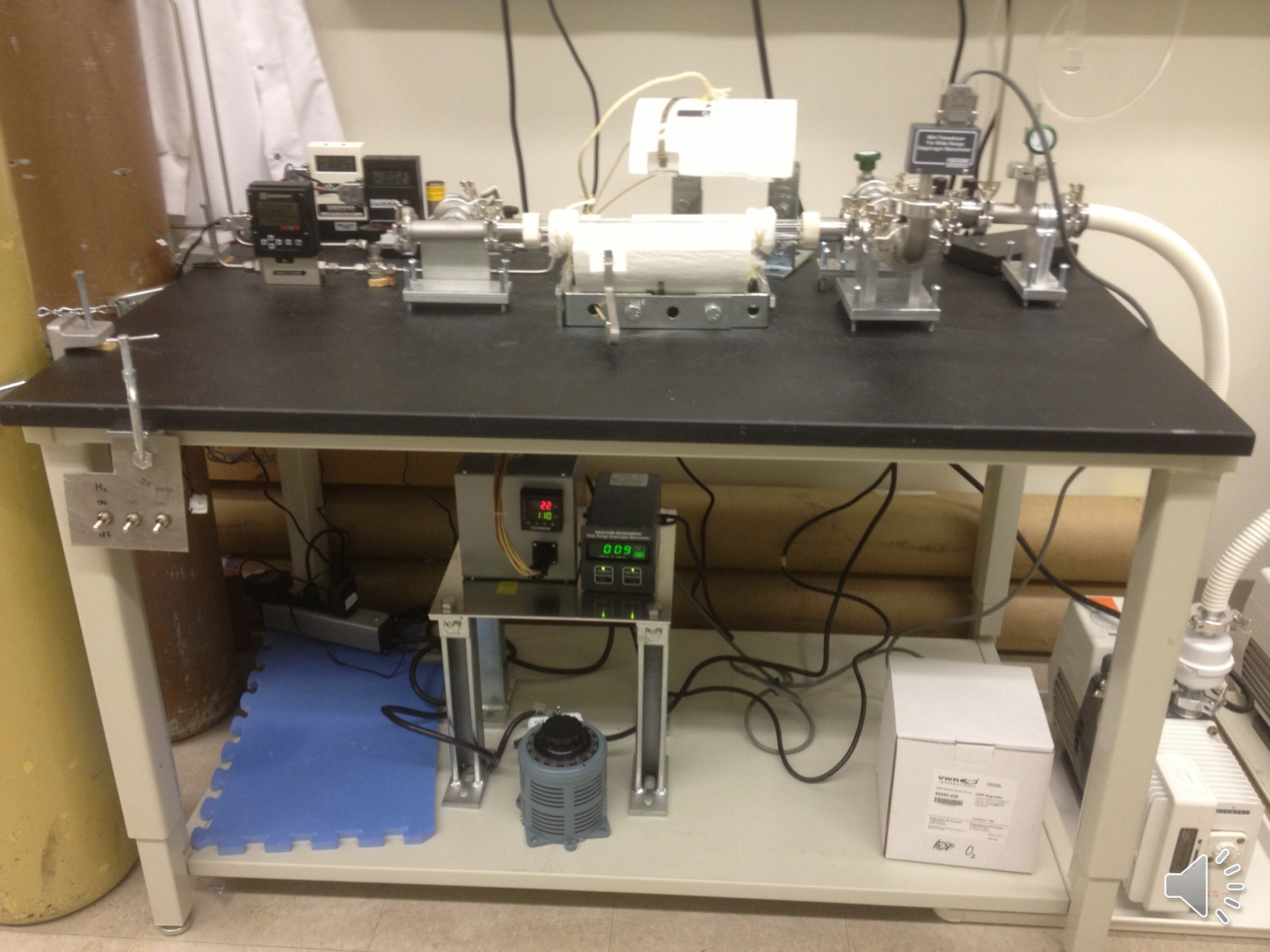
van der Waals Epitaxy

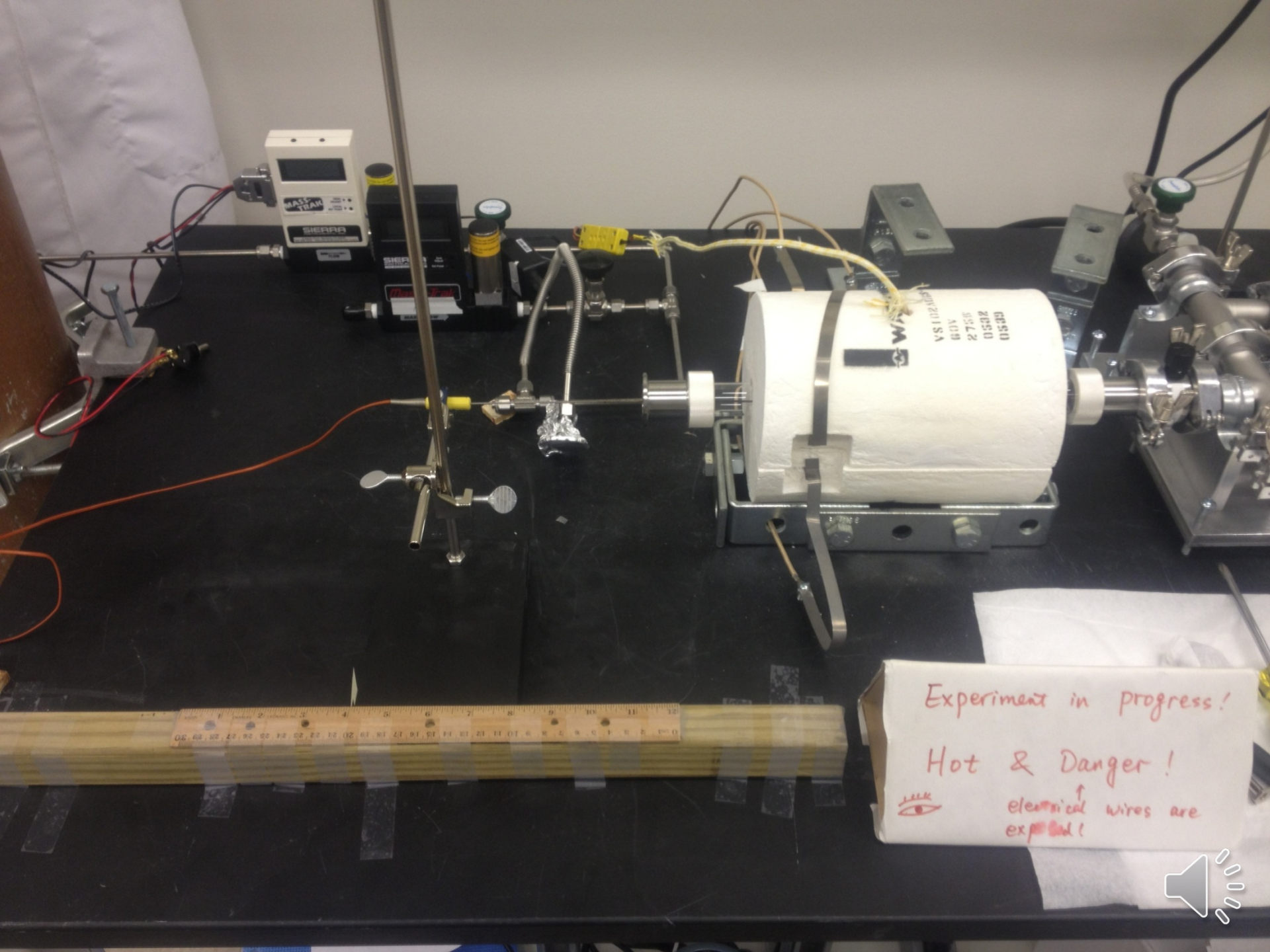


UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING







Experiment in progress!

Hot & Danger!

