

Intersubband Transitions in Semiconductor Heterostructures

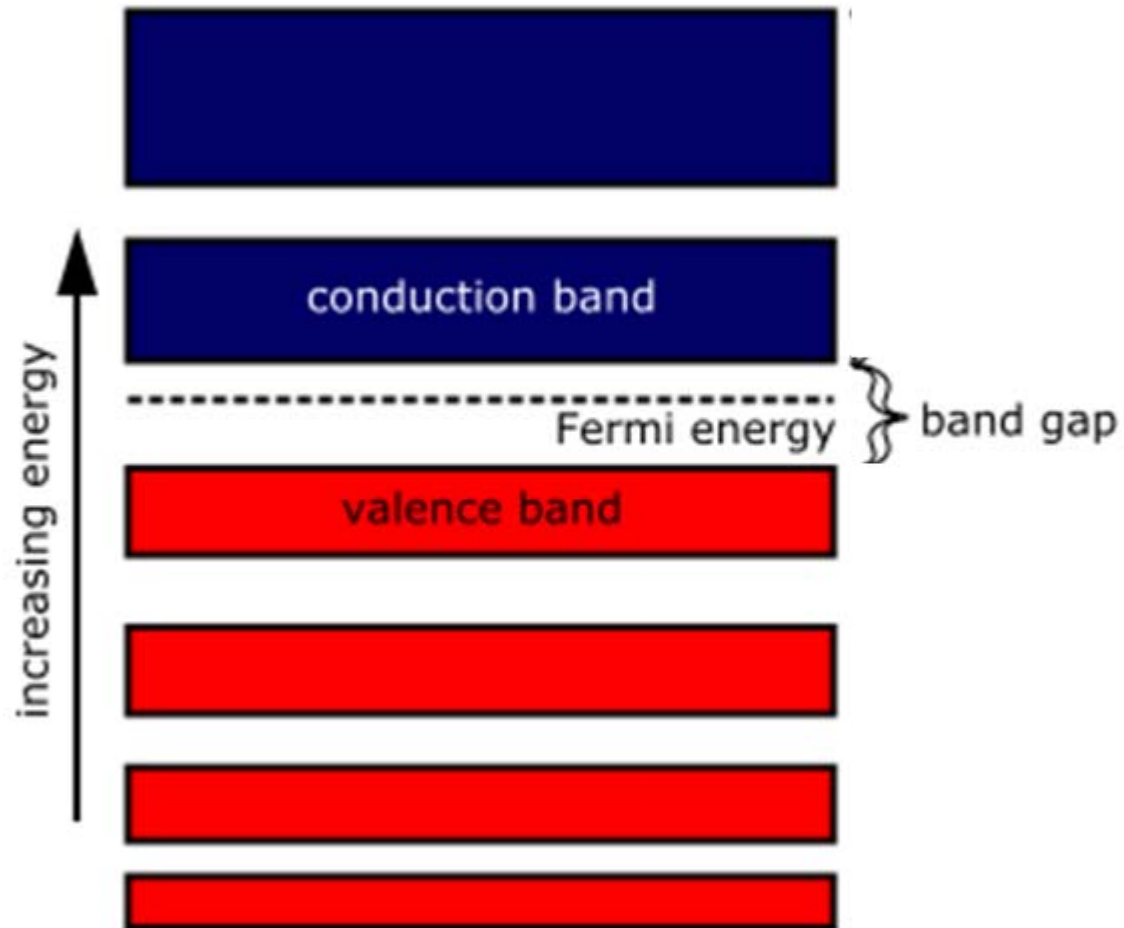
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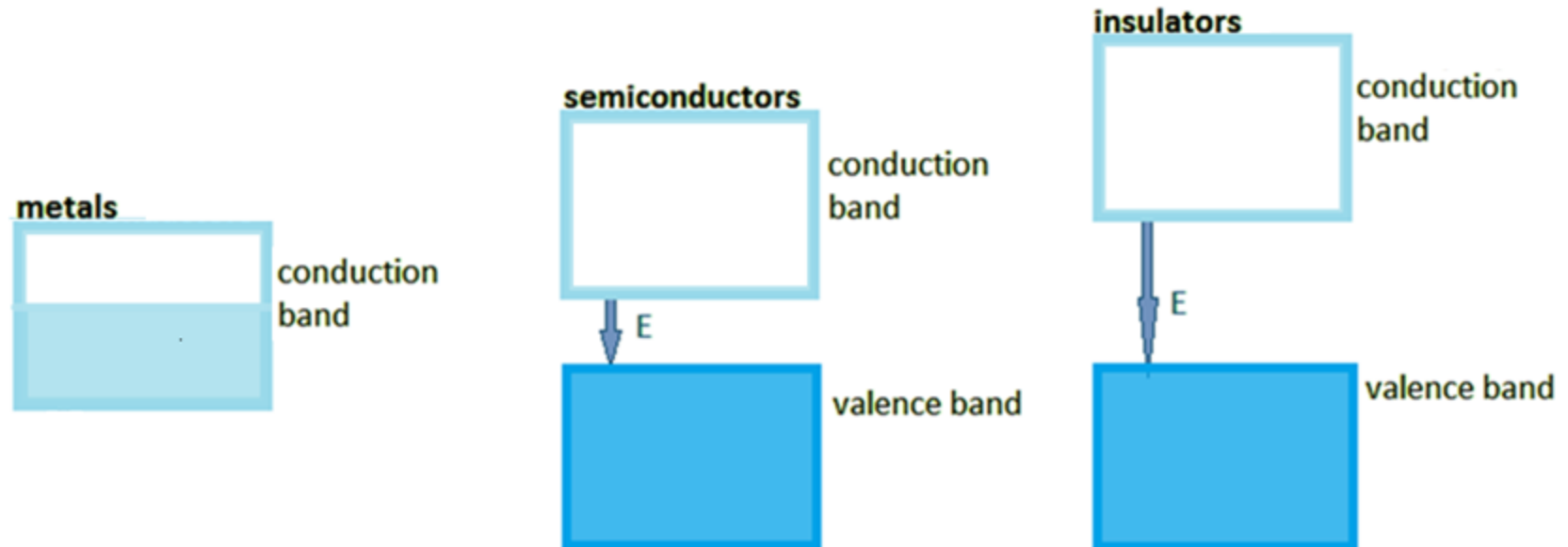
Introduction

Energy band structure



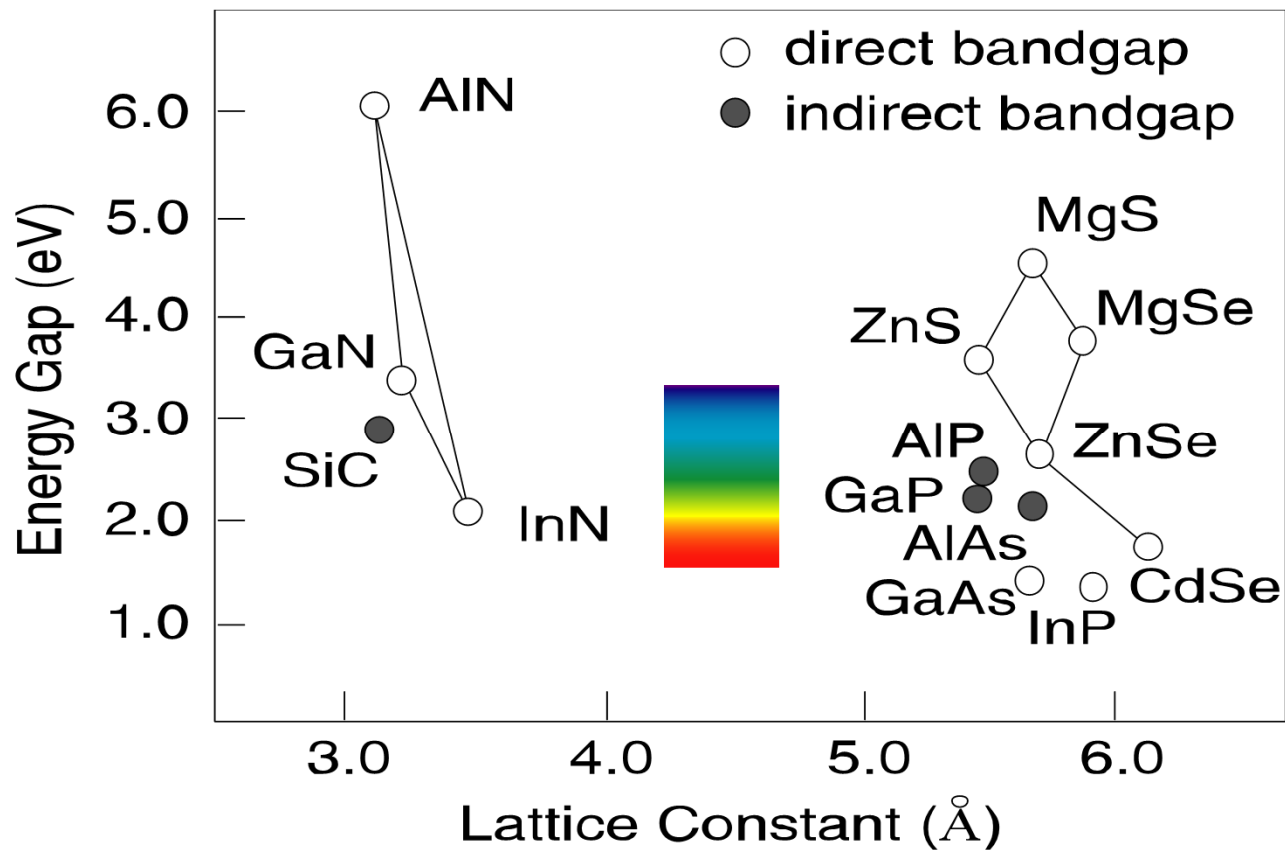
Classification of solids

Energy difference between conduction and valence bands determines classification of materials



