Worm Meeting Status Update

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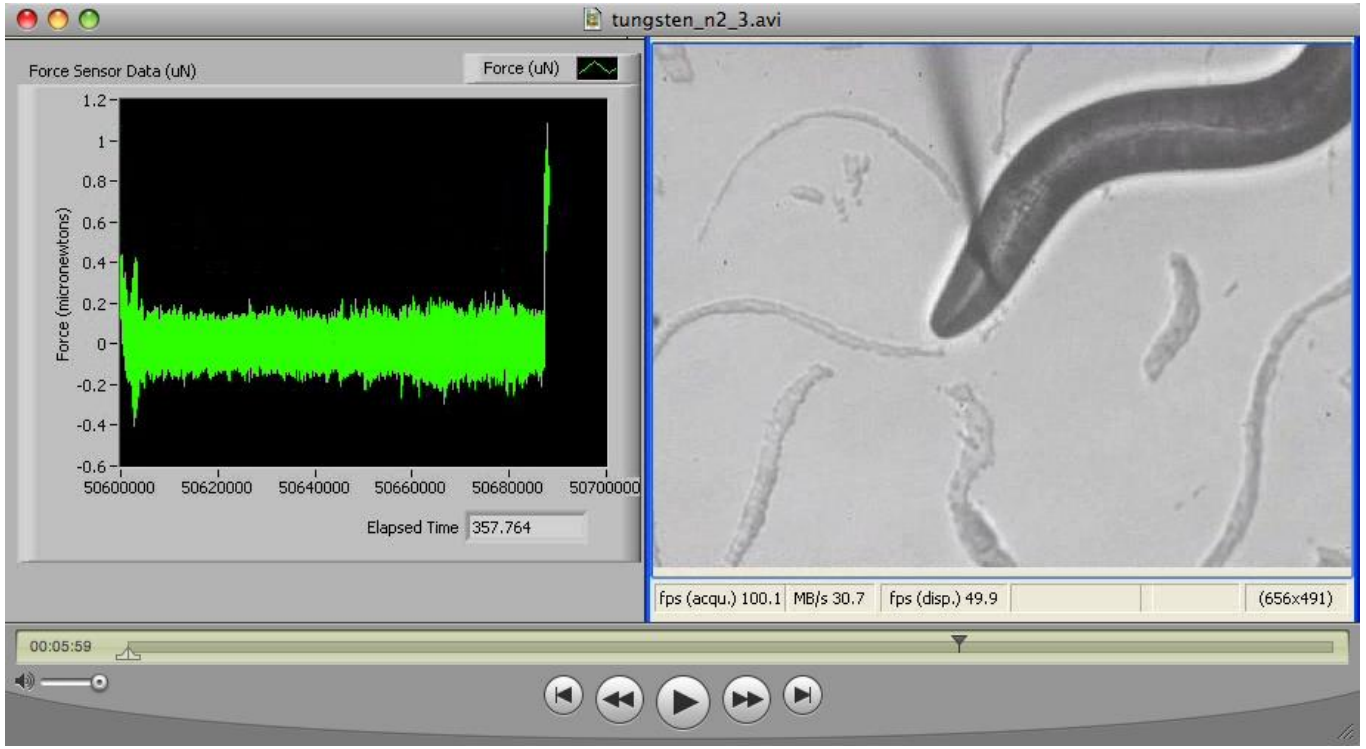
8/13/08

