

GaN Crystal Growth & TEM Sample Preparation

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Lab Group Funding:
DARPA & ONR

Special Thanks to: Ben Haskell & Patrick Waltereit

Project Focus

- First 3 weeks:
 - TEM Manual Sample Preparation
- Last 3 weeks:
 - Automated Sample Preparation (FIB) &
 - GaN Crystal Growth

Gallium Nitride

- Blue Light Emitting Diodes (LEDs)
& Lasers
 - Wide Band Gap (3.4 eV)
- Transistors
 - Electrical Properties
 - Stability



3 Methods to Grow GaN

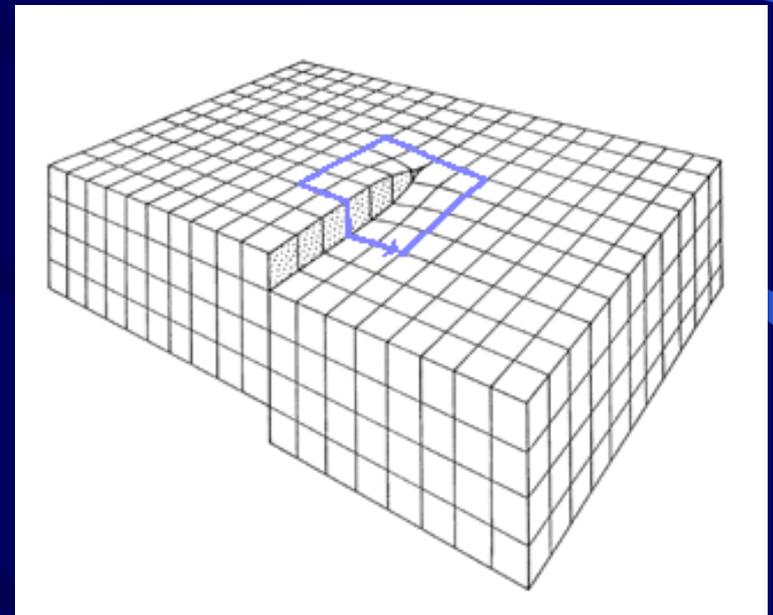
- HVPE
 - Hydride Vapor Phase Epitaxy
- MOCVD
 - Metal Organic Chemical Vapor Deposition
- MBE
 - Molecular Beam Epitaxy

Comparison of GaN Crystal Growth Methods

	HVPE	MOCVD	MBE
Temp	highest 1050 °C	medium 1000 °C	lowest 700 °C
Growth Rate	highest	medium	lowest
Film Quality	lowest	highest	

Crystal Defect Structures

- Caused by slight incompatibility between GaN & Substrate
 - Lattice Structure
 - Thermal Properties
 - Other
- Examples:
 - Point Defect 0-D
 - Dislocation 1-D
 - Stacking Fault 2-D

