

Biomimetic Micro-Structures

Three-dimensional biomimetic artificial muscles for micro-robotic applications

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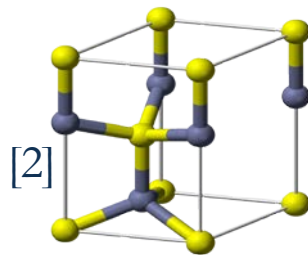
Southeastern Undergraduate Internship
in Nanotechnology, NSF EEC-1757579

Objective

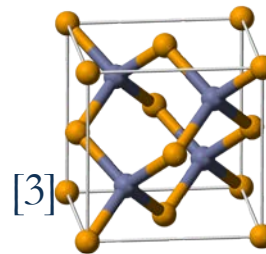
- + Produce a significant displacement and force.
- + Rely on low voltage for efficiency.

Constraints

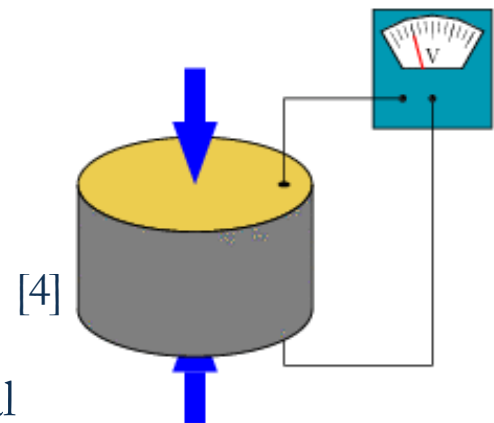
- + Inverse piezoelectric effect: when the voltage potential is applied to the structure it will expand in the same direction.
- + Reach for work density of $\sim 0.04 \text{ J/cm}^3$ or better than that of human muscle tissue.
- + Wurtzite crystalline arrangement
- + Zinc Oxide