Overview

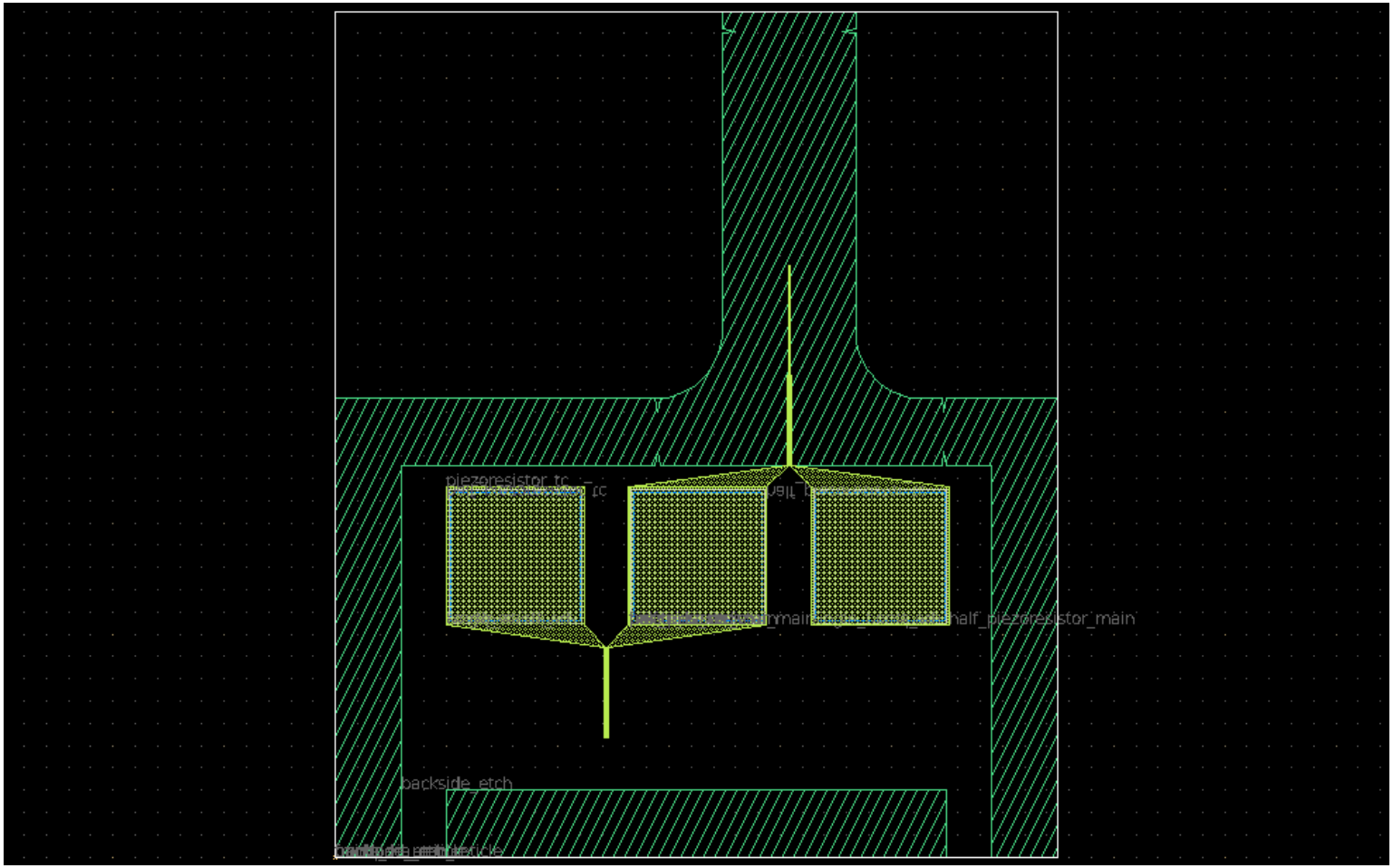
- Fast Cantilever Fabrication
- ETH Worm Data



