Status Update
Masks + Thin Films

Joey, 7/23/08

Overview

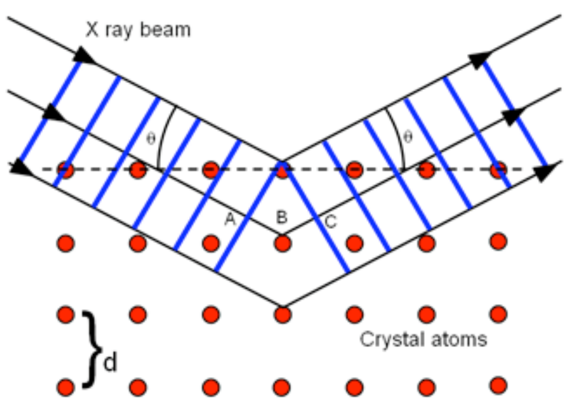
- X-Ray Diffraction
- Aluminum Nitride Progress
- Variable Angle Spectroscopic Ellipsometry
- Mask Layouts
- Cantilever Designs

X-Ray Diffraction

- Diffraction occurs only when the distance travelled by the rays reflected from successive planes differs by a complete number n of wavelengths:

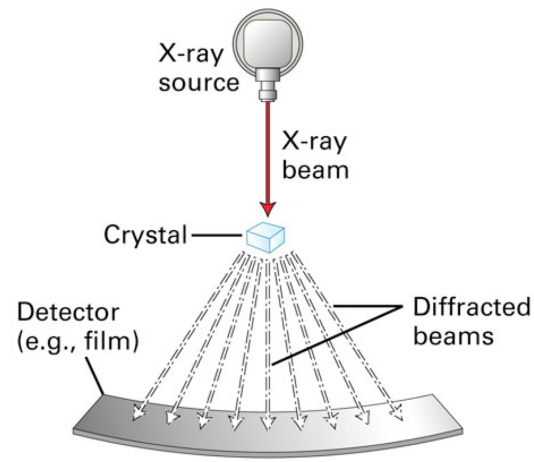
  $n\lambda = 2d \sin\theta$

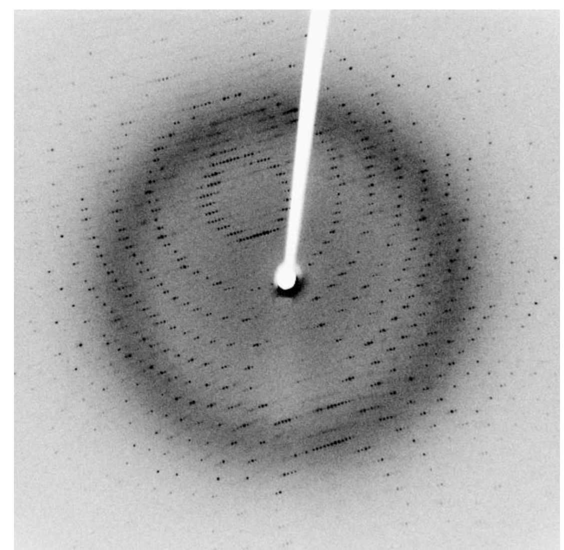
- By varying the angle θ, the Bragg's Law conditions are satisfied by different d-spacings in polycrystalline materials.
- A perfect crystal would give peaks that were delta functions.