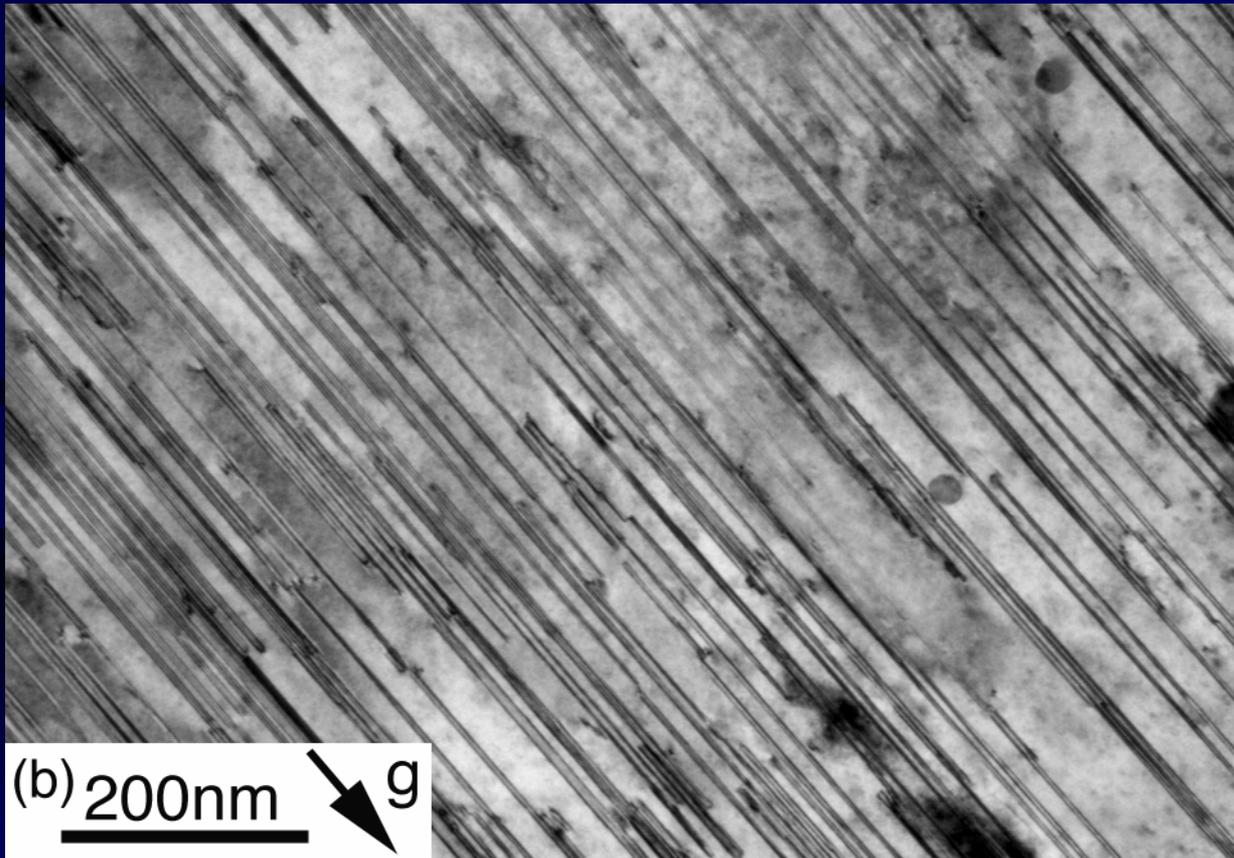


Structural Characterization Tools

- X-Ray Diffraction
- Atomic Force
Microscope (AFM)
- Optical Microscope
- Scanning Electron
Microscope (SEM)
- **Transmission
Electron
Microscope
(TEM)**