Semiconductors

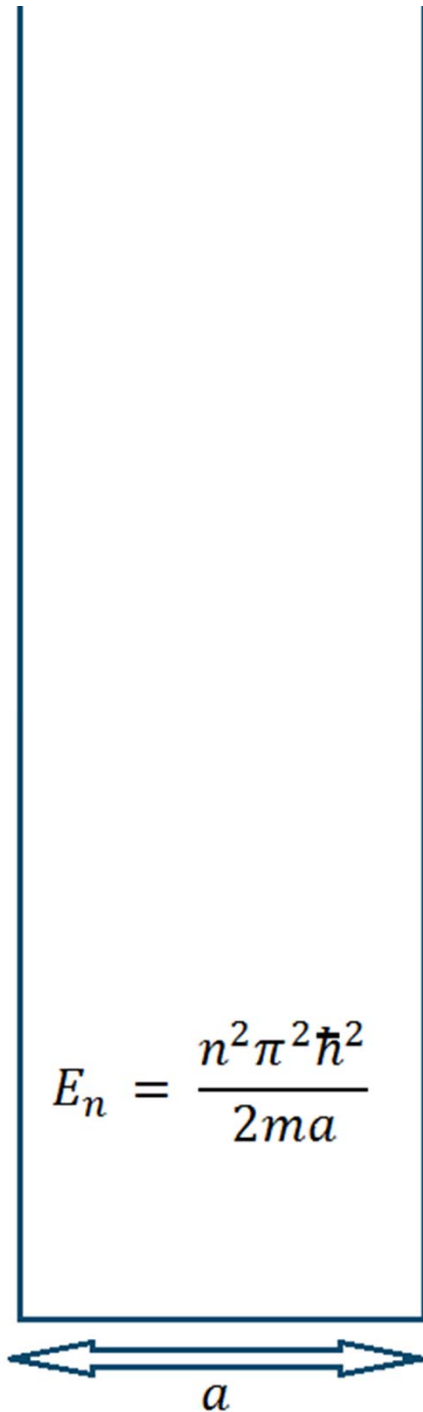
- Elemental vs. Compound semiconductors
 - Elemental — eg: Ge, Si
 - Compound — eg: GaAs, GaN
 - Addition of alloys— eg : $\text{Al}_x\text{Ga}_{1-x}\text{N}$



Quantum wells

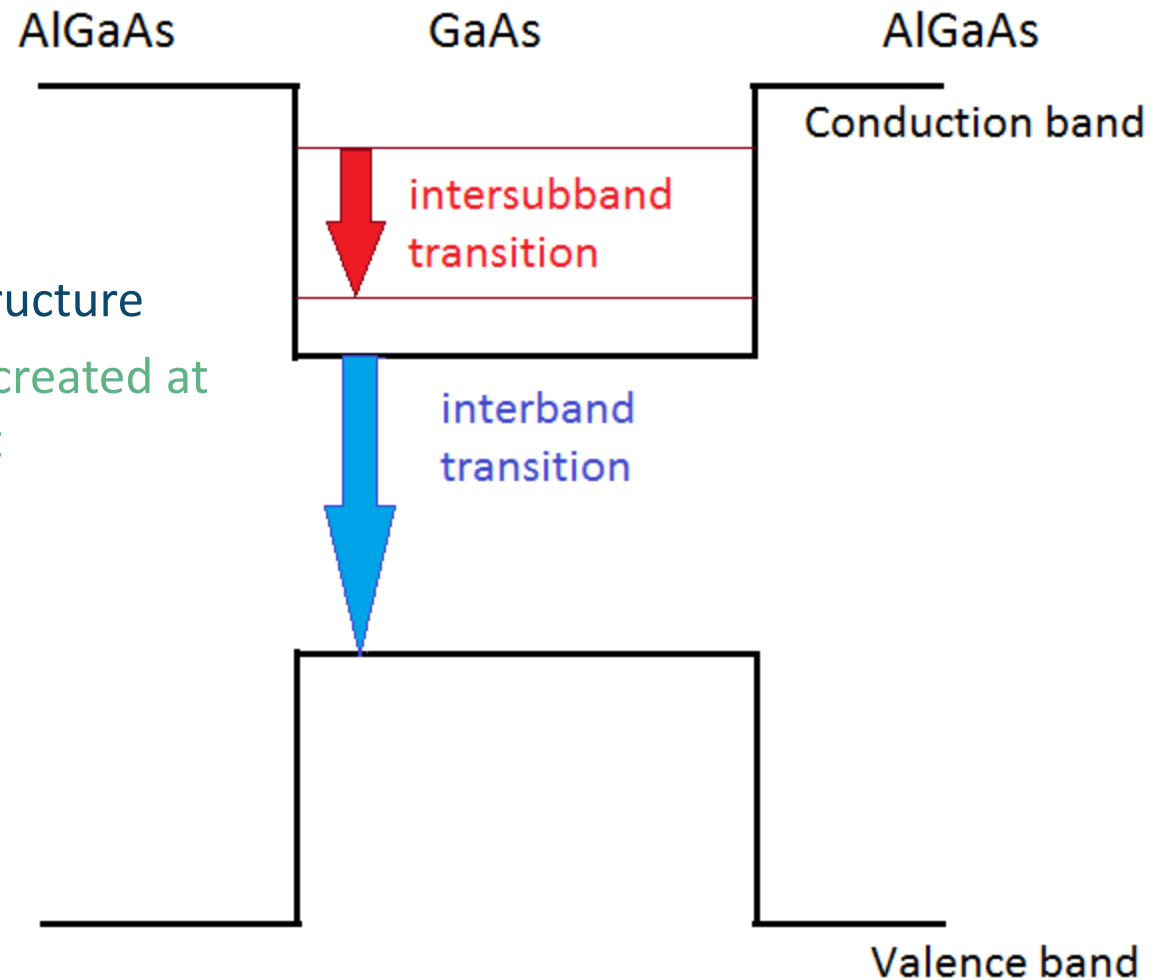
- Infinite well – discrete energy levels determined by width of quantum well
 - infinite number of bound states

- Finite well – energy levels dependent on width and depth of well
 - finite number of bound states

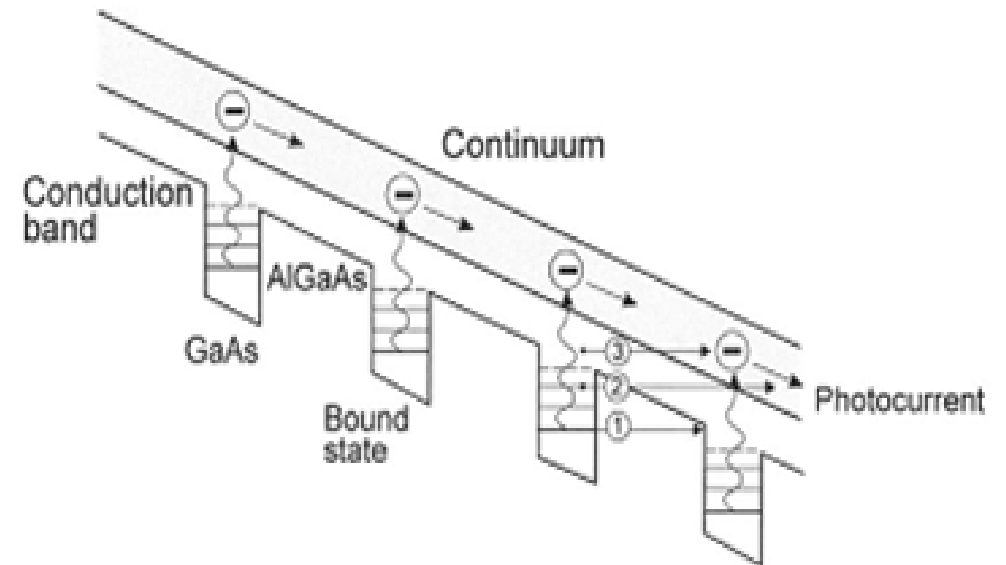
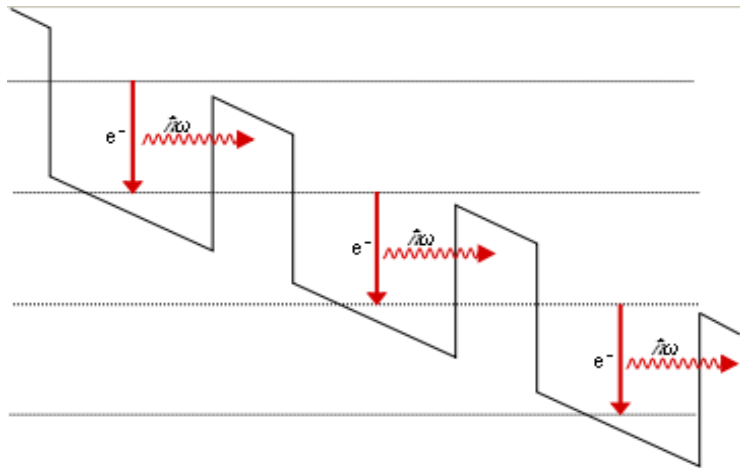


Intersubband transitions

- Heterojunction/Heterostructure
 - Finite quantum well created at interfaces of different semiconductors