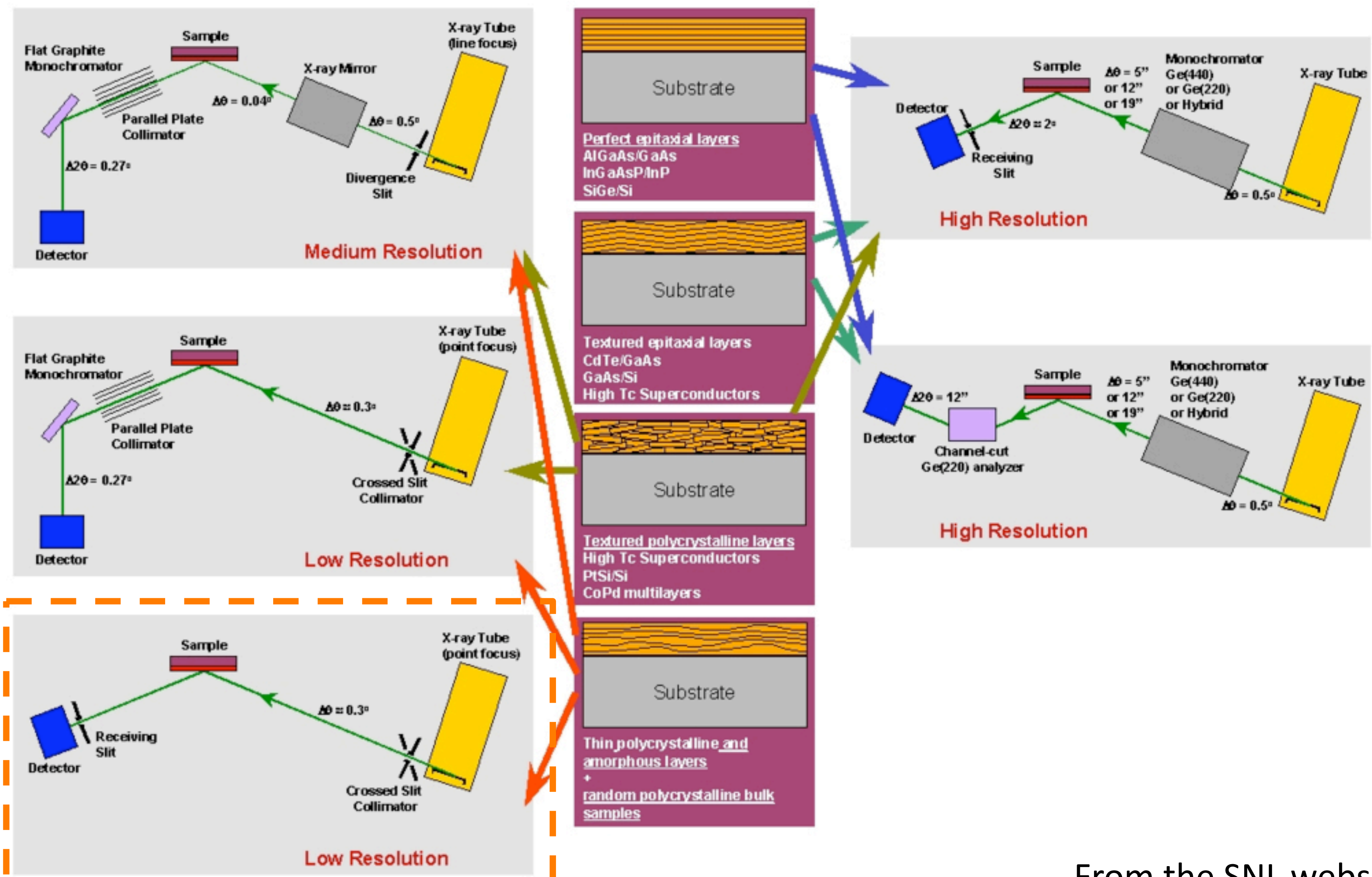
Images from images.google.com

Proteins, DNA, etc



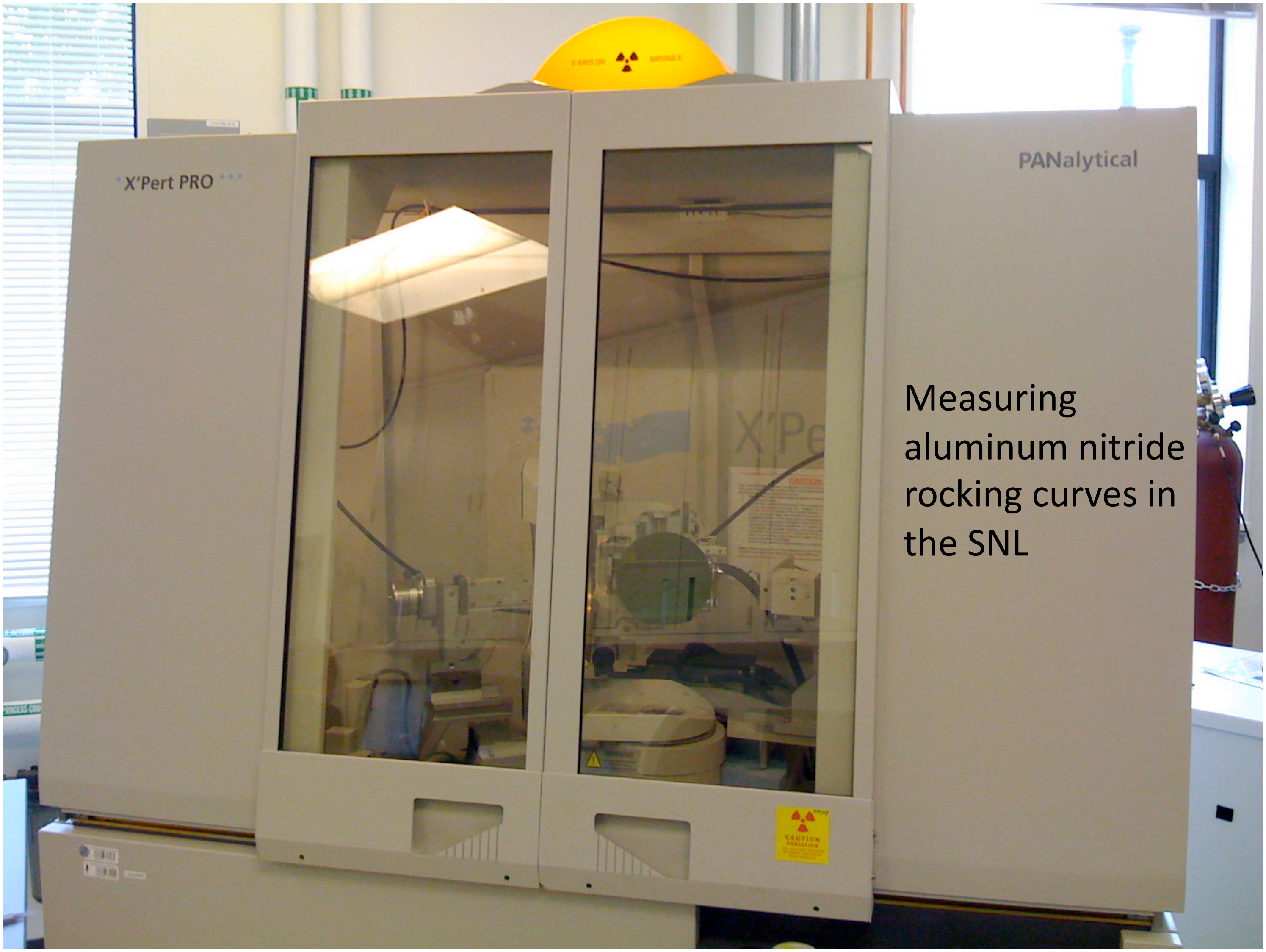


X-Ray Diffraction



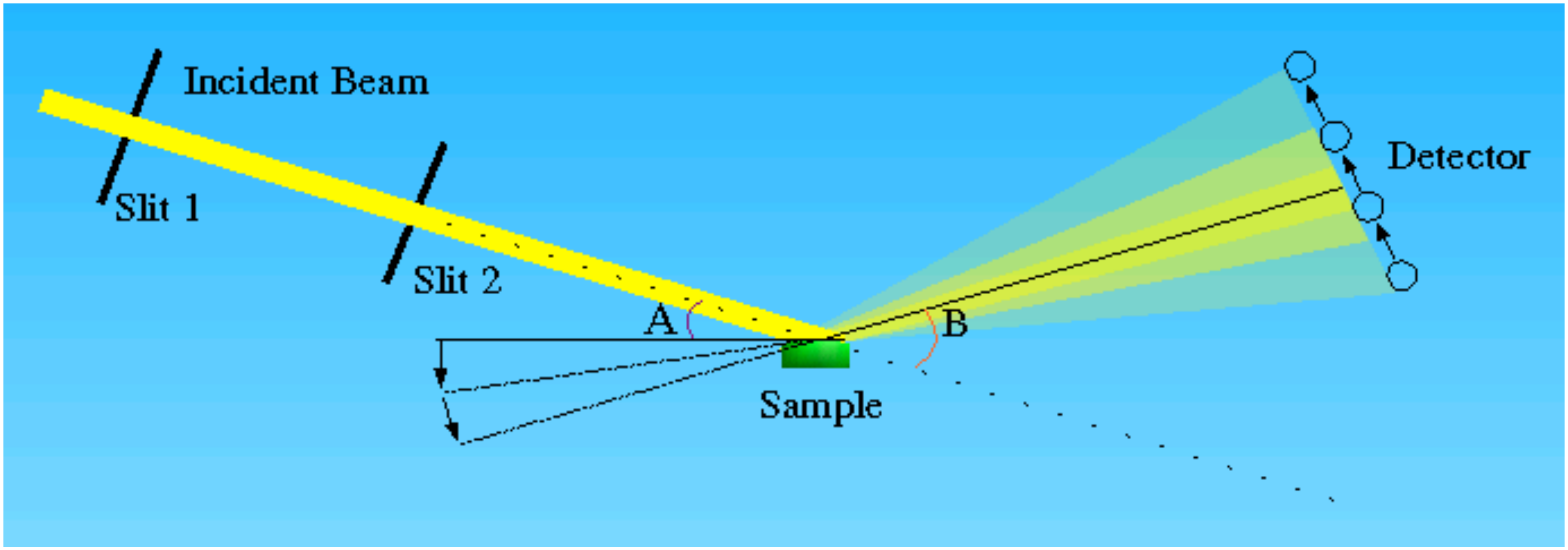
From the SNL website

X-Ray Diffraction

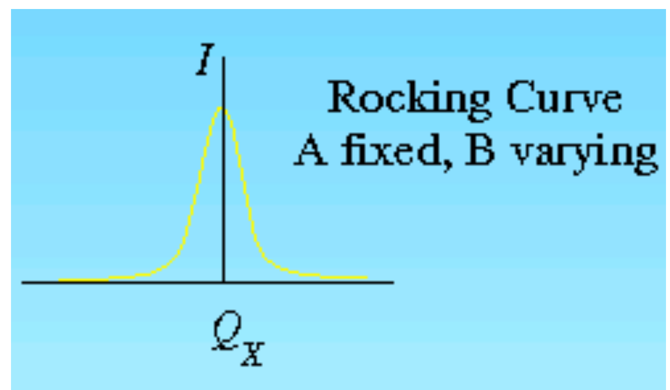


Measuring aluminum nitride rocking curves in the SNL

X-Ray Diffraction: Rocking Curve



Rocking curve: Keep the incident angle constant, vary the detector angle (theta), or keep angles fixed and rotate sample angle (omega). Width of peak indicates degree of grain alignment for polycrystalline materials.