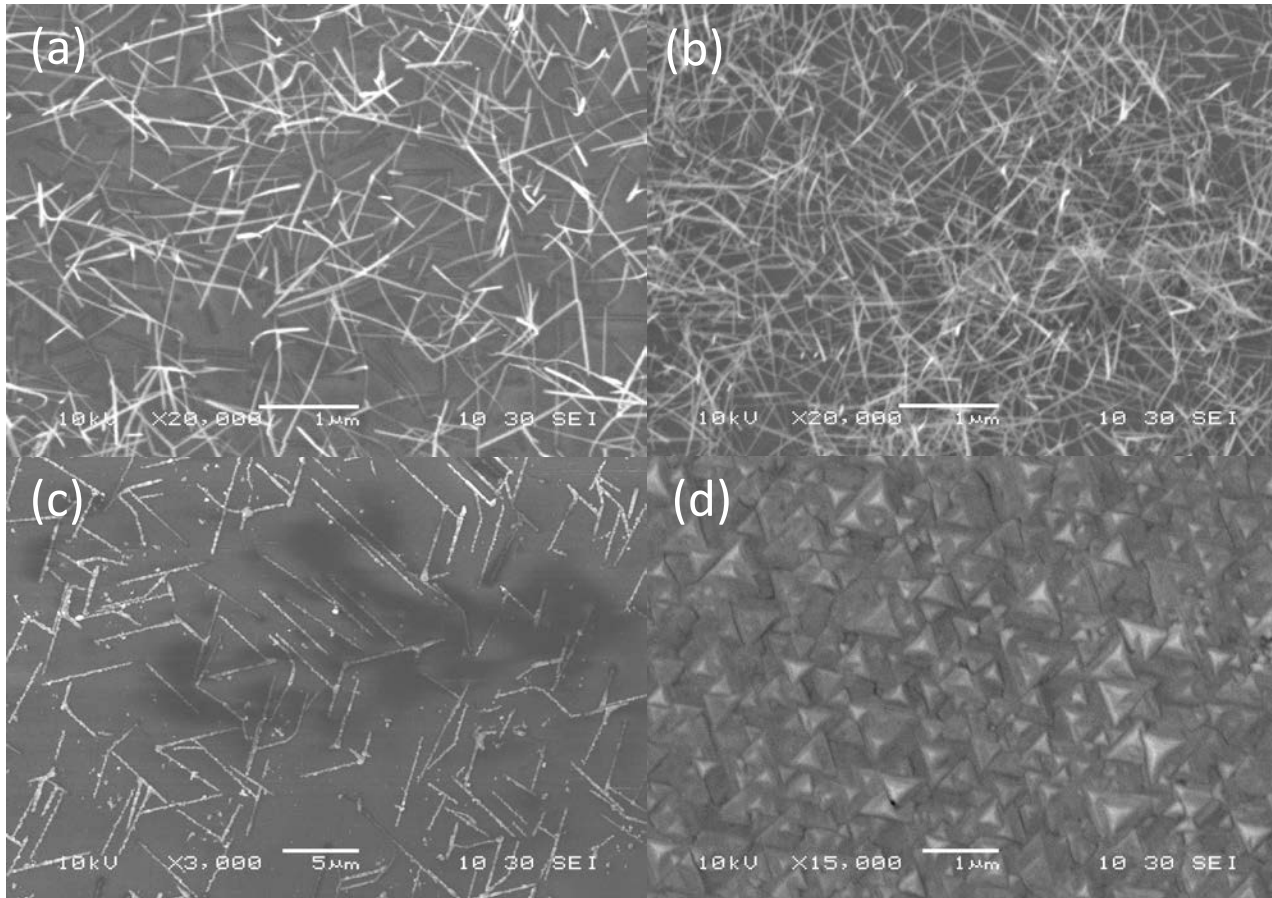


↑
electrical wires are
exposed!