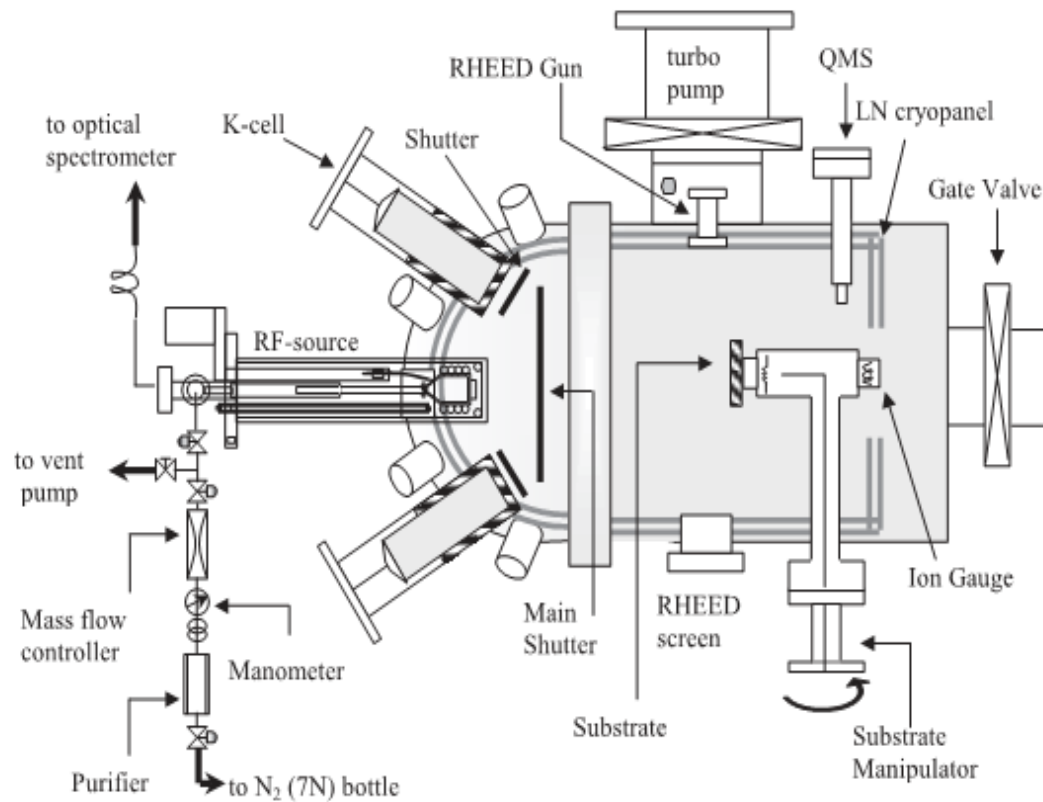


Overview of Devices : QCLs and QWIPs



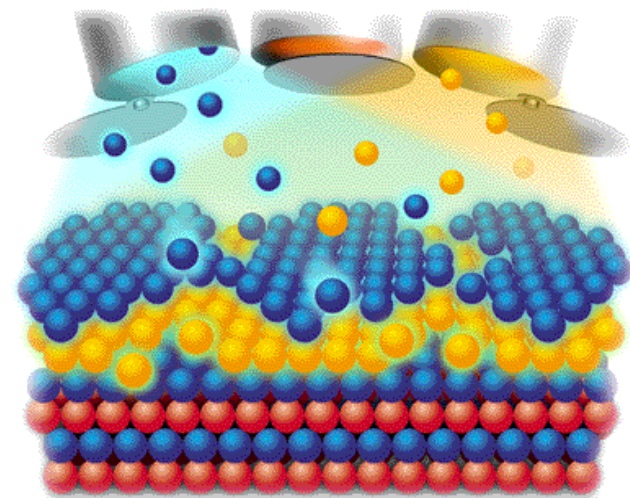
Creating devices

Growth : Molecular Beam Epitaxy

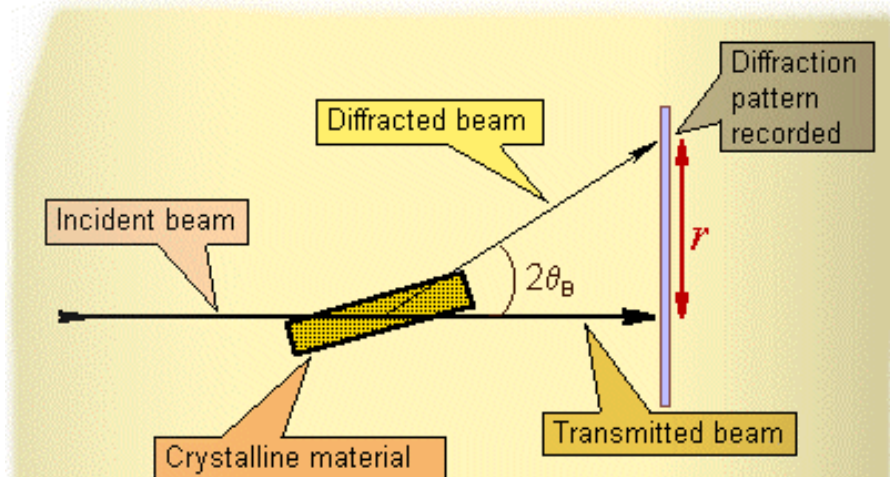
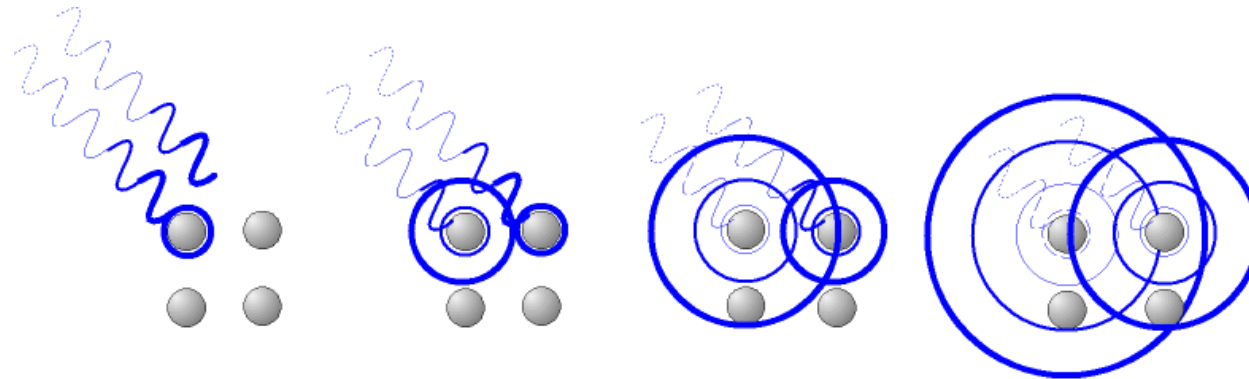


➤ Performed in ultra high vacuum

➤ Easy to control layer thickness because deposition rates are known



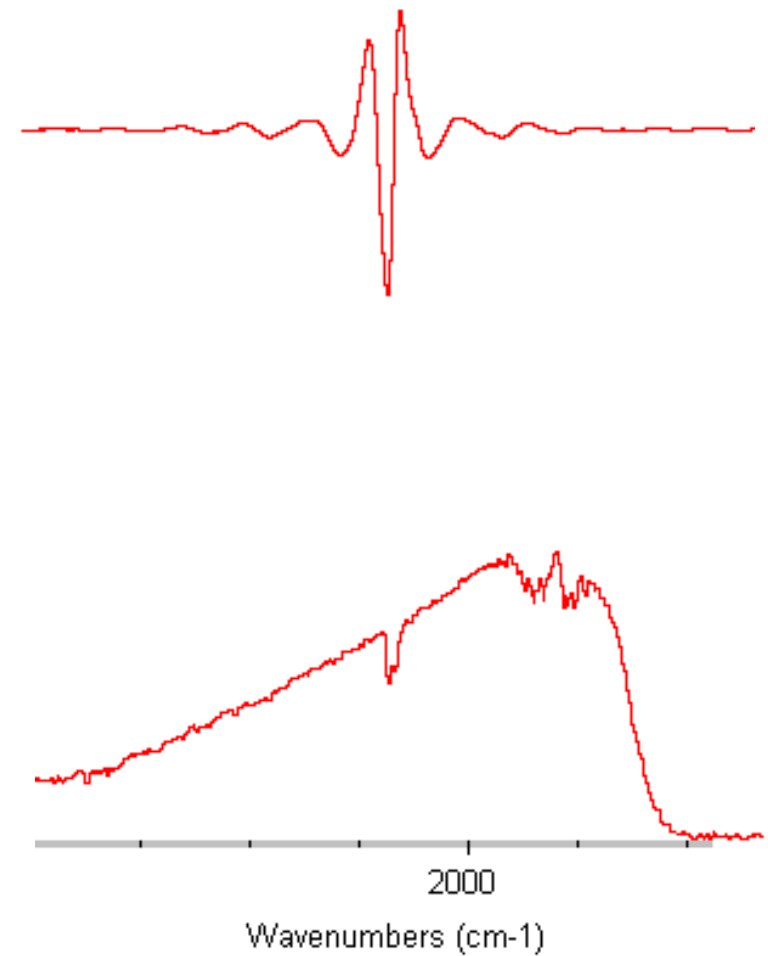
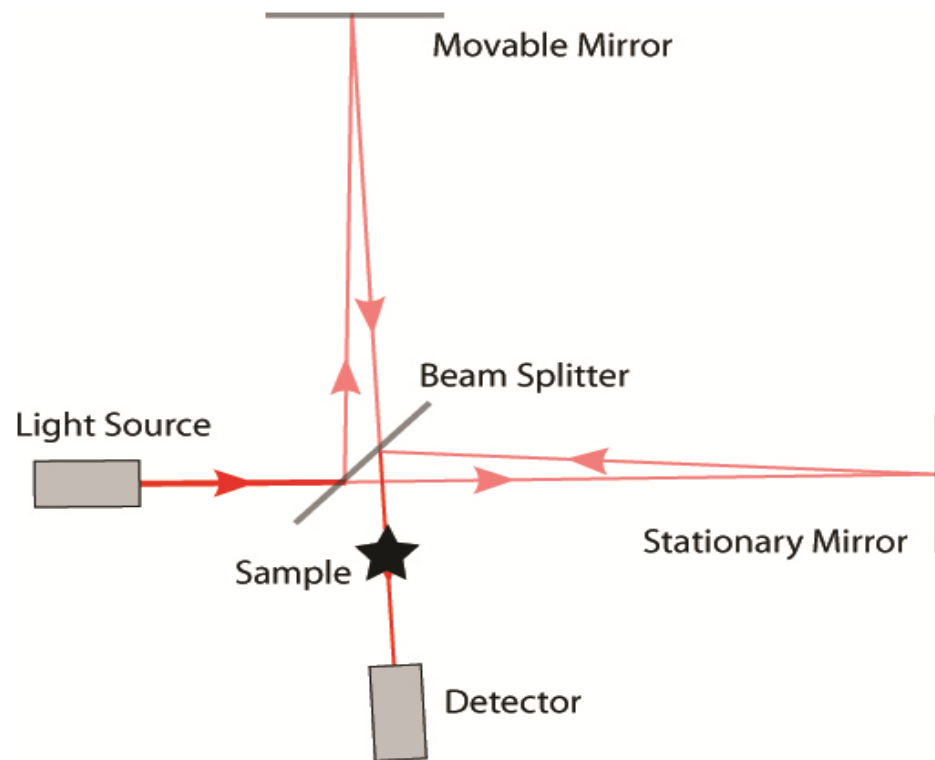
Characterization : X-Ray Diffraction