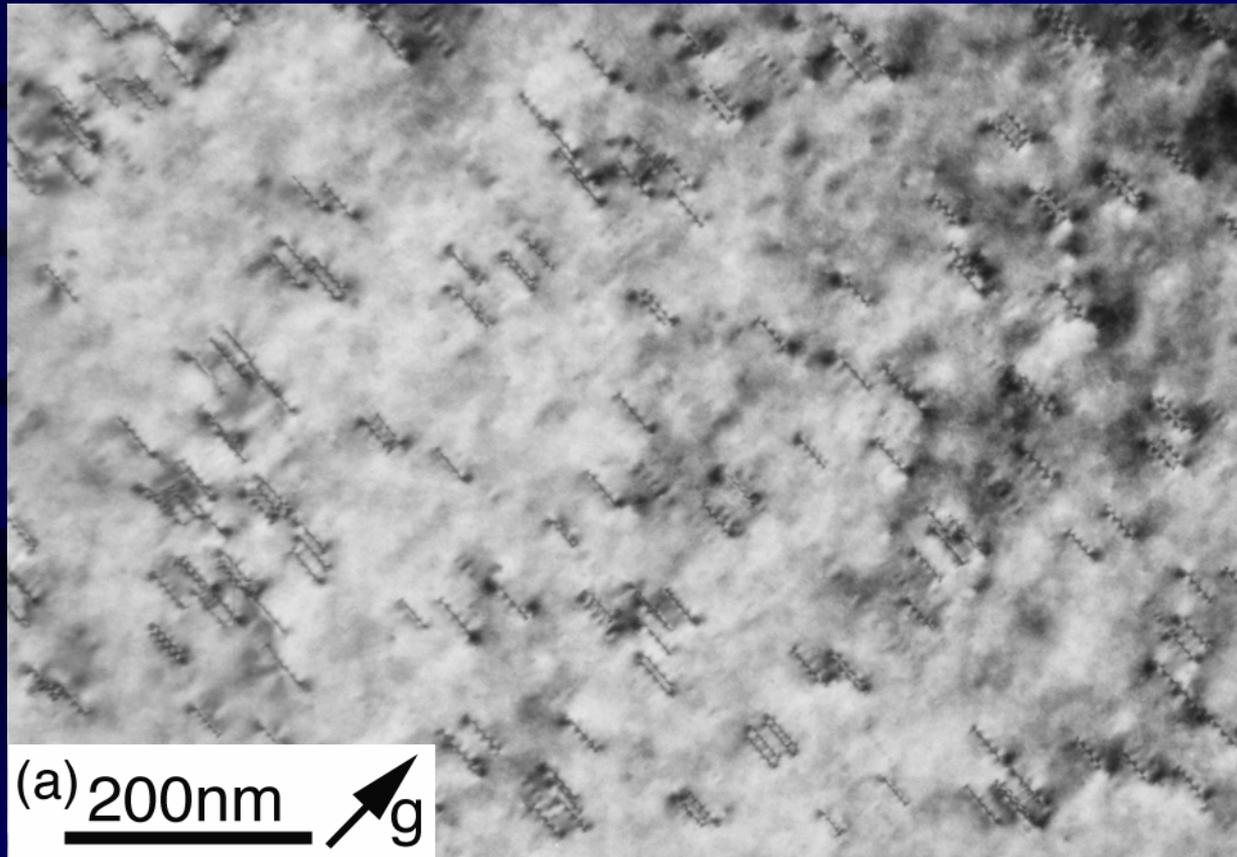


TEM Image Stacking Fault



Plan View

TEM image Dislocation



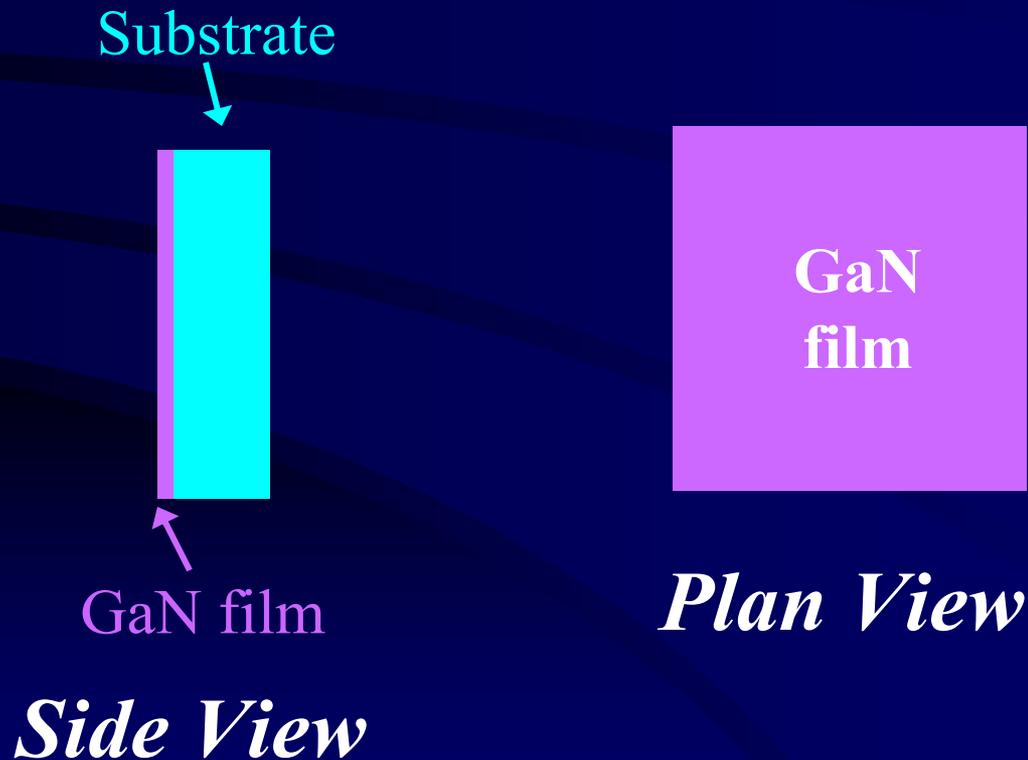
Plan View

TEM Sample Preparation

- Manual Polishing
 - 1 day – 2 weeks
- Automated Polishing
 - 2-4 hours
 - Focused Ion Beam (FIB)

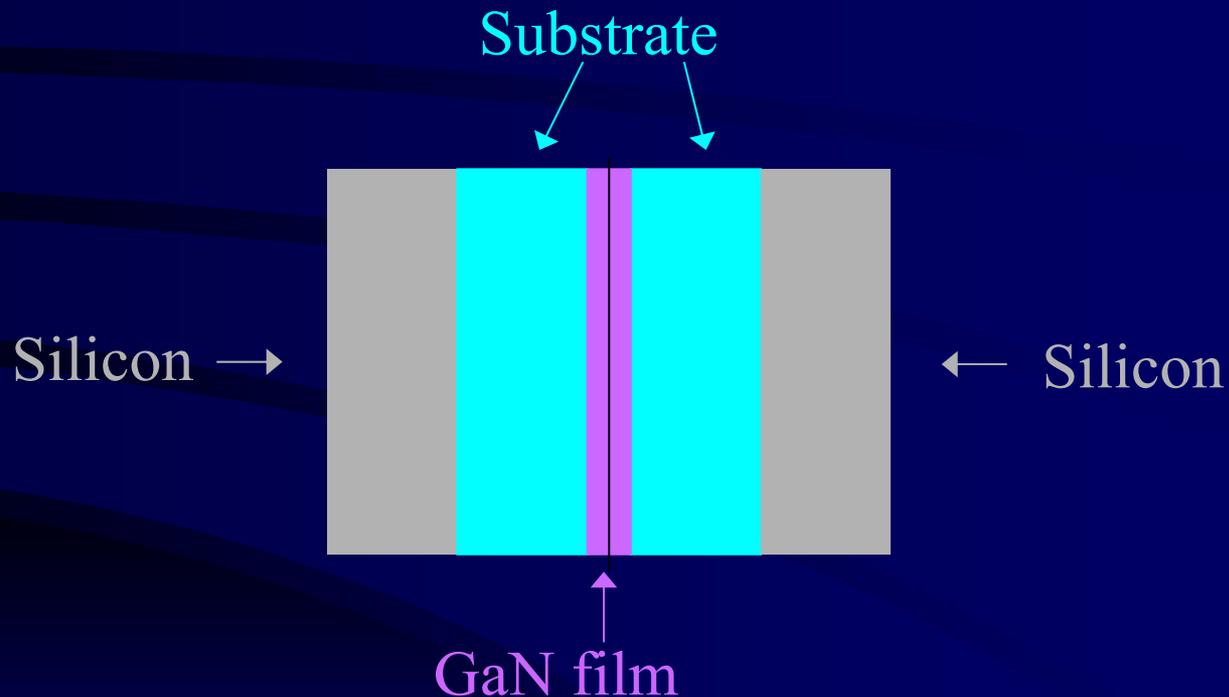
TEM Sample

- Thin film (GaN)
- Substrate (Sapphire or Silicon Carbide)