Images from the NIST website

Aluminum Nitride

APPLIED PHYSICS LETTERS **93**, 021903 (2008)

Influence of oxygen concentration in sputtering gas on piezoelectric response of aluminum nitride thin films

Morito Akiyama,[1,a)] Toshihiro Kamohara,[1] Kazuhiko Kano,[2] Akihiko Teshigahara,[2] and Nobuaki Kawahara[2]
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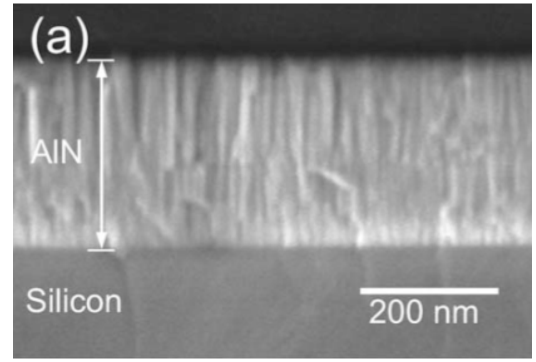
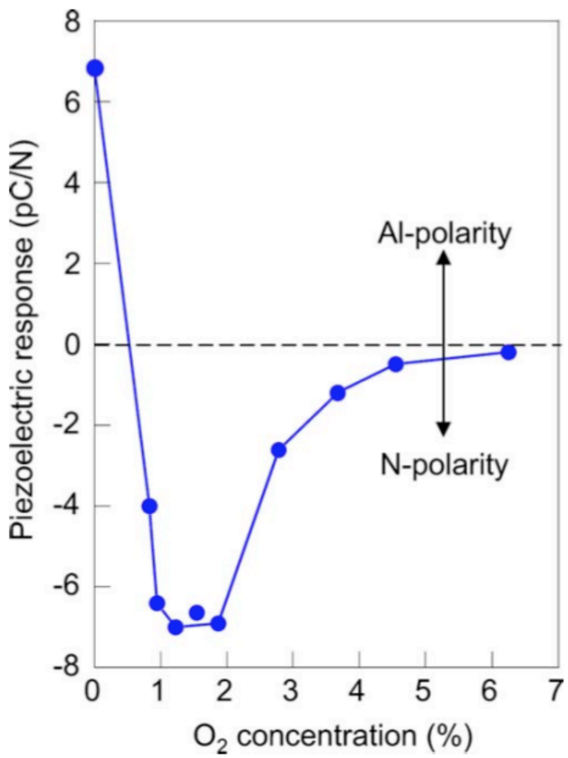
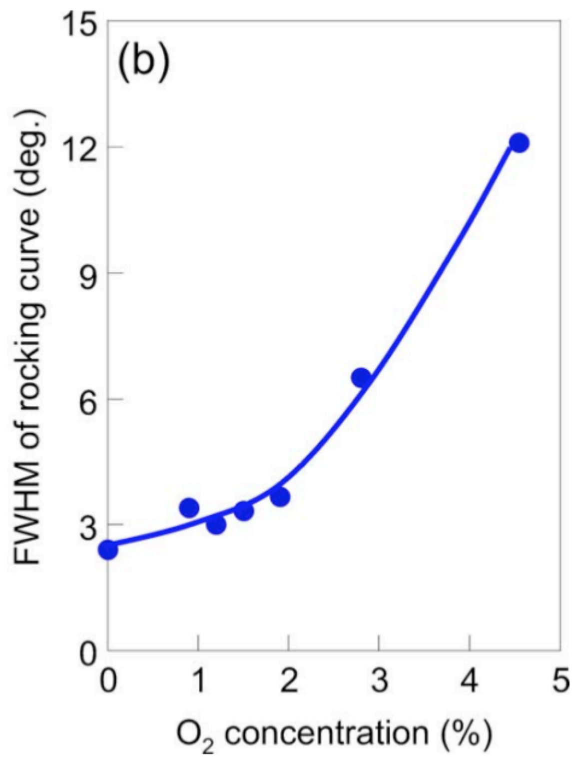
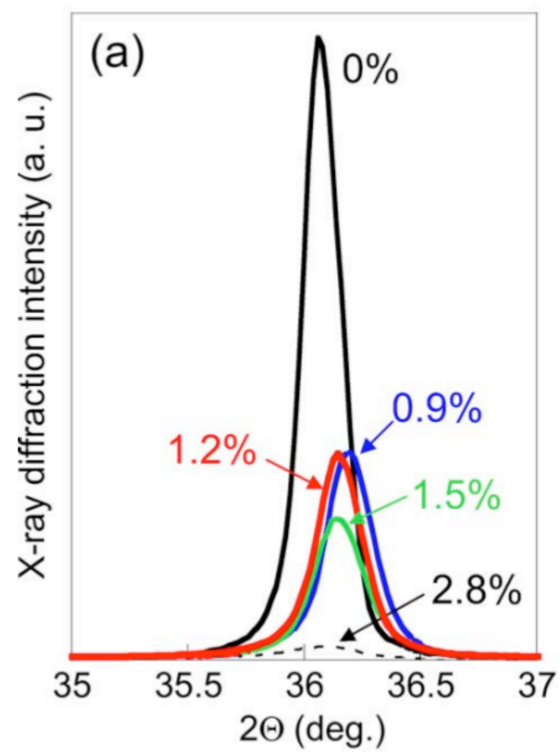








Aluminum Nitride Progress

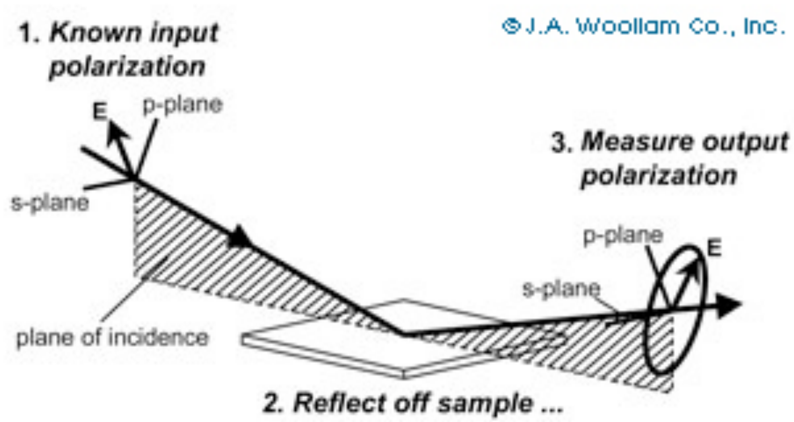
- Expect deposition ~700A/min (not checked yet)
- Have rocking curve FWHM of 2.8 degrees on Ti electrode, comparable to the better results in the literature
  - Haven't extracted figures yet
  - Measurements are quick, a few minutes each
- Having another round of samples fabricated and plan to measure piezoelectric coefficient

Spectroscopic Ellipsometry

- Probes thickness and optical properties of thin films based upon changes in polarization
- Works for layers thinner than light wavelength
- Thickness resolution = sub nm
- Spot size = 2mm, can be reduced to about 150 microns with a lens
- 200nm to 1.6 um (white light + monochromator)
- Whole wafer characterization
- A few seconds at each measurement point

Figure from J.A. Woollam website

Spectroscopic Ellipsometry



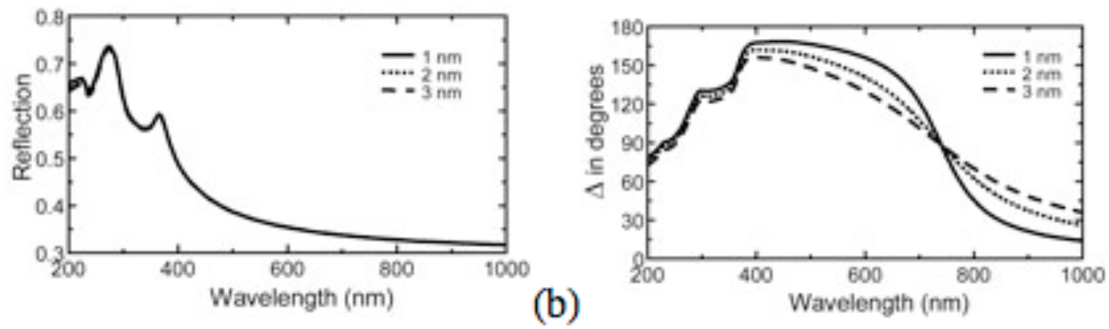


Figure 12 (a) Reflected intensity and (b) ellipsometric delta for three thin oxides on silicon show the high sensitivity of Delta to nanometer scale films not observable with the intensity measurement.

Spectroscopic Ellipsometry

Example

AlN thickness [nm]	
Average	464.6
Min	458.6
Max	466.8
St. Dev	1.15
3 sigma distribution	0.75%
Min-Max range	0.88%

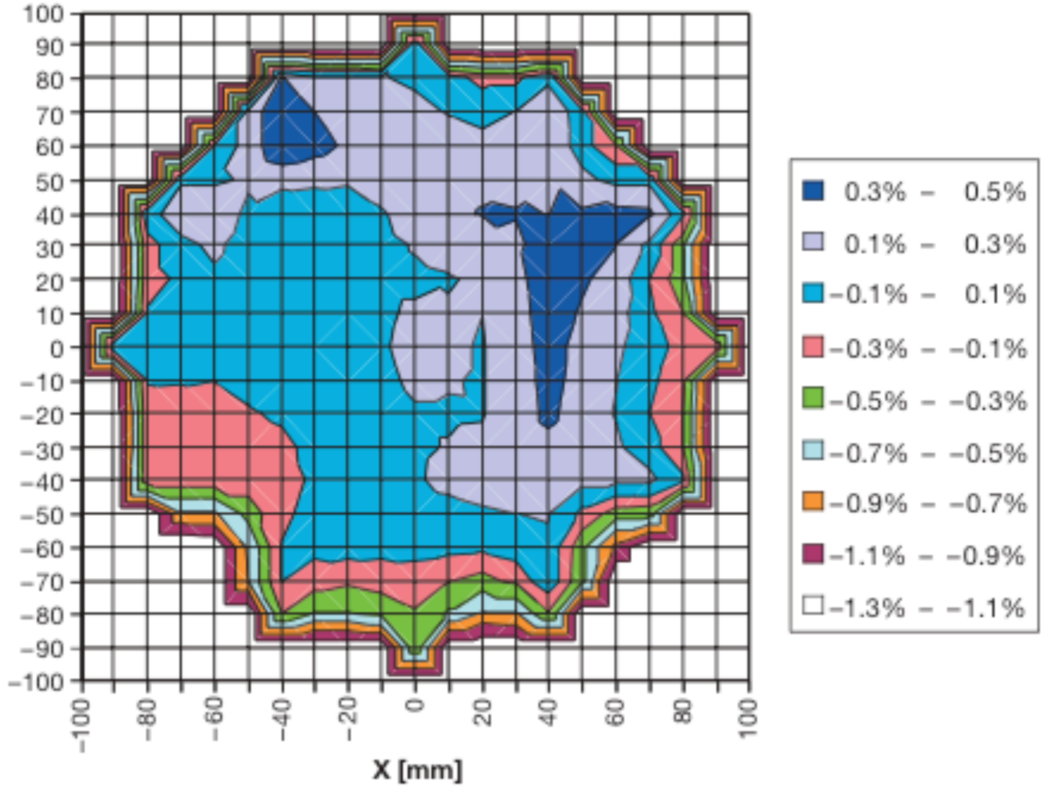


Figure from Unaxis Semiconductor literature

Spectroscopic Ellipsometry

Characterization of polycrystalline AlN films using variable-angle spectroscopic ellipsometry

Li-Peng Wang,[a] Dong S. Shim, Qing Ma, and Valluri R. Rao
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Eyal Ginsburg and Alexander Talalyevsky
Technology Manufacturing Group, Intel Corporation, Jerusalem, Israel

(Received 29 September 2004; accepted 24 January 2005; published 28 June 2005)

- Used to characterize AlN thin films
- Measure thickness, optical properties, roughness all at once
- Optical properties correlated to XRD FWHM

Spectroscopic Ellipsometry

Metrology of sub-0.5 μm silicon epitaxial films

Weize Chen and Rafael Reif[a)]
Microsystems Technology Laboratories, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

(Received 29 October 1997; accepted 6 February 1998)

Nondestructive measurements on films from 65nm to 14um thick, results comparable to SIMS, only applicable to very high doping levels

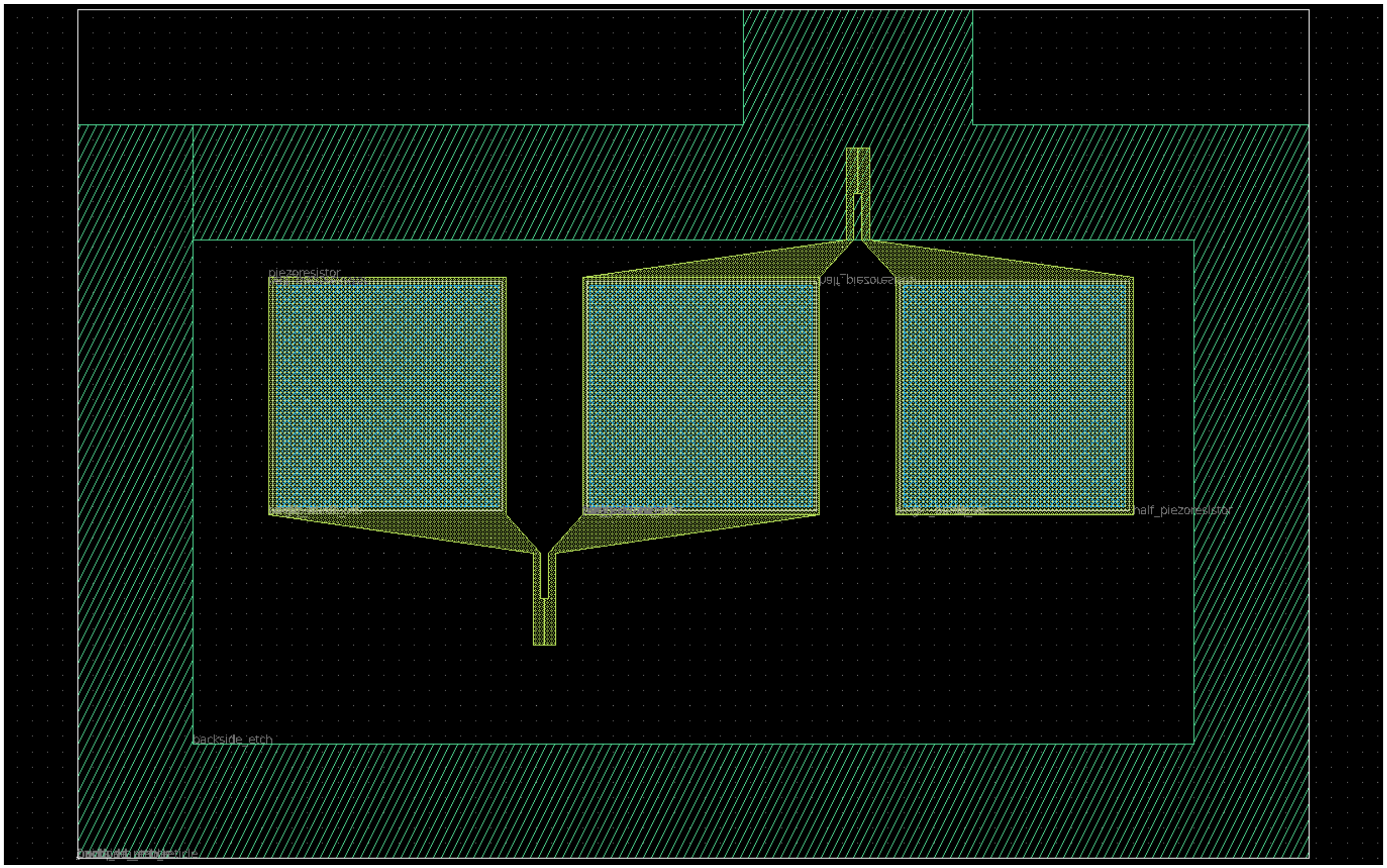
TABLE I. Results of SPME analysis for the seven samples plotted in Fig. 2.

		$N(\times 10^{19}\ \mathrm{cm}^{-3})$			d_{epi} (Å)		d_{SiO_2} (Å)
Sample	Dopant	SPME	SIMS	4-pt	SPME	SIMS	SPME
A	Boron	3.96±0.04	2.37	2.77	654±6	570–760	18.9±0.1
B	Boron	9.53±0.11	5.47	7.17	1032±2	1000–1200	17.7±0.1
C	Arsenic	1.74±0.05	1.84	1.47	1056±5	910–1300	17.2±0.1
D	Boron	1.43±0.07	0.95	0.90	2412±10	2280–2700	17.4±0.1
E	Arsenic	1.60±0.05	1.61	1.43	3400±8	3380–3800	17.1±0.1
F	Boron	8.61±0.07	5.02	6.72	5050±2	4960–5370	17.3±0.1
G	Boron	1.21±0.07	1.01	0.88	13 893±14	13 250–13 860	17.4±0.1