Bragg's Law

$$n \lambda = 2d \sin \theta$$

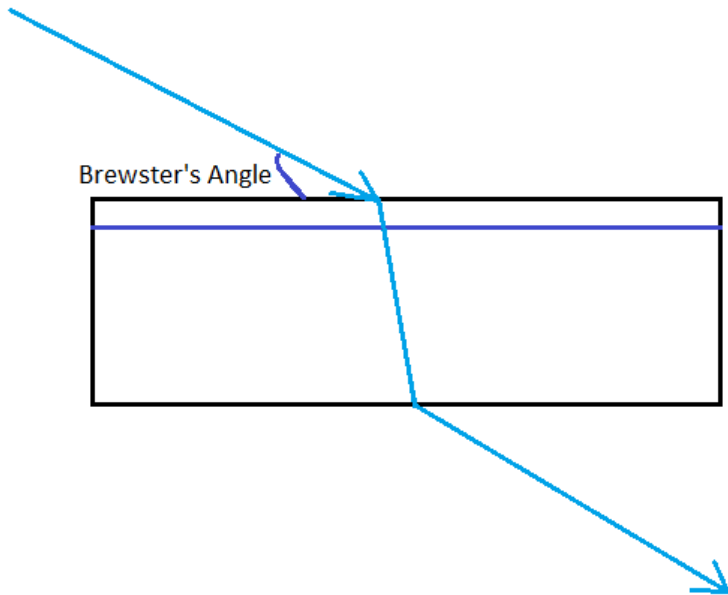
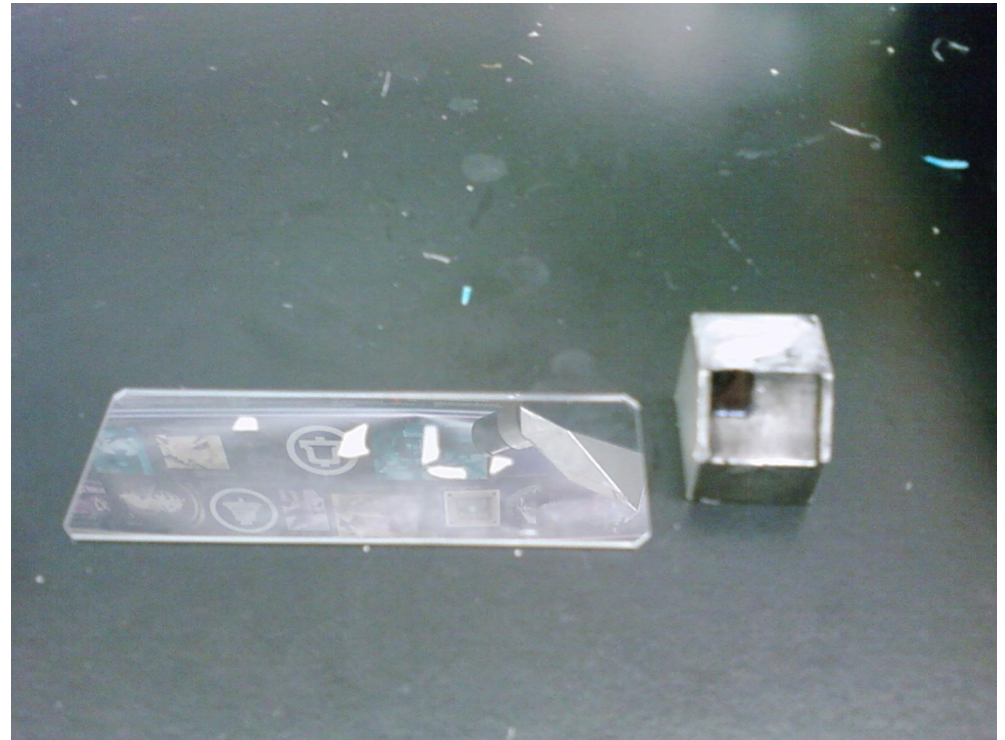
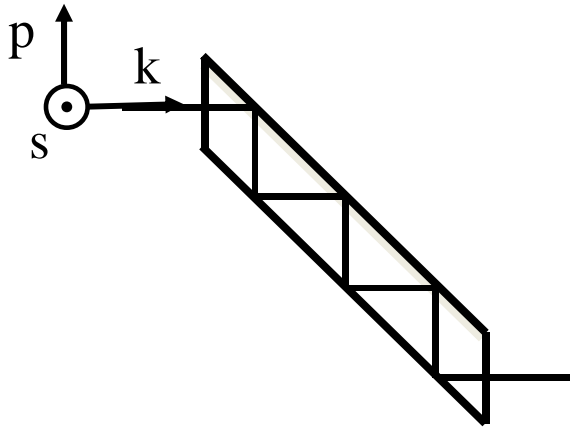
Characterization : Fourier Transform Infrared Spectroscopy



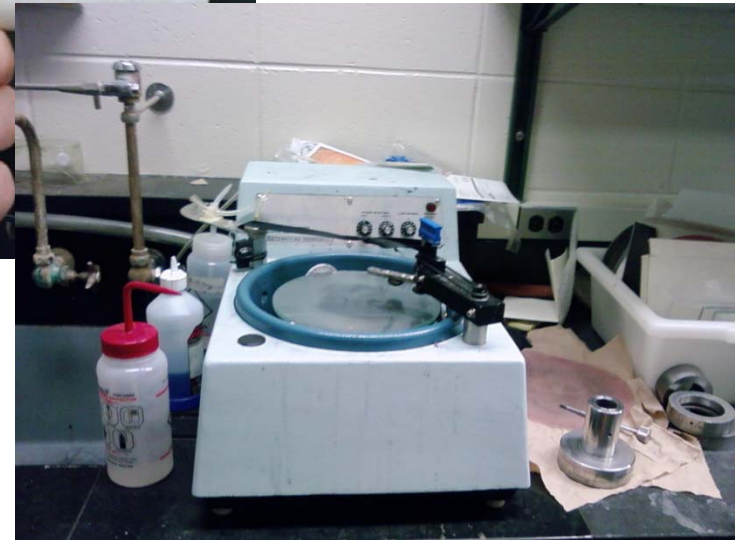
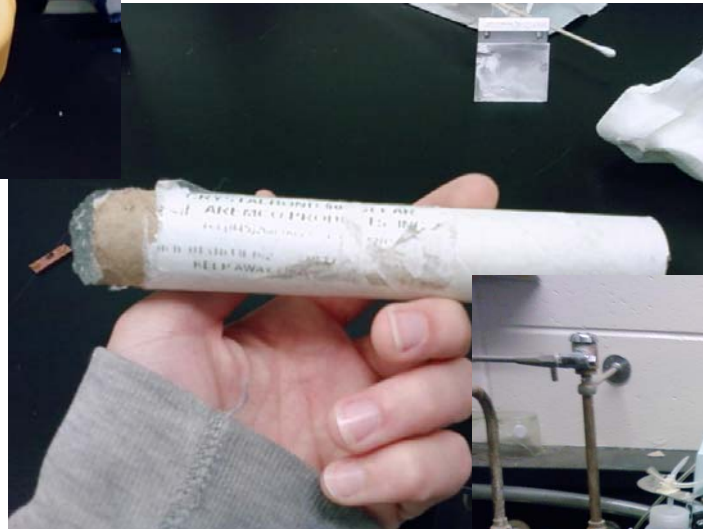
FTIR : detectors and beam splitters

Range	Beam Splitter	Detector
Near IR	CaF ₂	Indium antimonide (InSb)
Mid IR	KBr	Mercury cadmium telluride (MCT, HgCdTe)
Far IR	“Solid substrate “	Deuterated Triglycine Sulfate (DTGS)

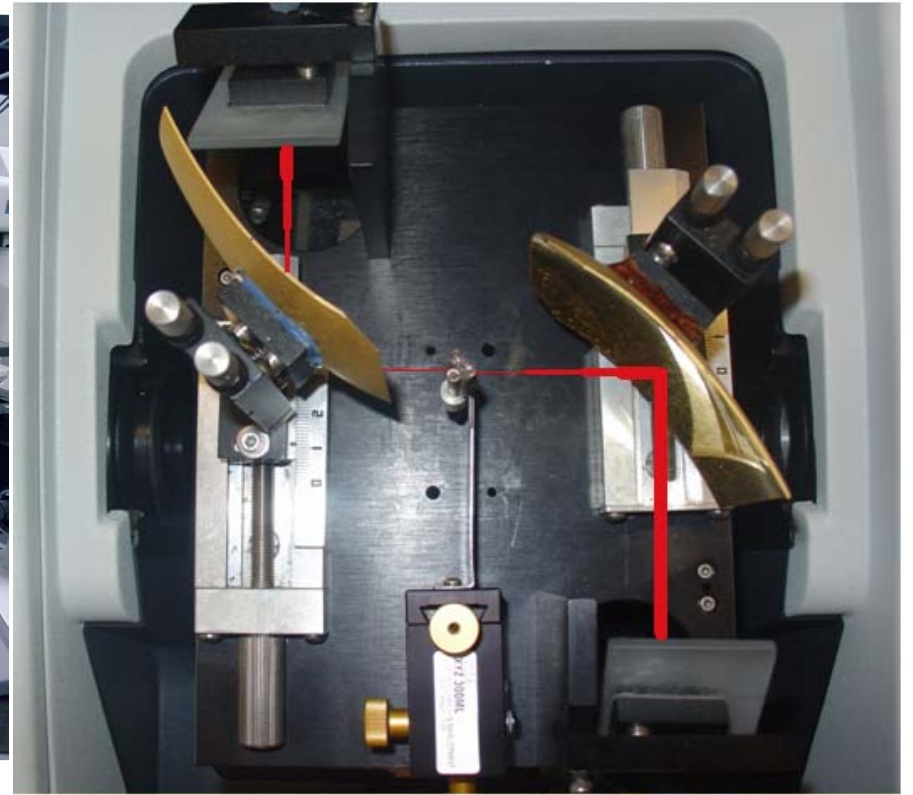
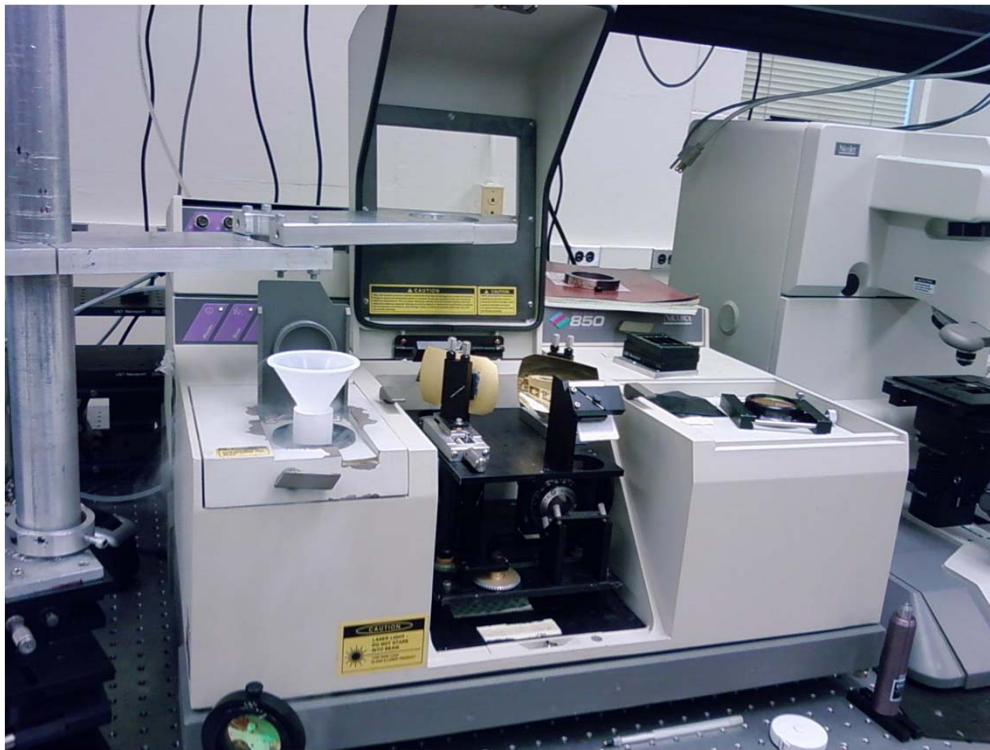
Preparing sample