Results and Discussion

— ZnTe on Mica



Pressure

~50 Torr

Temperature

800 °C

Time

30 min

H₂

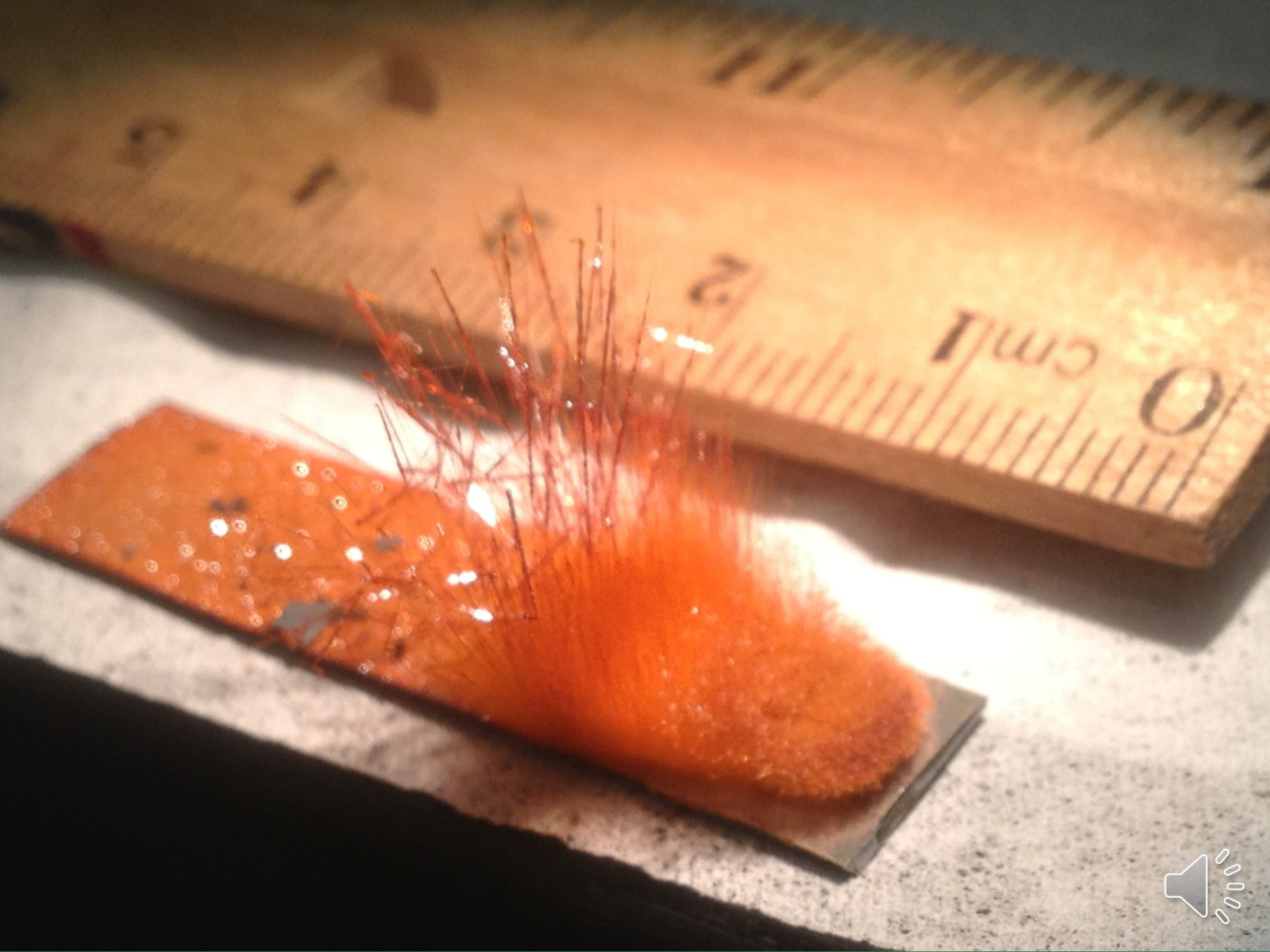
1.5 sccm



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING





-ZnTe Flag on 10 nm Au/Si



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING



Summary

- ZnTe on mica
 - Tiny nanowires upstream of the source.
 - Downstream, the growth turned directly to a thick film
 - Film showing epitaxial growth
- ZnTe on Si with Au catalysts
 - Ultra-long micro-wires up to 20mm at high temperature zone: ~680 - 630
 - Ultra-long nanowires up to 10mm at medium temperature zone : ~630 - 575
 - Dandelion-like nanowires at low temperature zone : ~575 - 480
 - Flag structures waving under SEM



Future Work

- Modify temperature profile
- Study crystal structure and epitaxial growth relation
- Investigate the evolution of nanowires
- Improve crystal quality and uniformity
- Core-shell II-VI nanostructure



Acknowledgements

- Financial support from NSF Ceramics program DMR-1006547 and UNC Charlotte Faculty Research Grant FRG 1-11769
- Group members: Alex Owen, Tao Sheng
- Xu group: Youfei Jiang
- Advisor: Haitao Zhang
- Department of M.E. : Tracy Beauregard



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING