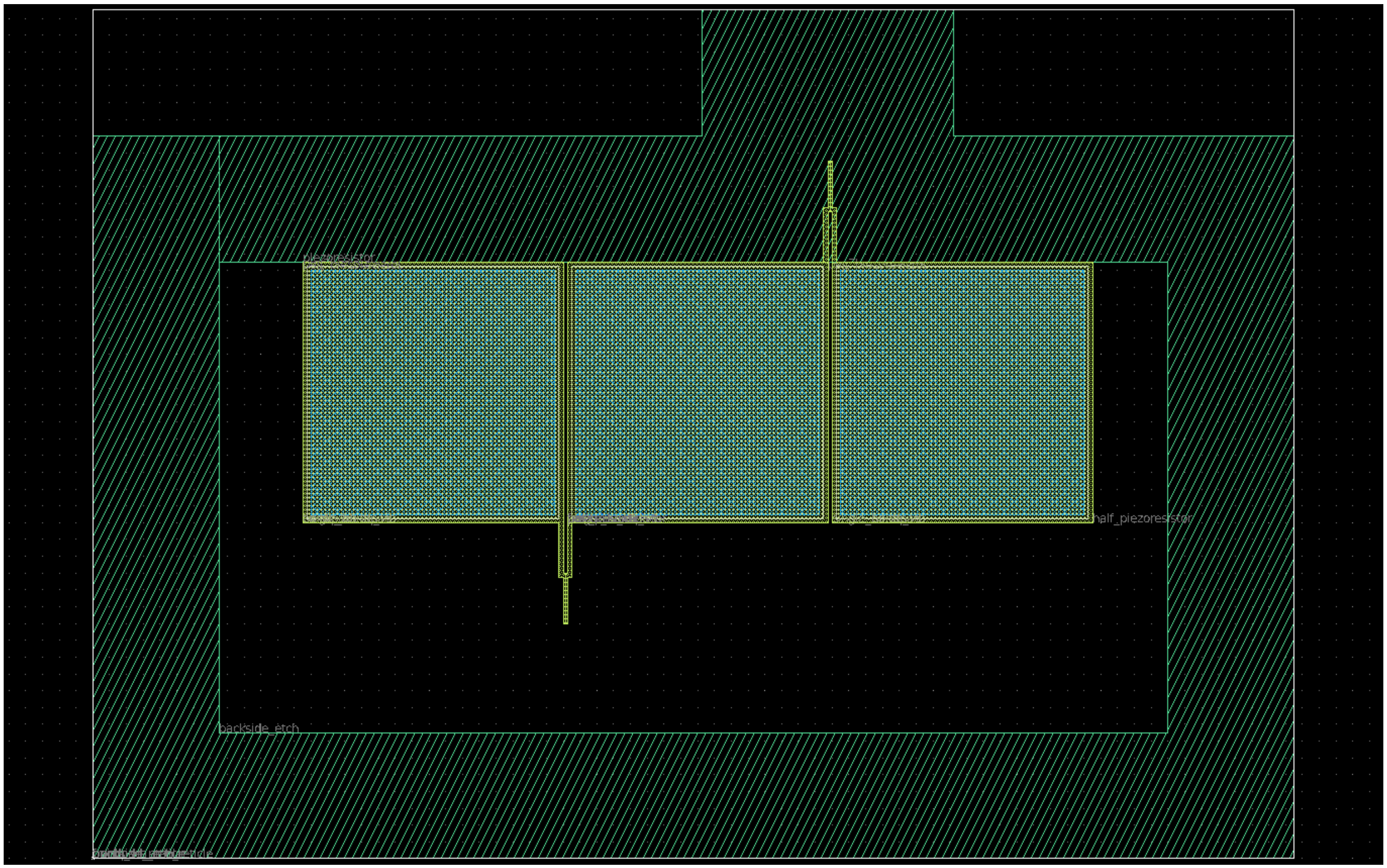
Mask Layouts

- Designs
  - Piezoresistor only
  - Piezoelectric only
  - Piezoresistor and piezoelectric
- Reticles
  - Approx. 6 geometry variations for each
  - Share bondpad/oxide via reticles
  - Test structures (still in progress)