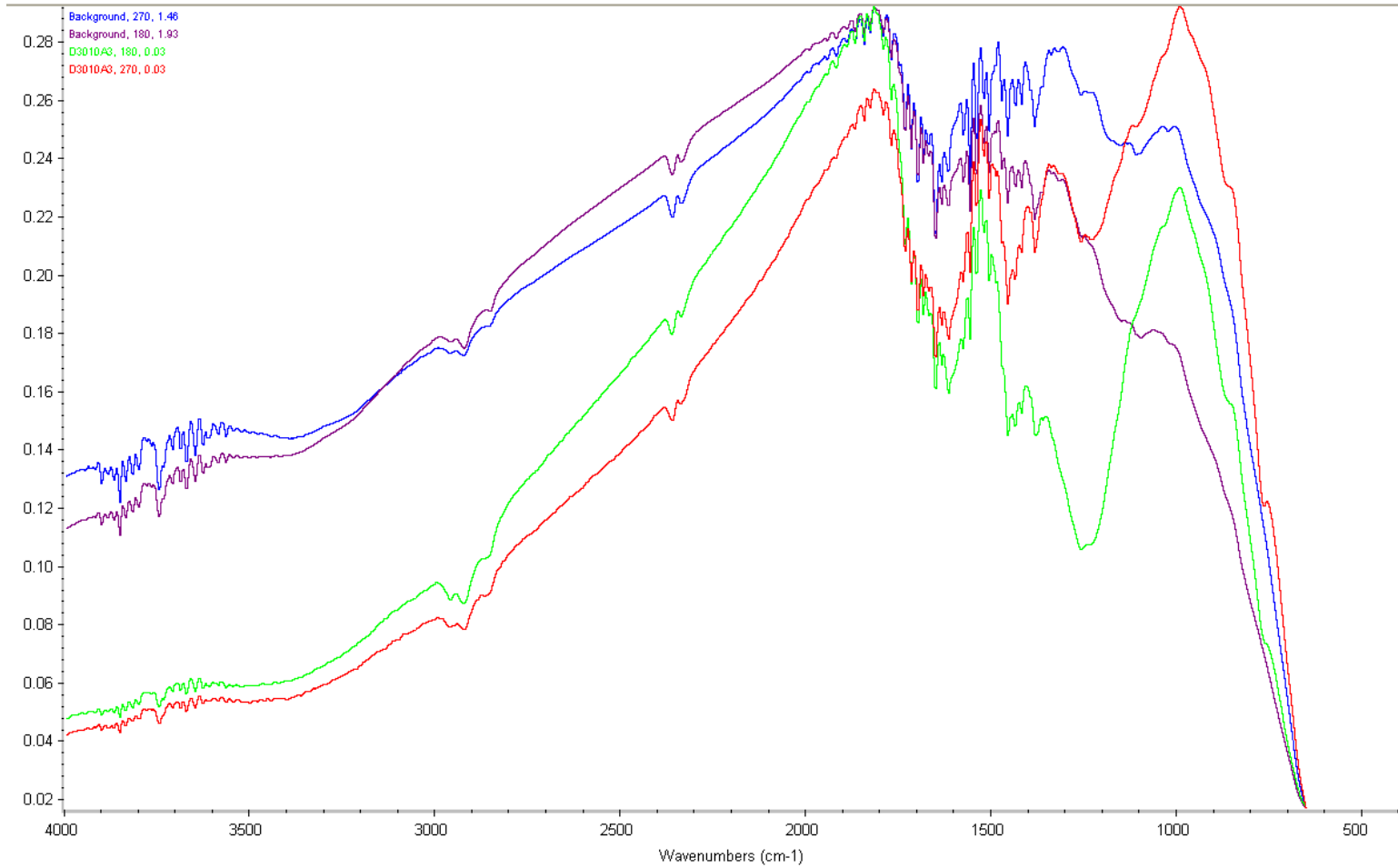
Preparing sample



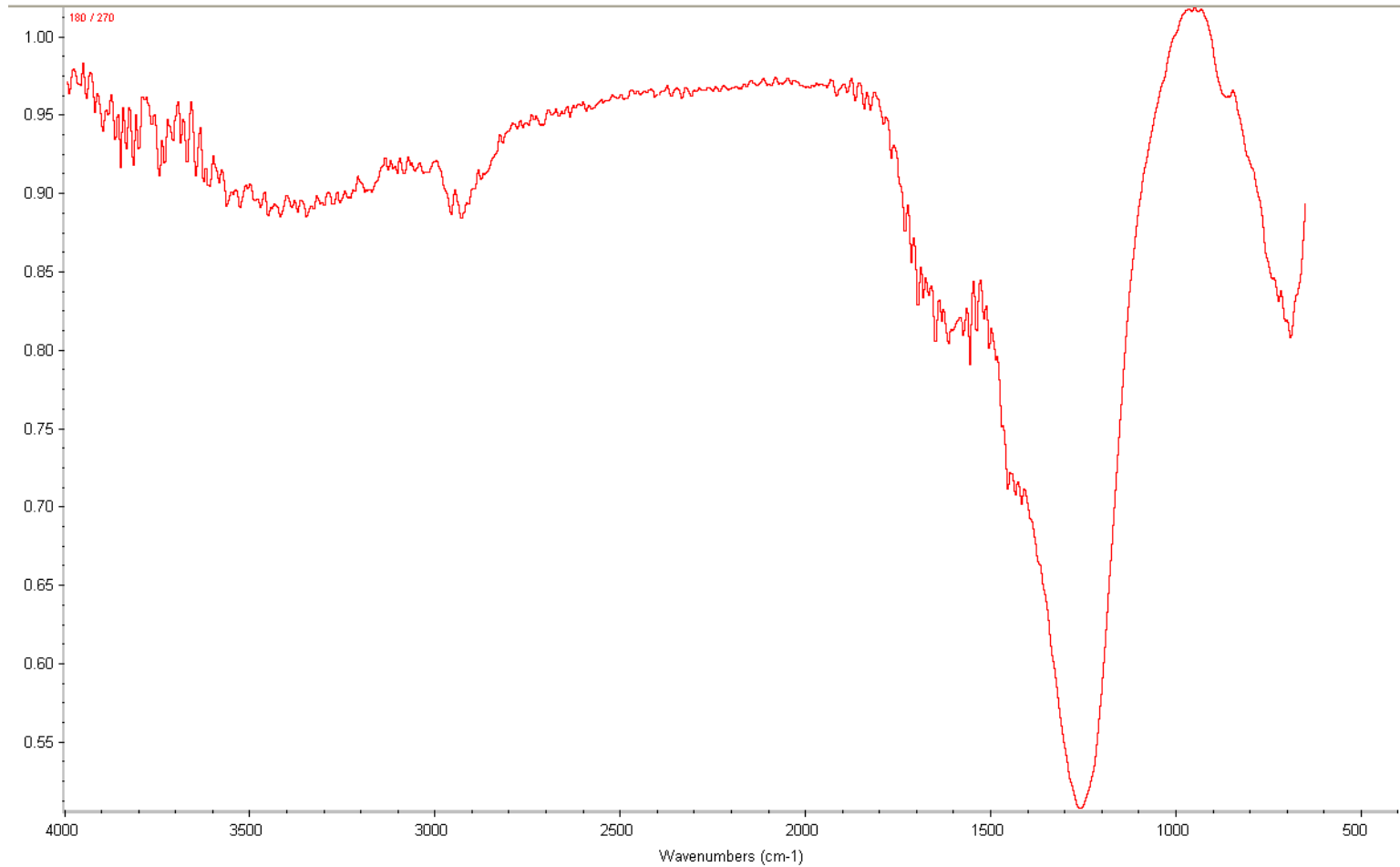
FTIR absorption measurements



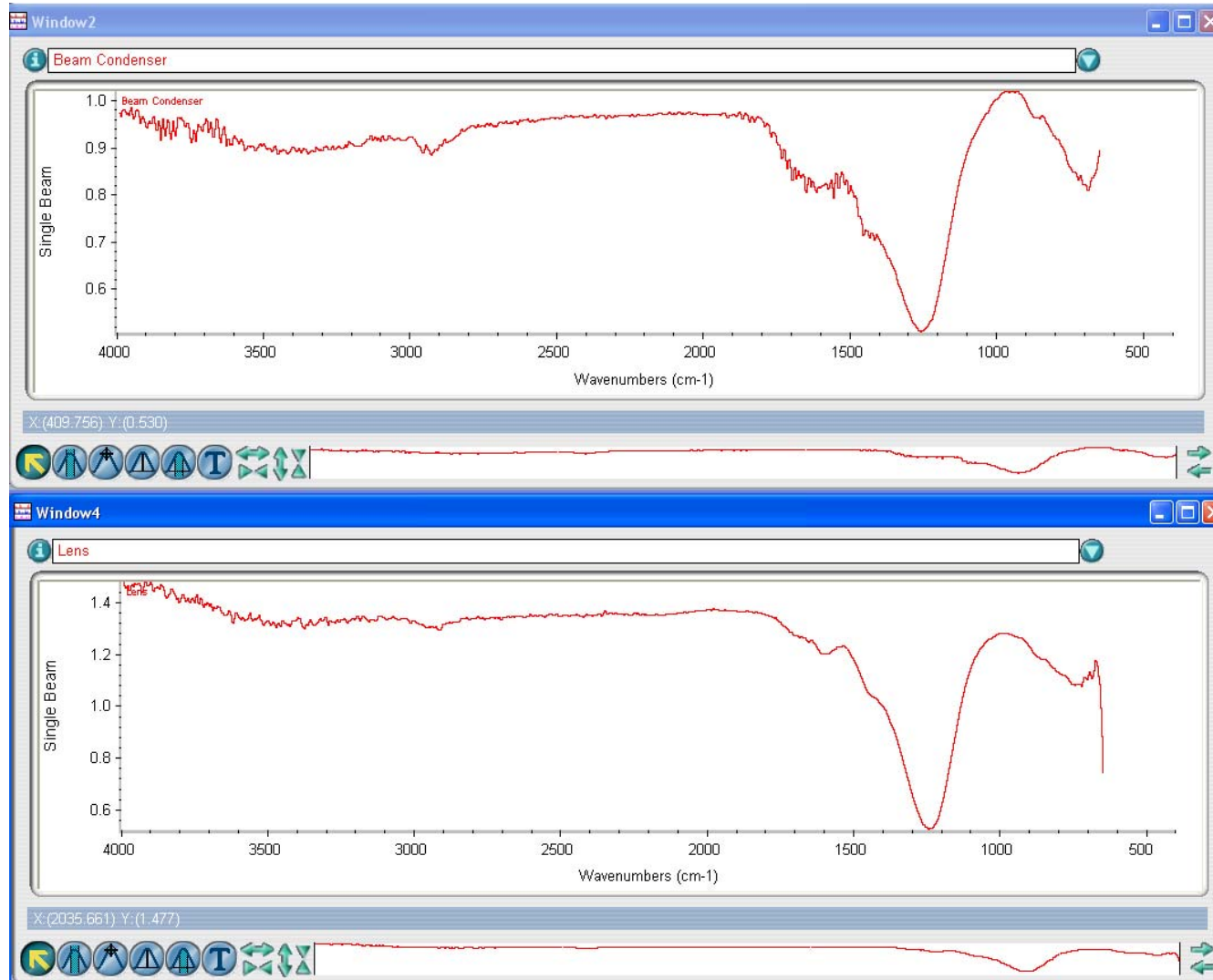
Example measurements



Example measurements



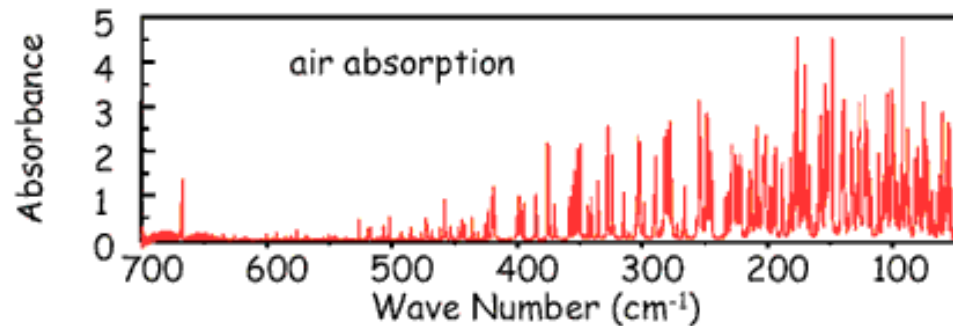
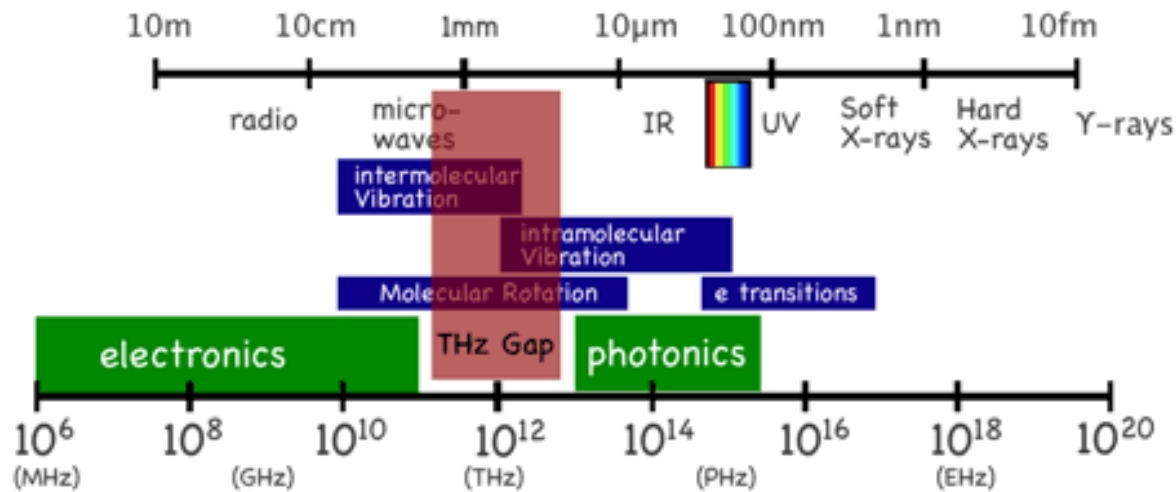
Example measurements