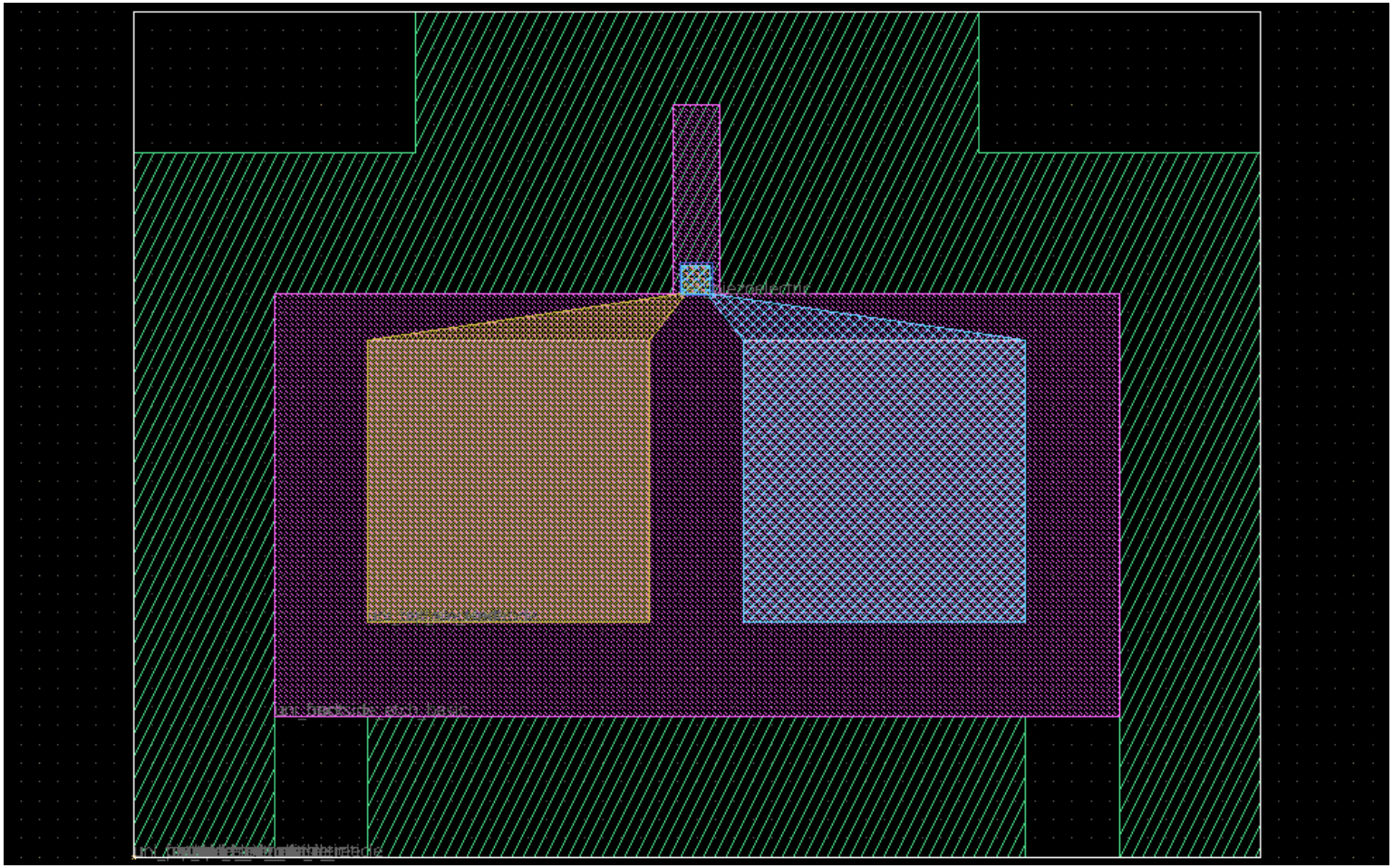
Fast Cantilever Status Update

- Mask design complete
- Mask is not being made yet by vendor to allow time for creating job file, will not affect timing (September now)
- Three device types
  - Piezoresistor only (4 layers, 19 design variations)
  - Piezoelectric unimorph actuator only (6 layers, 4 design variations)
  - Piezoresistor and piezoelectric (7 layers, 5 design variations)