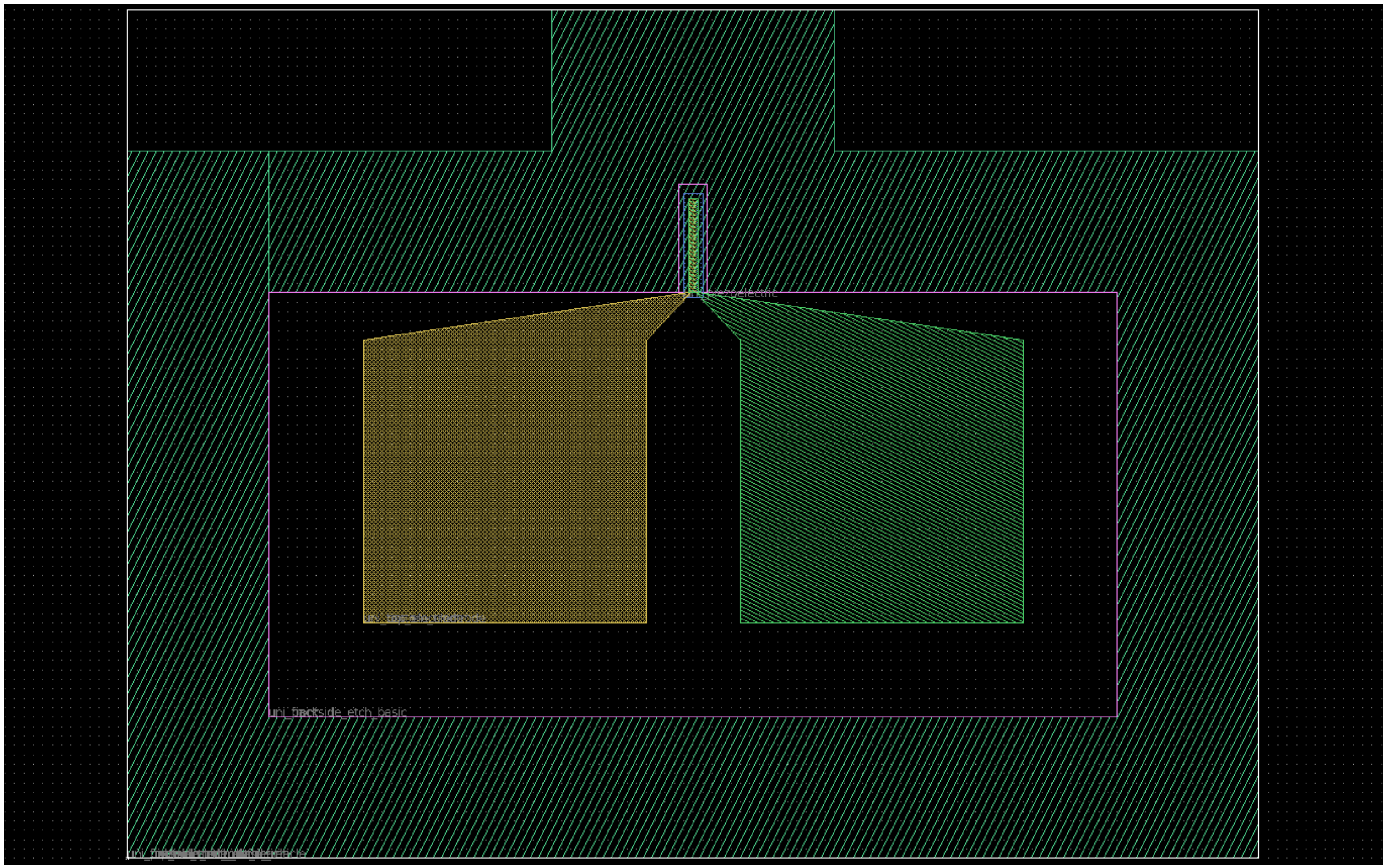
Piezoresistor Only



Piezoresistor Only



Piezoelectric Only



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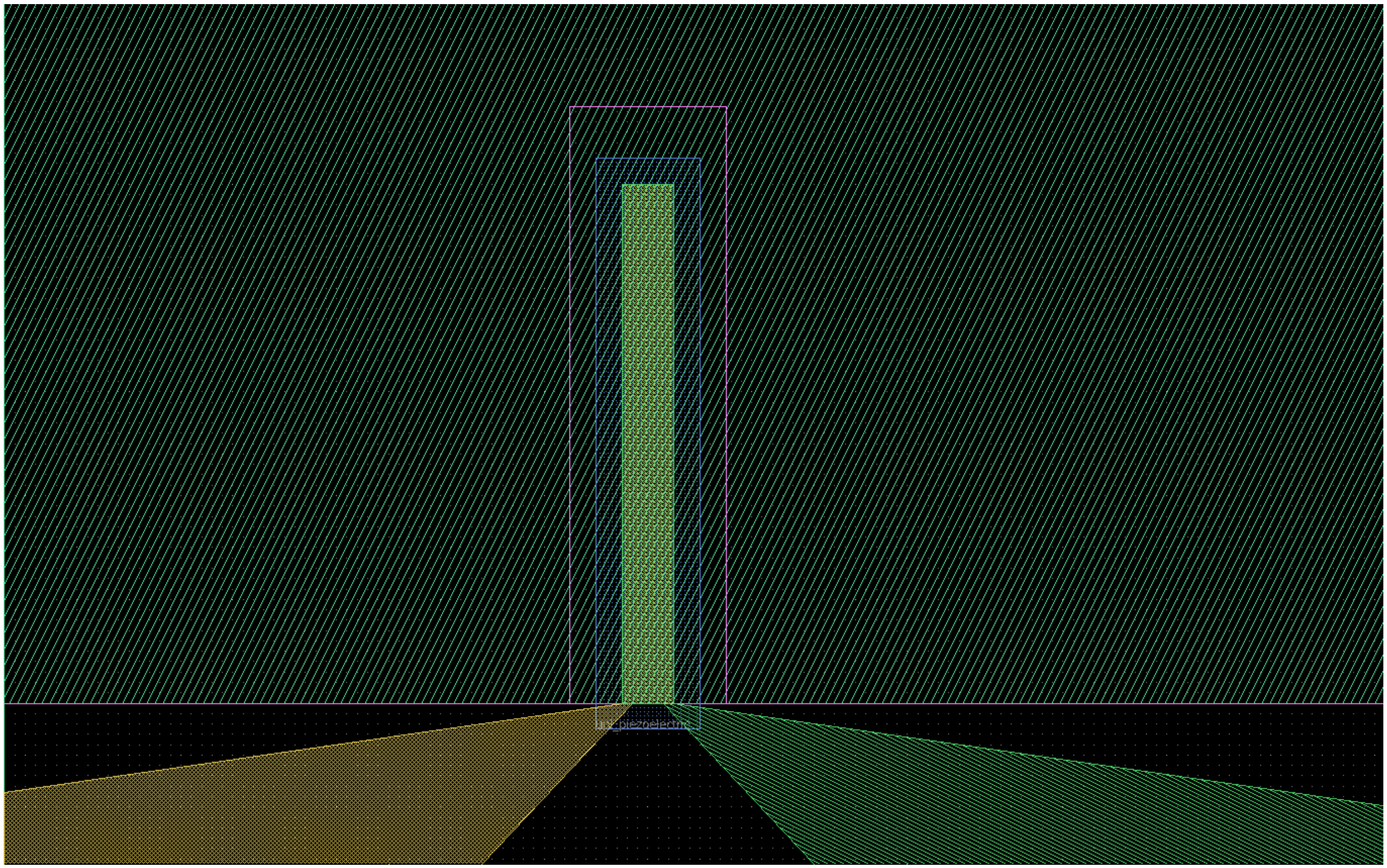