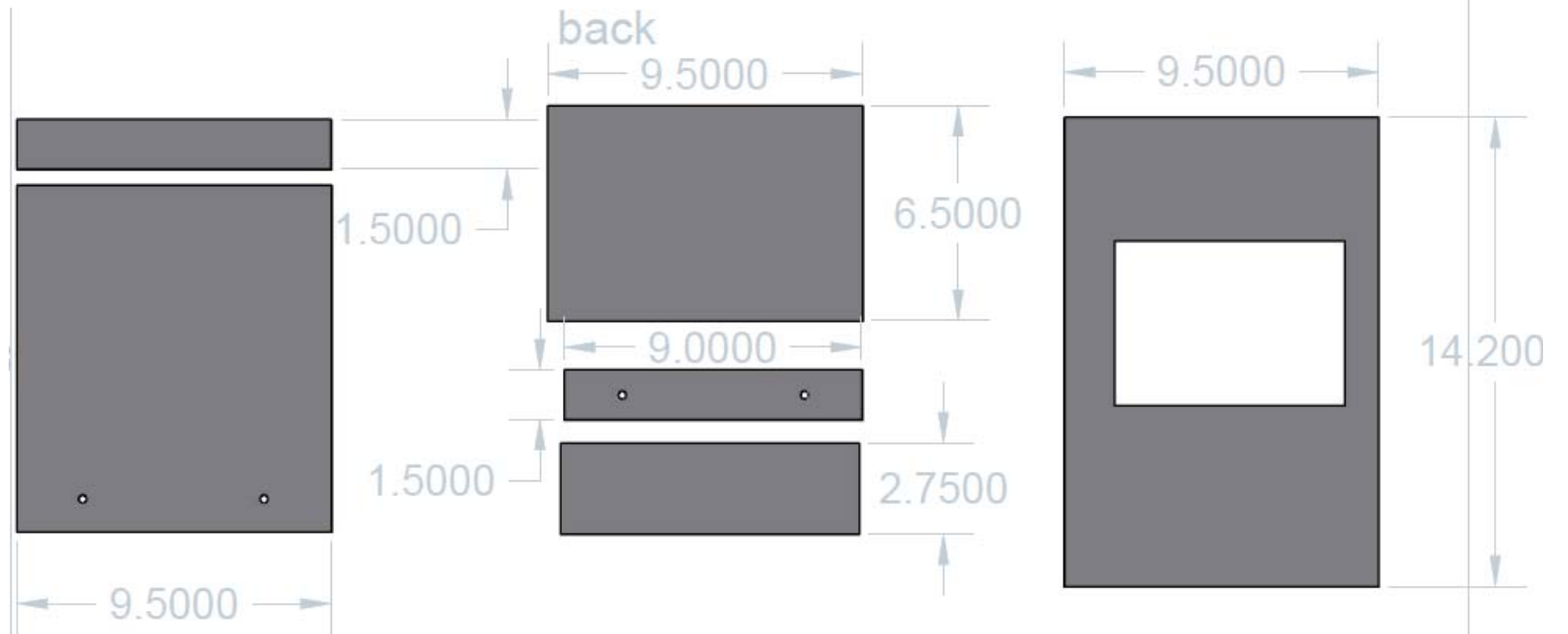
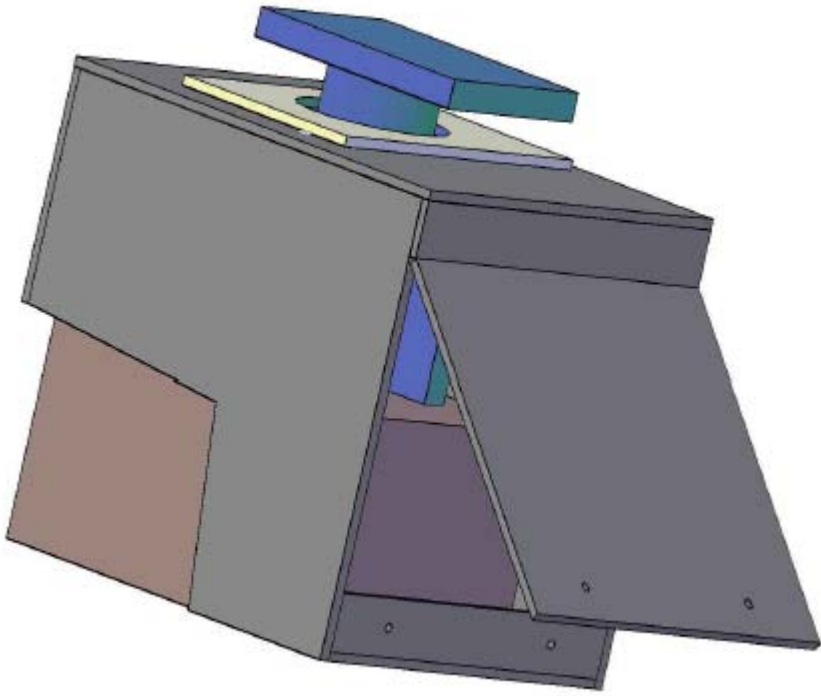
Recent Work

New setup needed

- High absorption by water in atmosphere in terahertz region
- Beam condenser too large to fit in current FTIR hood

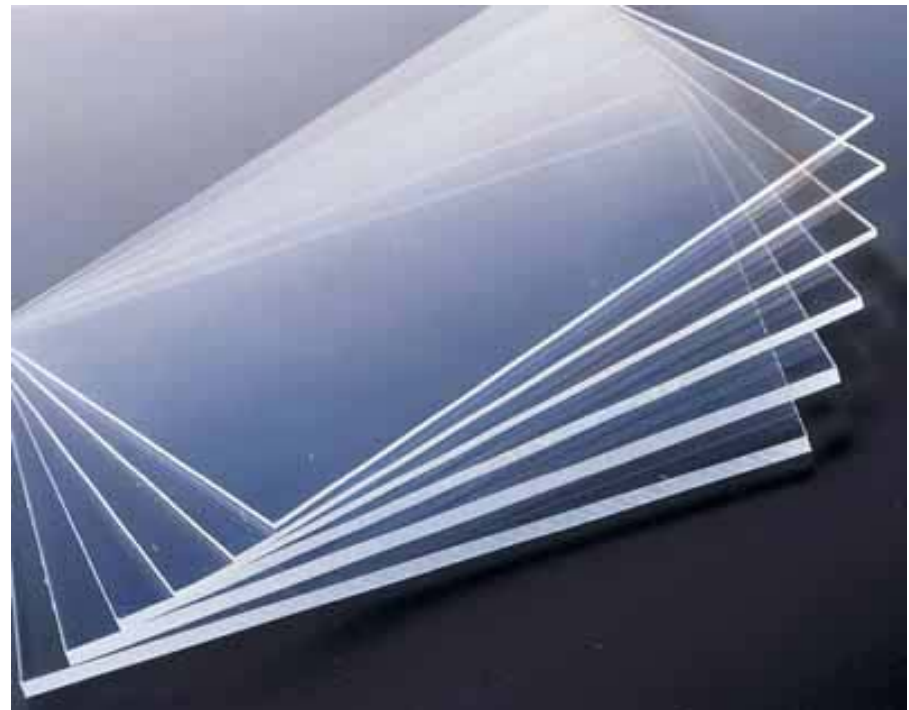


Design of new hood

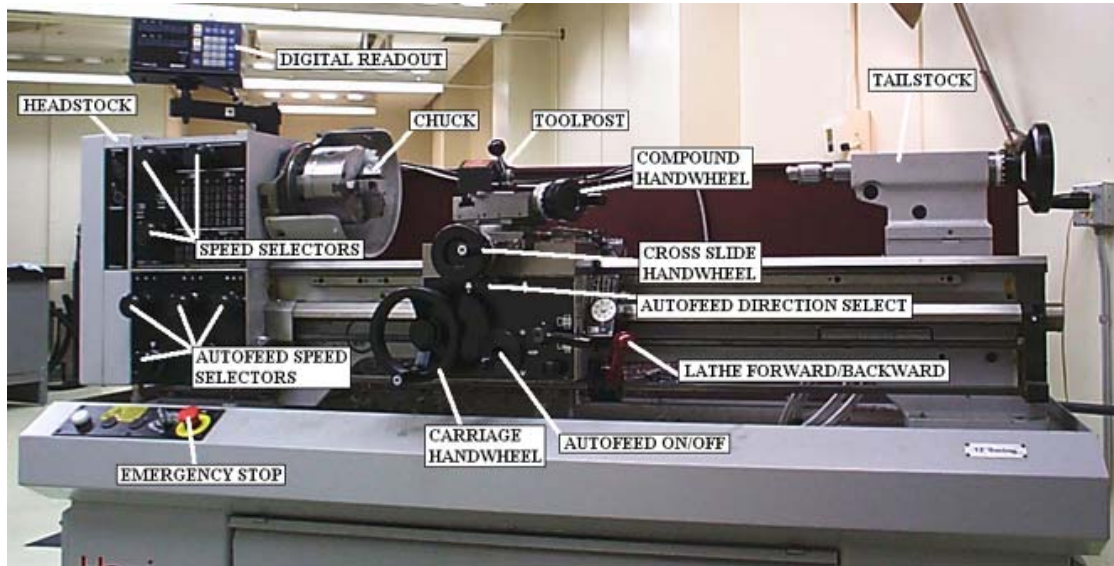


Working with acrylic : cutting

- Scoring vs. cutting
 - Sheets less than or equal to 1/8" can be scored
 - Acrylic used for design 1/4" thick