Manual Polishing

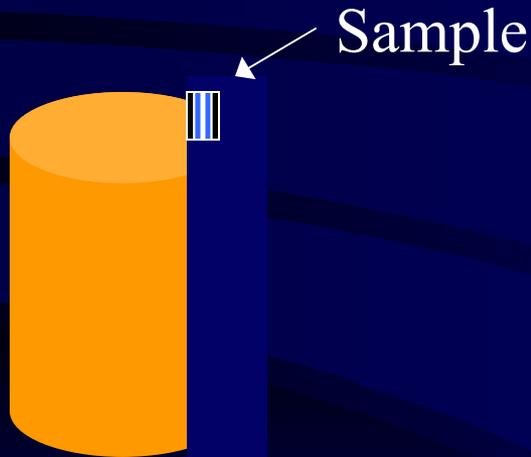
1. Cut & Glue the Sample



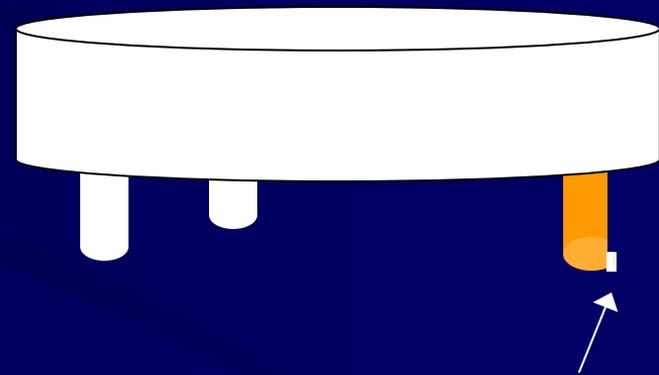
Side View

Manual Polishing

2. Attach sample to Pyrex holder
3. Insert Pyrex holder into Tripod



Pyrex Holder



Tripod

Manual Polishing

4. Polish 1st side of Sample on Diamond Lapping Film until smooth
5. Glue Sample onto Copper Grid
6. Polish 2nd side of Sample until 10 μm thick
7. Ion Milling until 100 nm thick