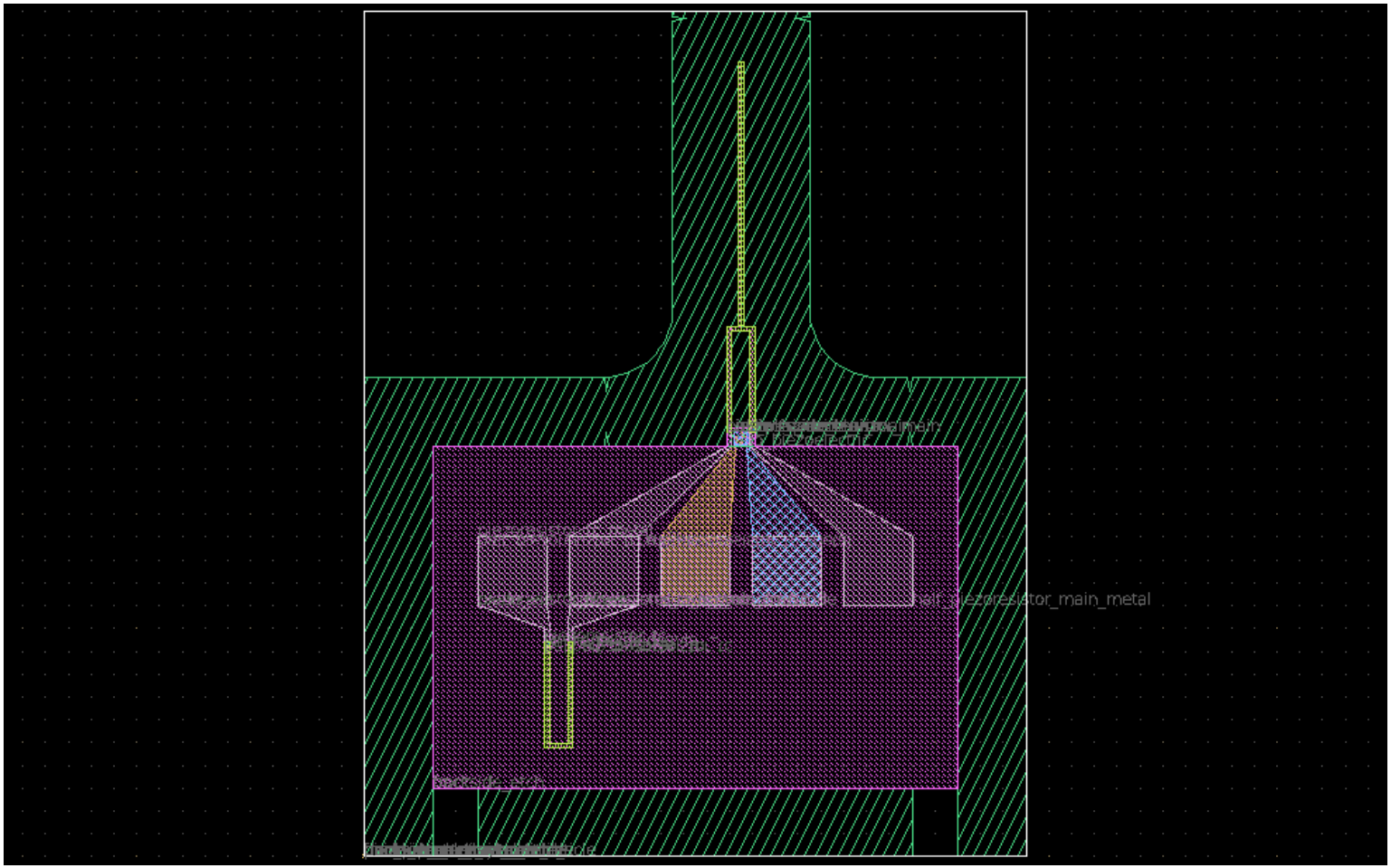
Piezoresistor Only



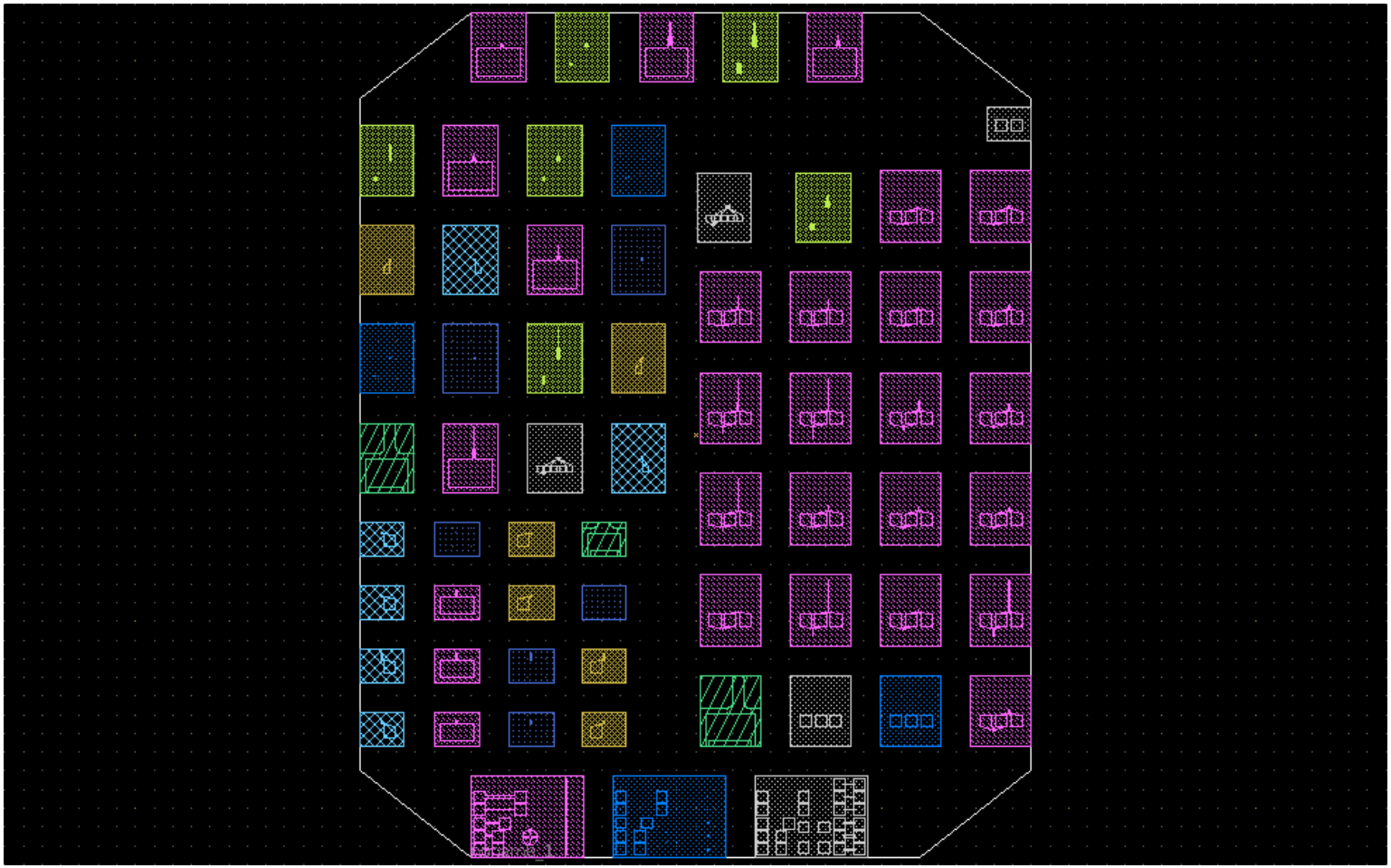
Piezoelectric Only



Piezoresistor and Piezoelectric



Reticle Layout



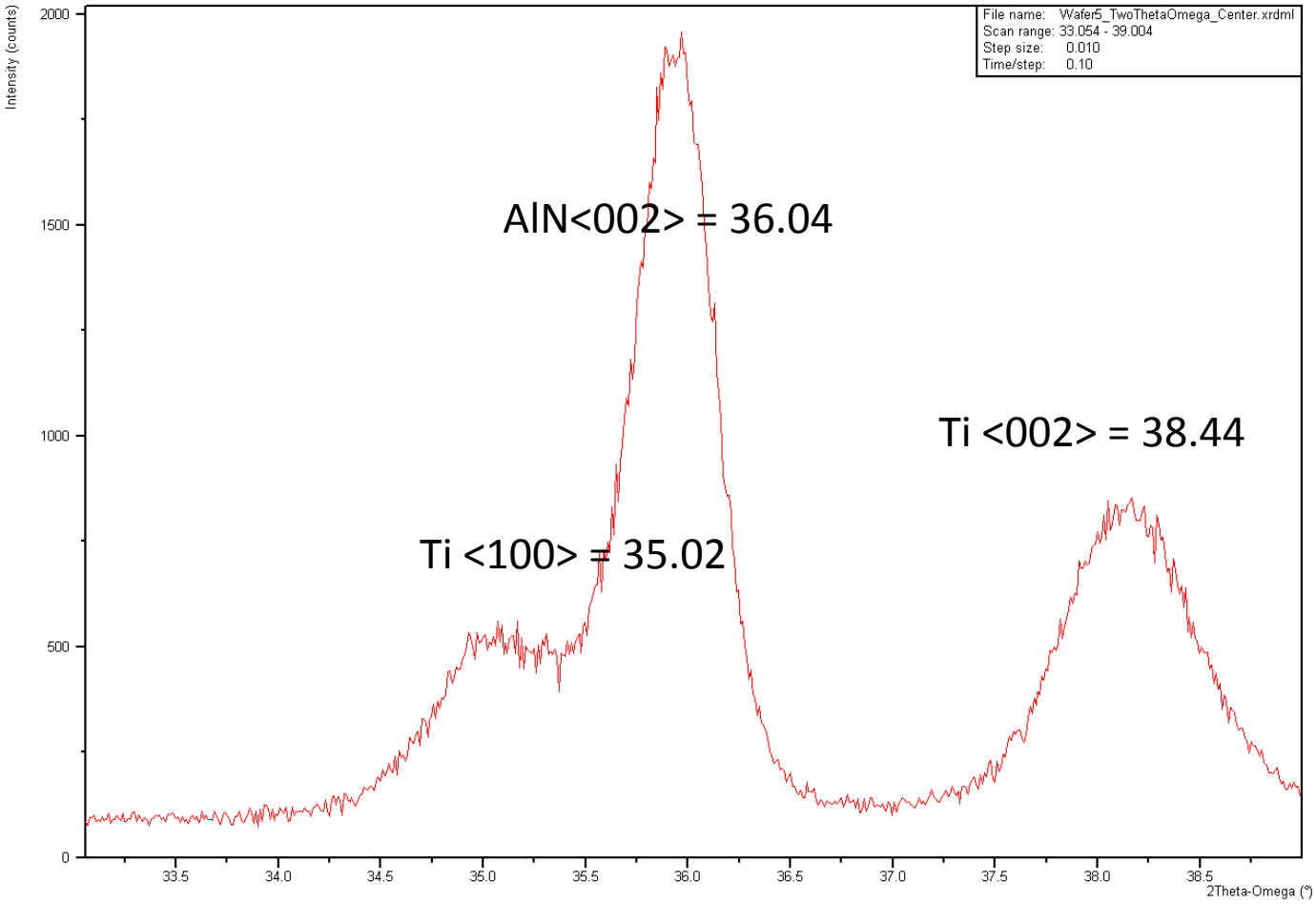
Designs and Force Resolution

- Current designs for 0.3, 2, 5 and 10 micron device layer thicknesses (fabricating 2, 5 and 10 initially)
- Starting with thicker cantilevers to robustness, used to validate design methodology
- Designed performance
  - 10Hz – 1kHz: 1.5 pN (0.3um), 5 pN (2um)
  - 1Hz – 20kHz: 10 pN (0.3um), 120 pN (2um)
  - 1Hz – 50kHz: 35 pN (0.3um), 278 pN (2um)
  - 1Hz – 100kHz: 60 pN (0.3um), 576 pN (2um)
  - 1Hz – 200kHz: 100 pN (0.3um), 1.16 nN (2um)
- Notes
  - Power < 10mW, V_{bias} < 5V
  - Resonant freq in vacuum = 5x max freq (water freq ~3x)
  - Q varies from 0.5 to 5 in water