Machine shop



Lathe



Mill

Band saw

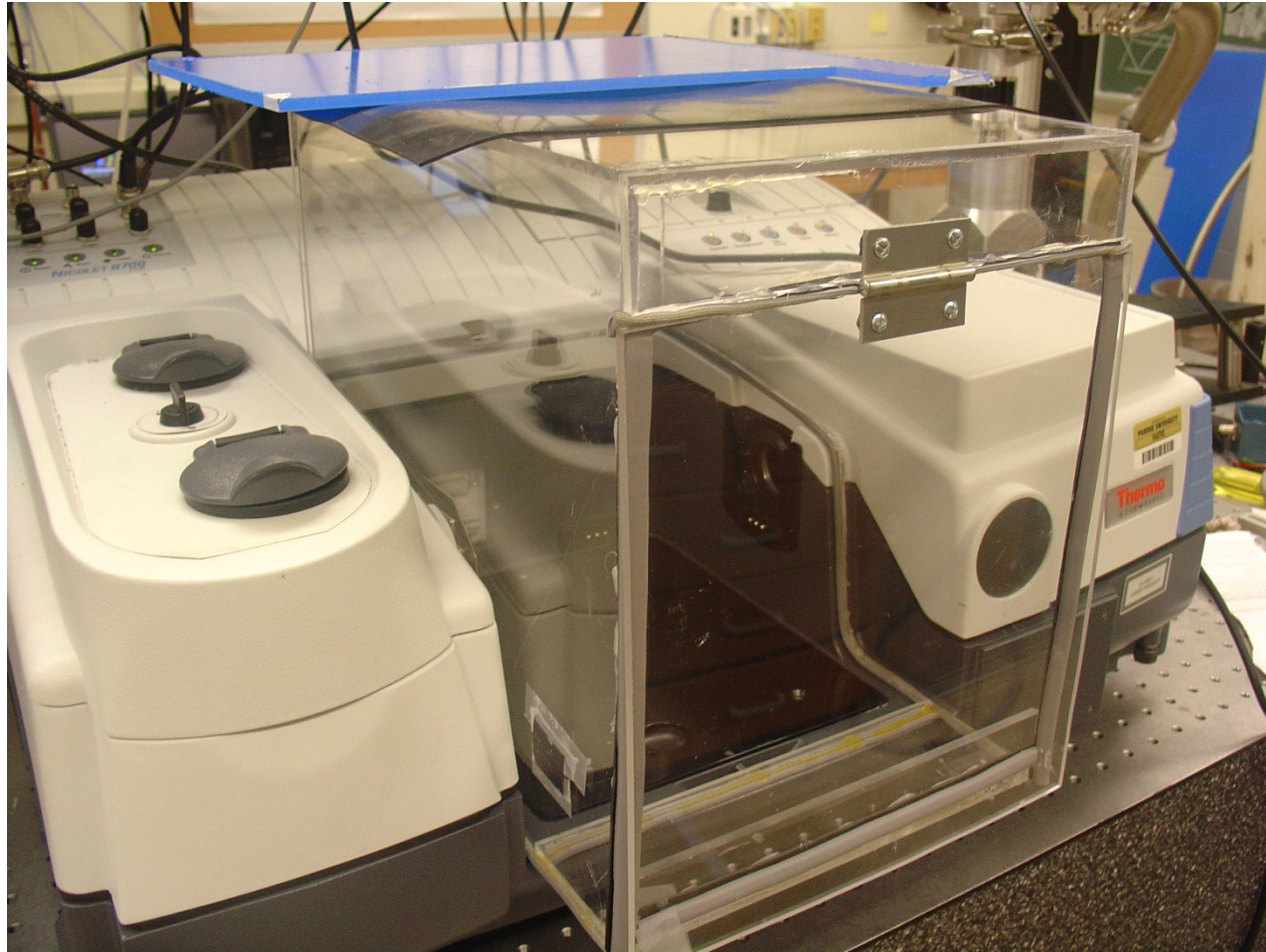


Working with acrylic : 'gluing'

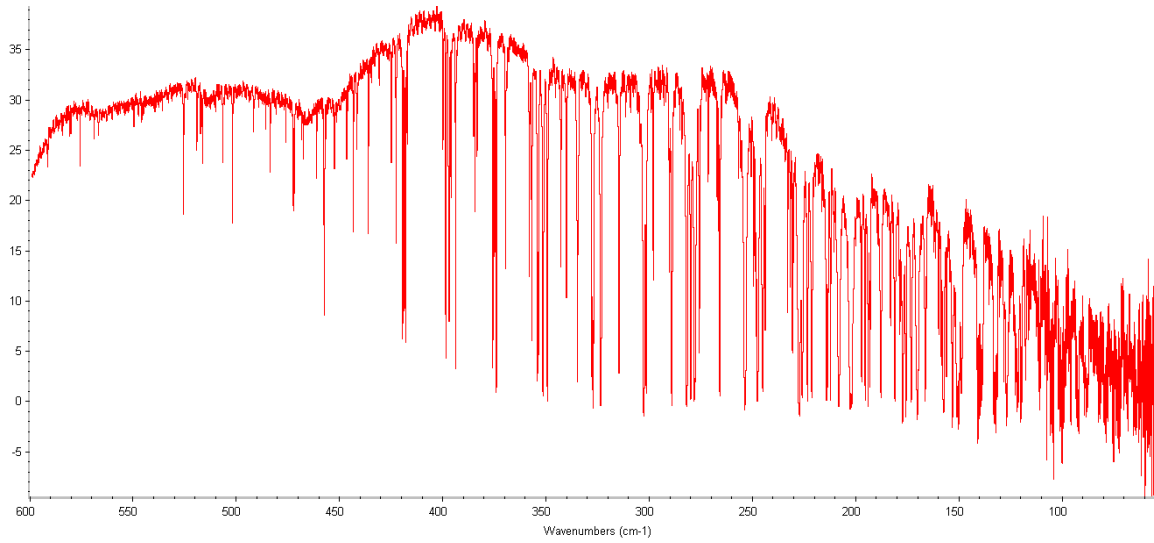
- Acrylic cement used



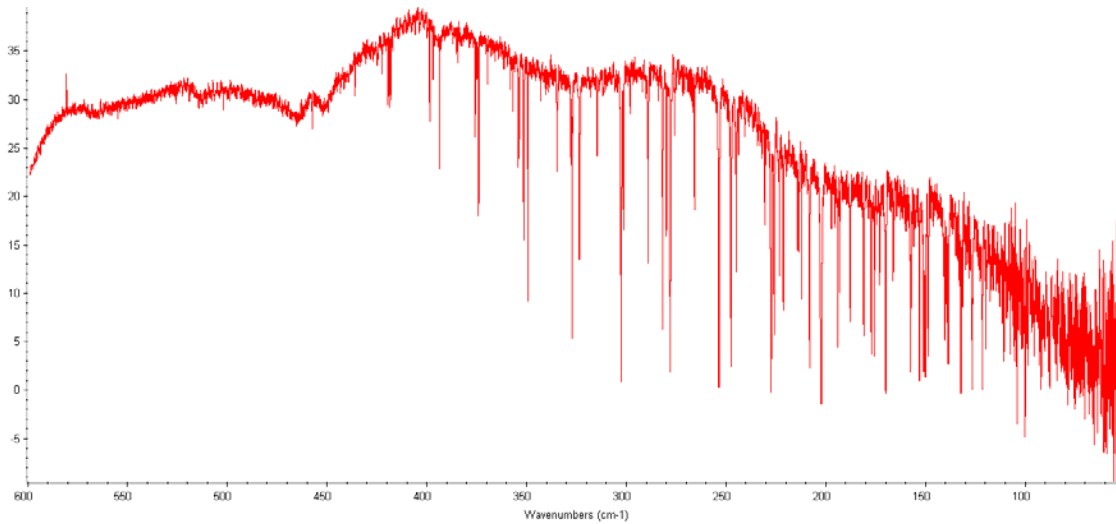
Final Product



Tests

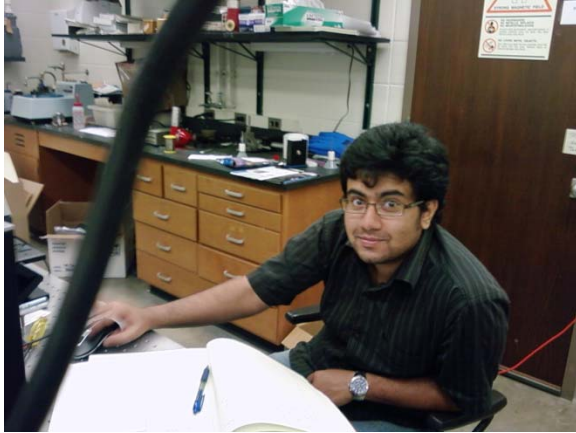


No purge



With new hood

Thank you!



Thanks to all the people in my lab group who helped me out this summer. I really enjoyed working with all of you (and I hope you don't mind these pictures on my presentation 😊) !



Questions?