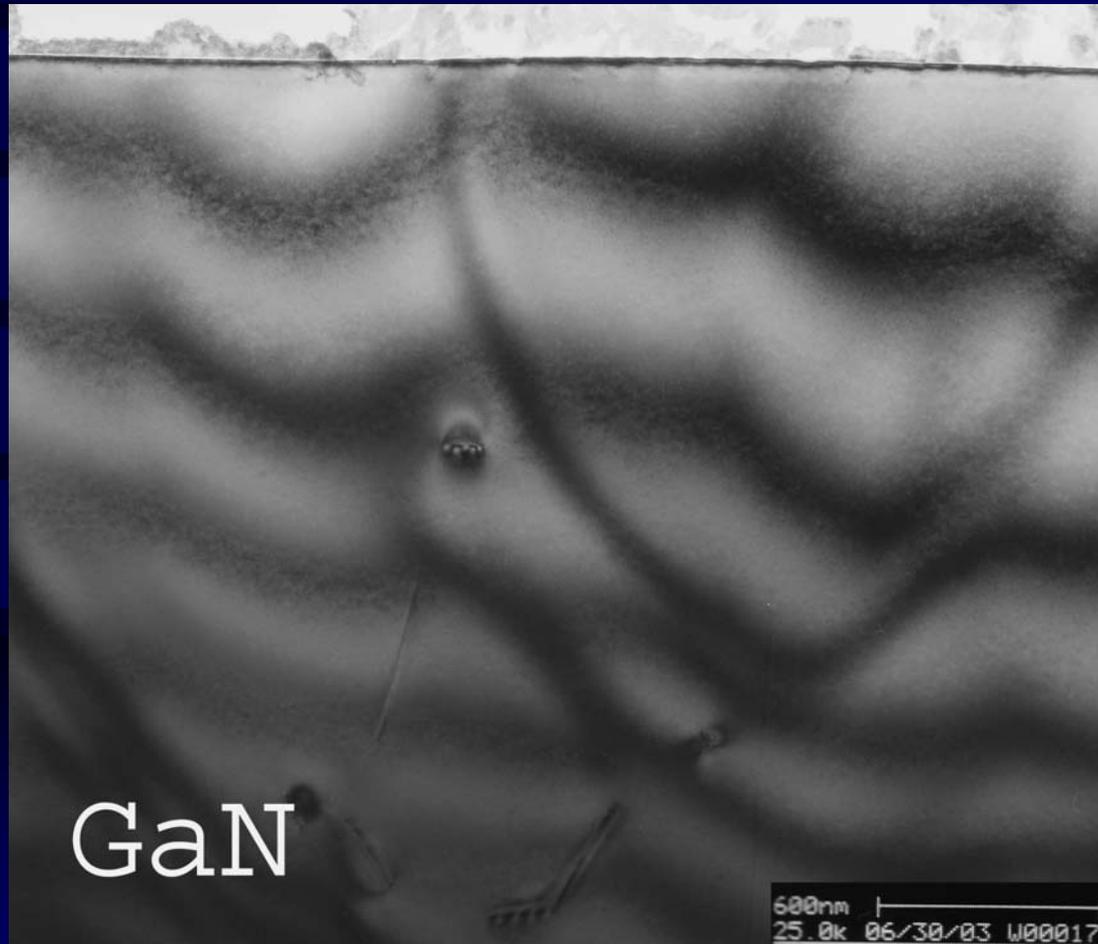


TEM image Dislocation



Plan View

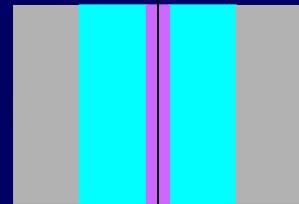
TEM image Defects?