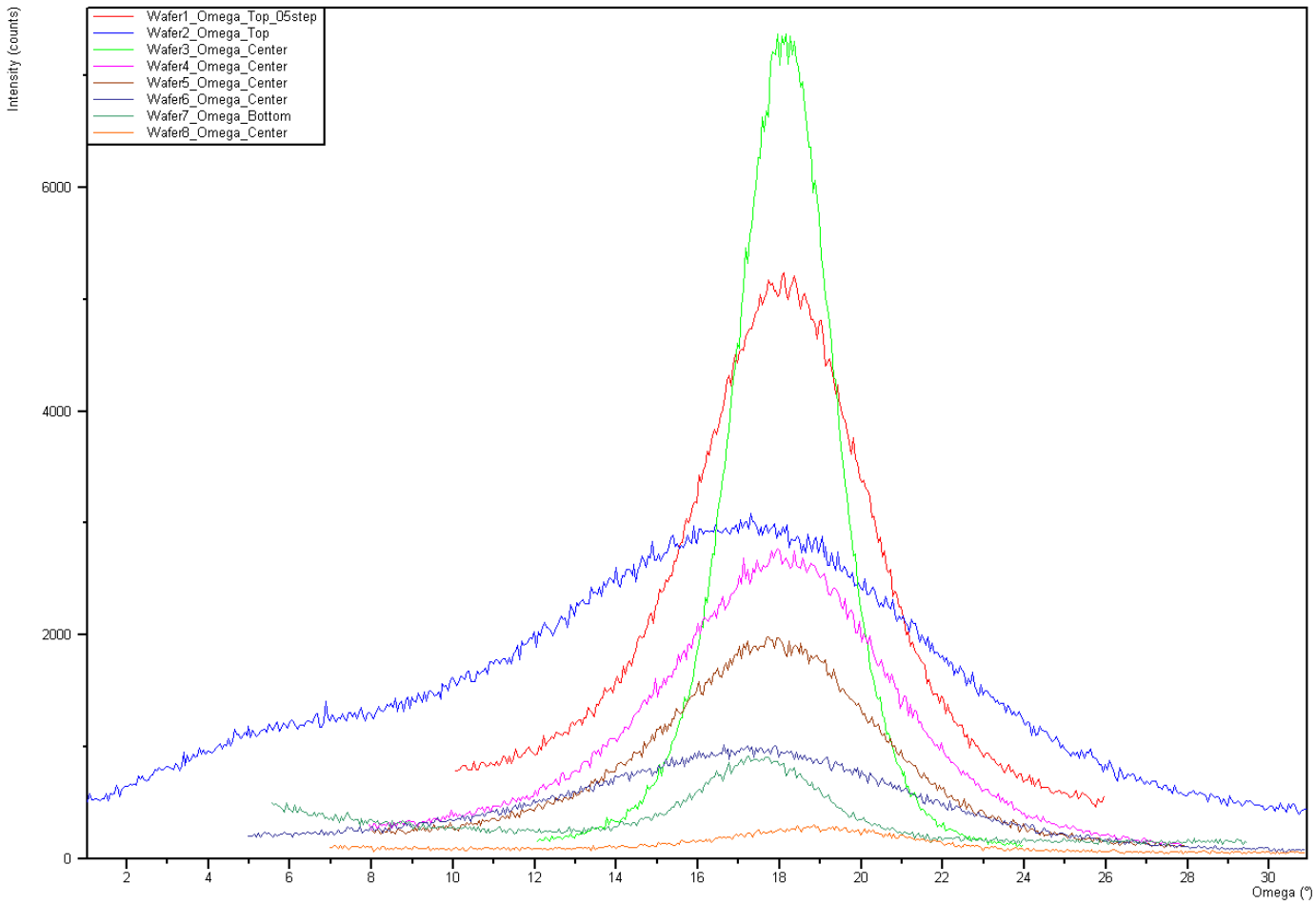
Current Work

- Characterizing aluminum nitride piezoelectric actuator
  - Finished first round of XRD (looking good) and AFM
  - Working on thickness characterization
  - Vendor has deposited additional samples around conditions identified as good in first round of testing
- Driving and PI control circuit
  - Put some thought into it pre-Zurich, not much since
  - Analog with bank of resistors and capacitors for gain control
- Characterization on the AFM (freq and spring constant)