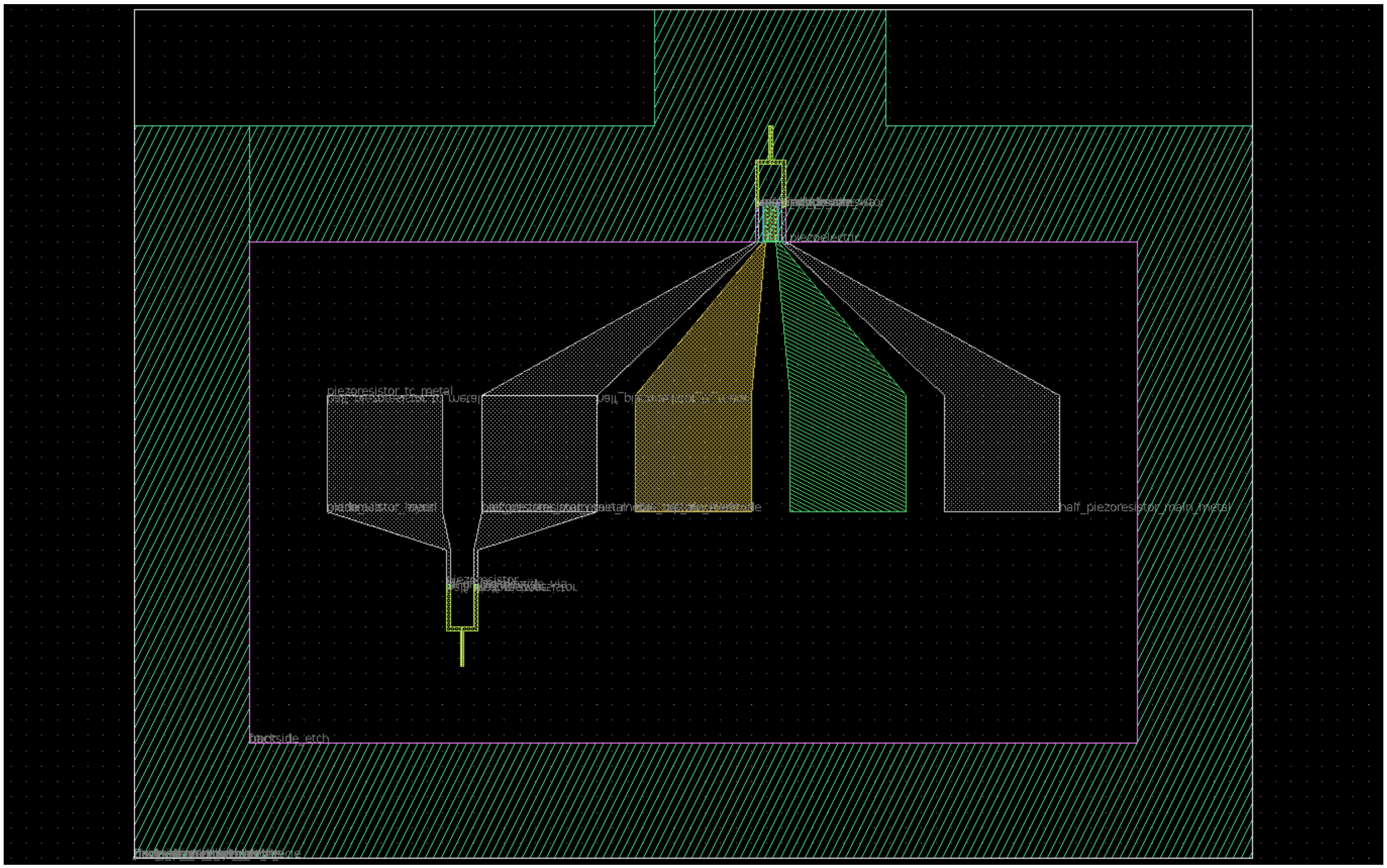
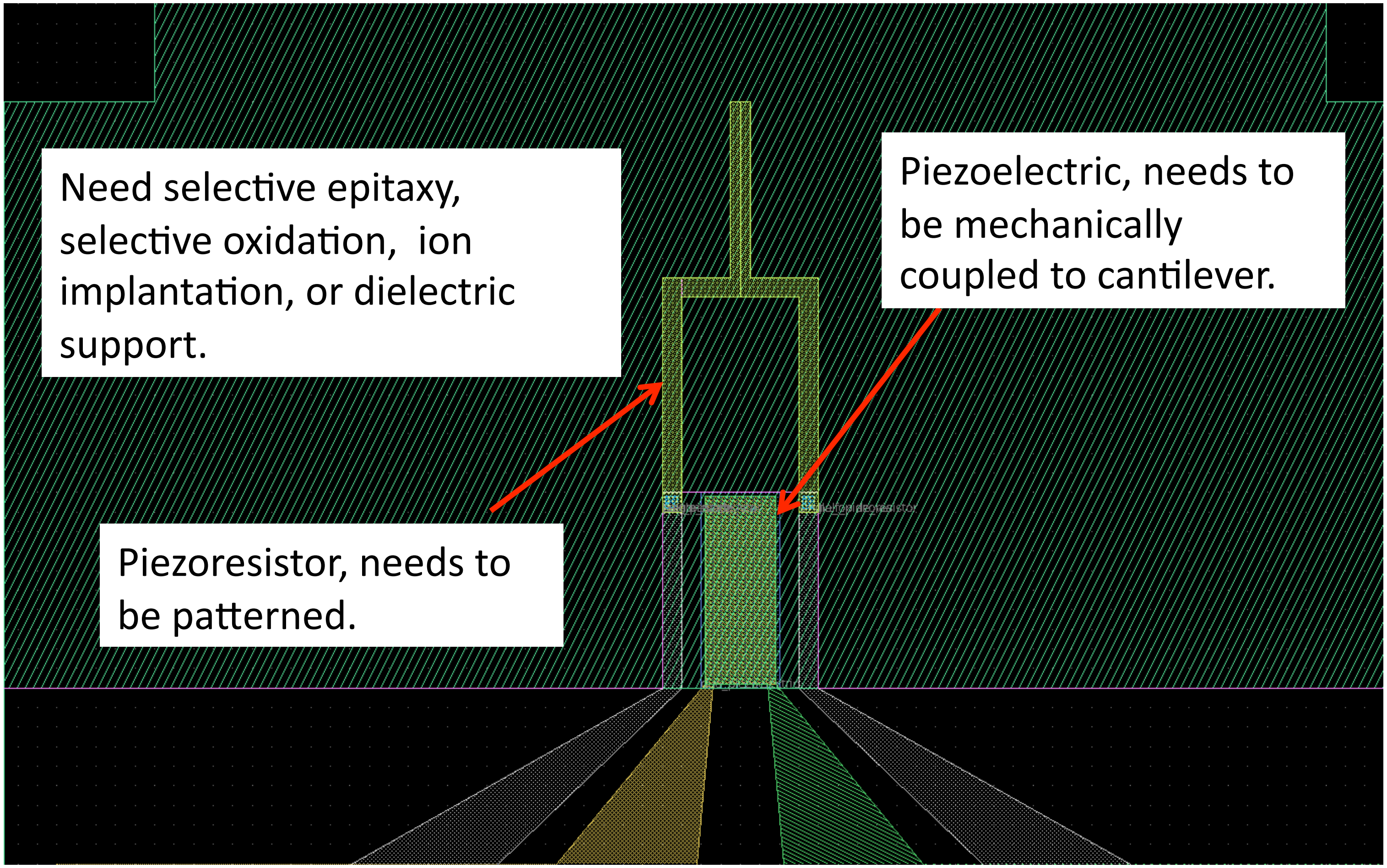


Piezoresistor and Piezoelectric



Piezoresistor and Piezoelectric



Cantilever Designs

- See Excel