GaN

600nm
25.0k 06/30/03 W00017

Cross Section



FIB

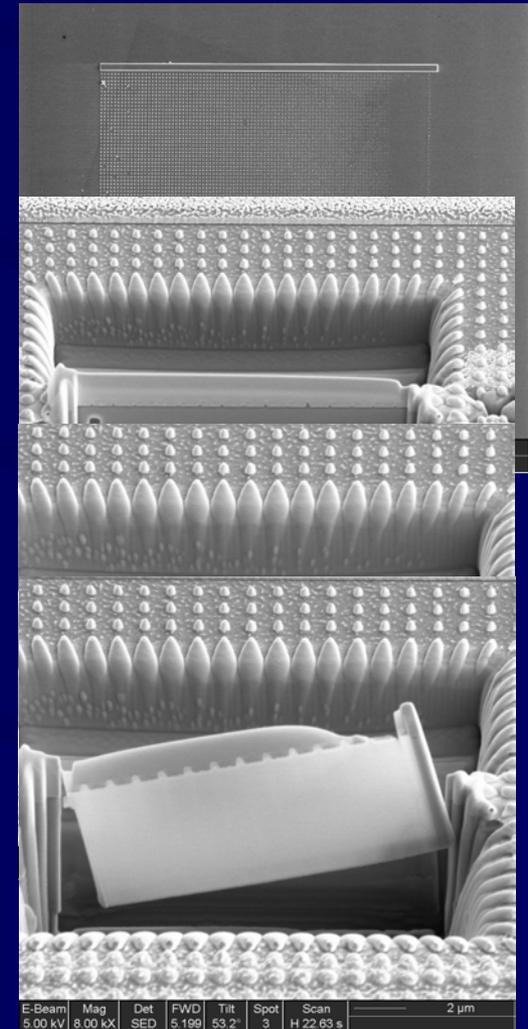
Focused Ion Beam

- No Sample Preparation
- 2 Beams
 - Electron
 - Ion

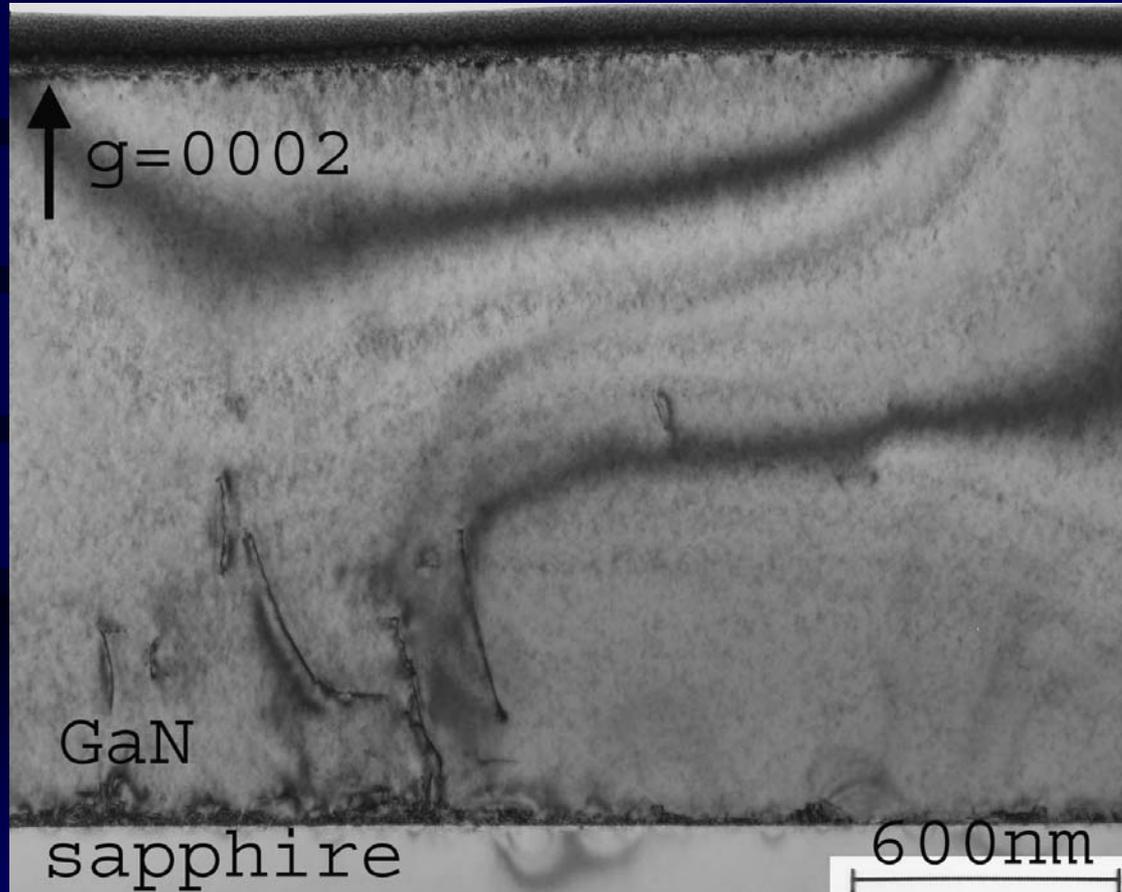


FIB Procedures

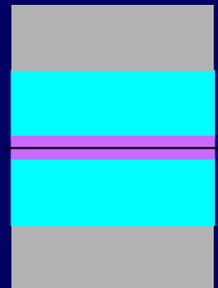
1. Locate Site of Interest
2. Mill a trench on either side
3. Thin the wall
4. Cut it out



TEM image Dislocation



Cross Section



Reflections...

- Research Lessons:
 - TEM Sample Preparation
 - Time-Consuming
 - Delicate
 - Easy to Make Mistakes
 - TEM images give most detailed info
 - Other forms of Microscopy used as a gage
- Classroom Applications:
 - Interviewing experts key
 - Learning about other components made it more interesting/meaningful