X-Ray Diffraction

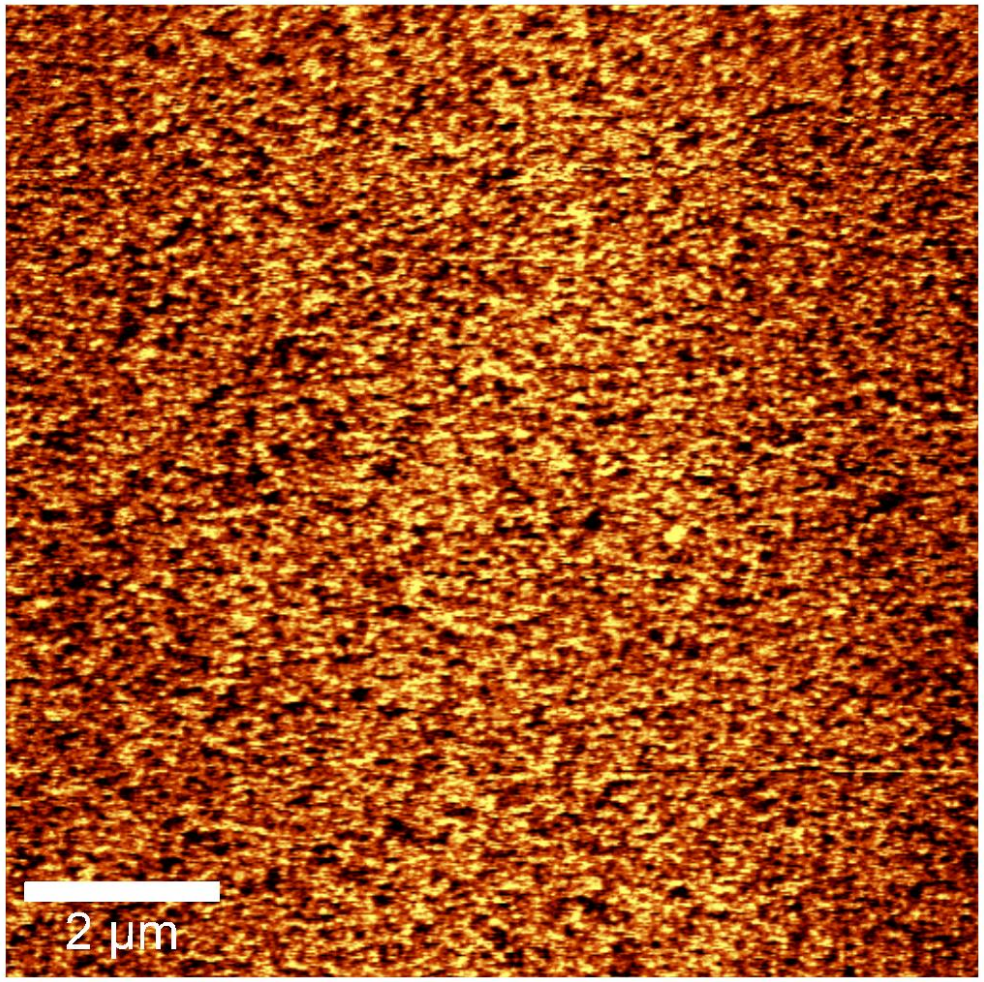


X-Ray Diffraction

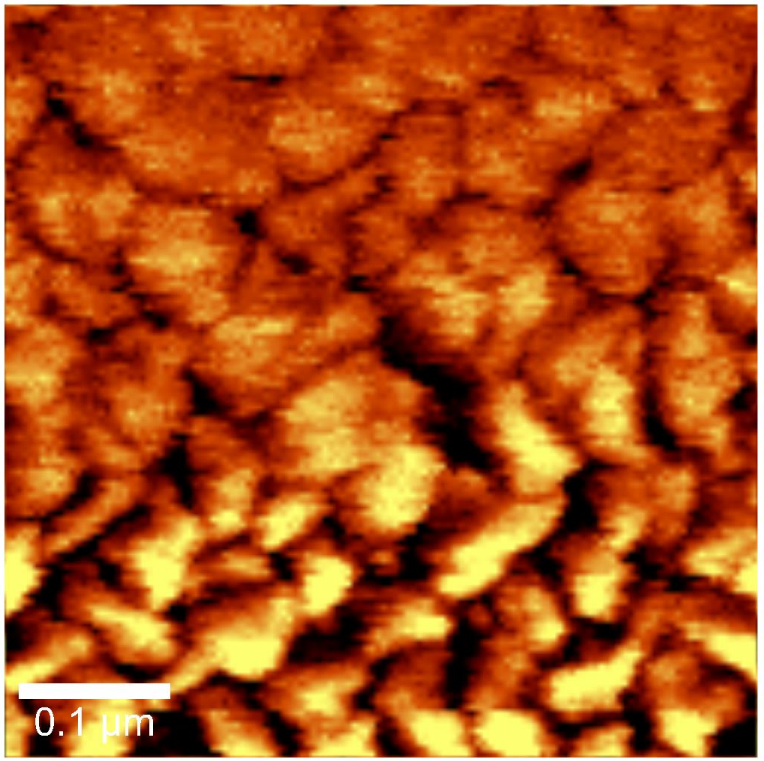


AFM on Aluminum Nitride

Topography (roughness)

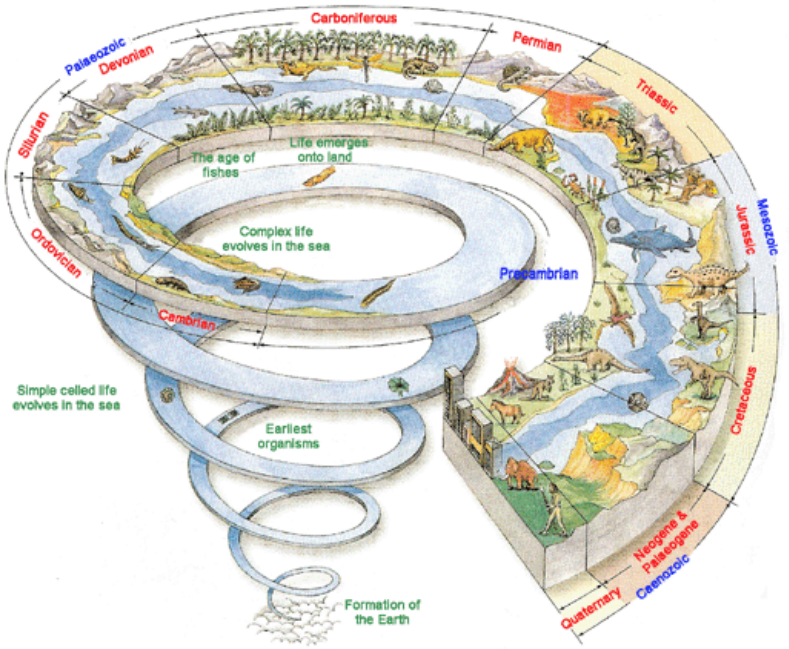


Phase (grain size)



Timeline

- **September**: Fabrication
- **October**: Fabrication and characterization
- **November**: Characterization and circuits



ETH Worm Data

- Four strains measured (N2, HA1134, OSM9, OCR2)
- Data from 3/27-4/2 (silicon force sensor tip)
  - Quantified peak force only
  - Had issues with agar sticking to tip, rounding it
  - Large size of probe tip (50 x 50 microns) obscured view of touch location on worm
- Data from 5/12 (tungsten wire tip)
  - Have not analyzed yet
  - Finer tip (approx. 1 micron) worked really well
- Synchronized L4 worms moved freely on 2% agar unseeded plates
  - Constraining worm movement (sinusoidal PDMS channels) would make the measurements easy enough to be used as a screening tool
- Analyzing tungsten data now, will reanalyze earlier data

ETH Worm Data

- Details
  - Identify measurement times
  - Record screenshot for easy later reference
  - Extract some parameters automatically, some manually

Strain	Worm #	Time (s)	Stage Moving	Worm Response	Distance from Nose (um)	Force Duration (s)	Incident Angle (deg)	Peak Force (uN)	Peak dF/dt (N/s)
N2	1	79.533	No	Yes					
	1	124.332	Yes	Yes					
	2	48.922	No	Yes					
	3	132.469	No	No					
	3	357.764	Yes	Yes					
	3	367.03	Yes	Yes					
	3	482.154	Yes	Yes					