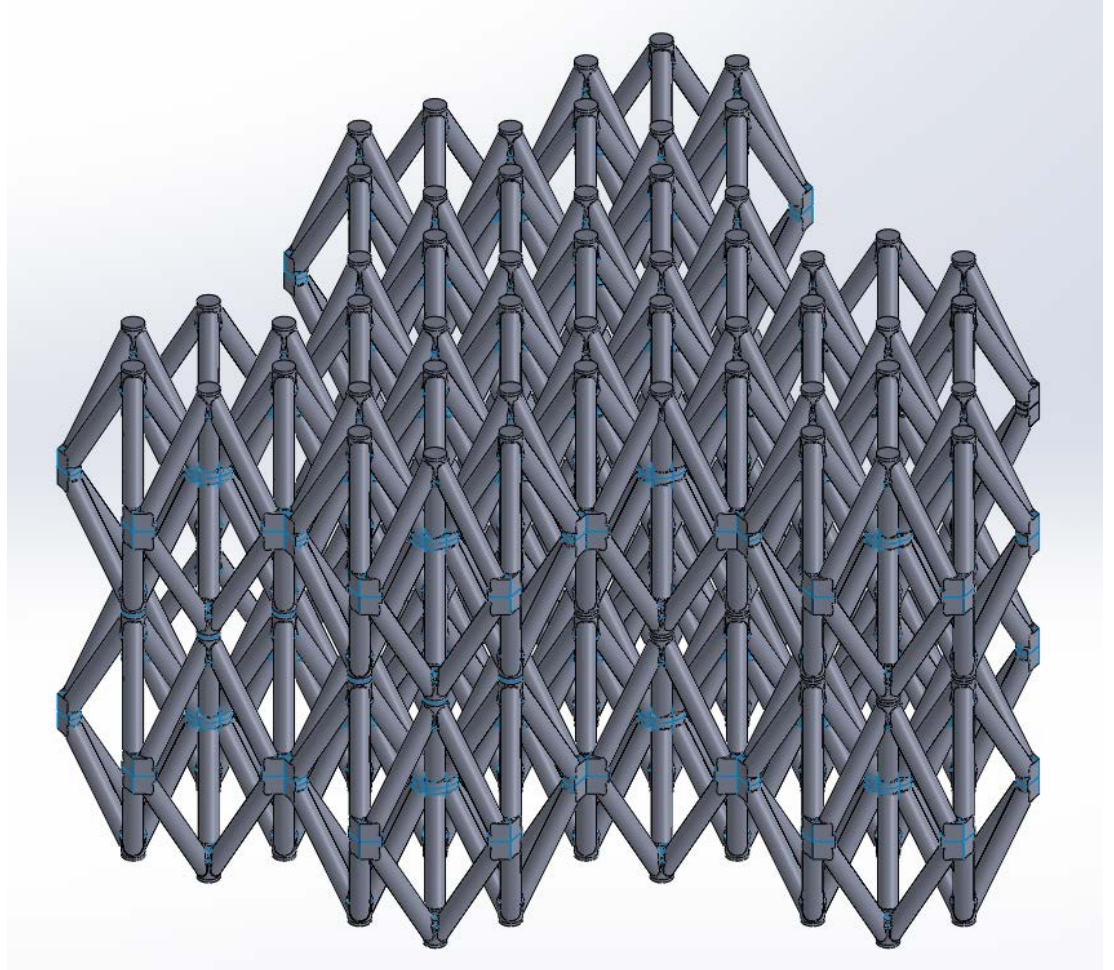
Wurtzite



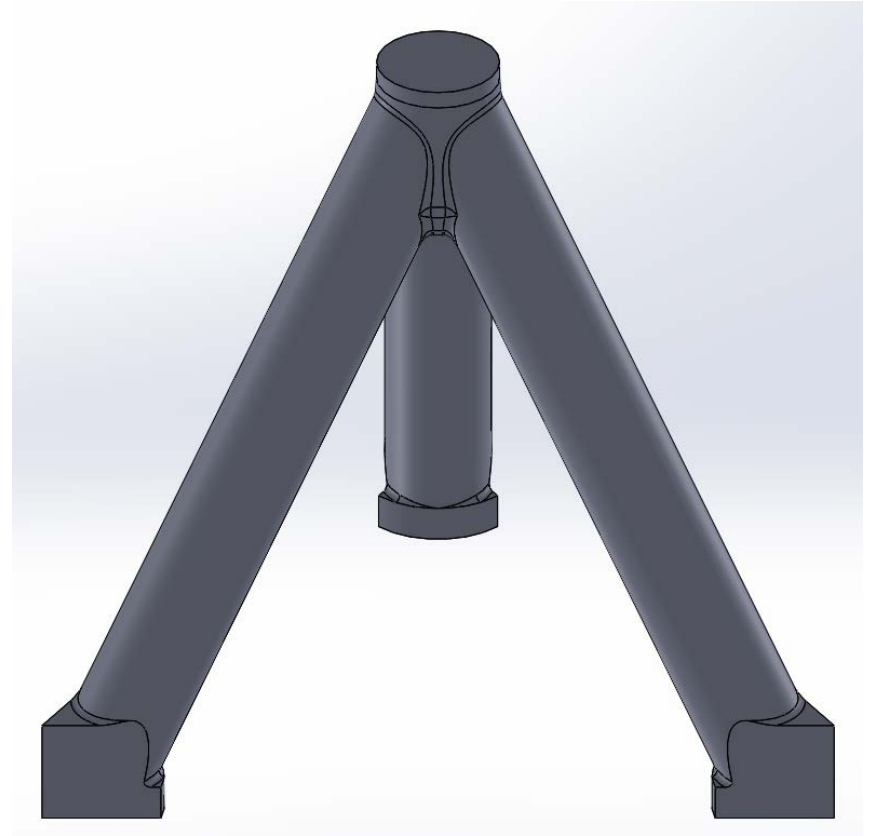
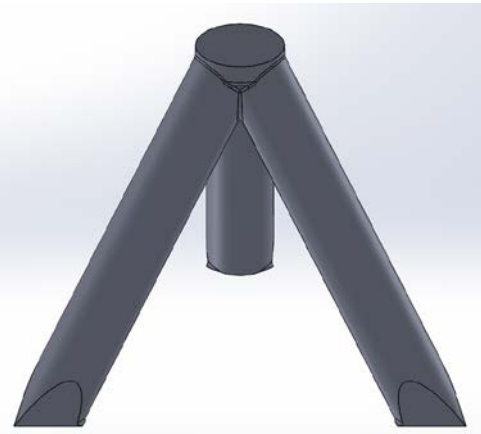
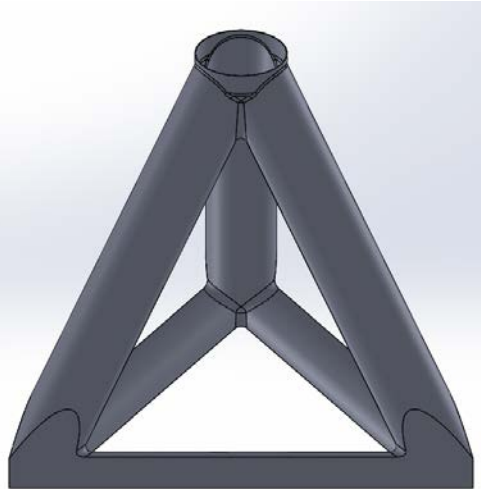
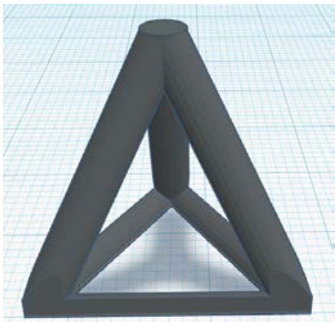
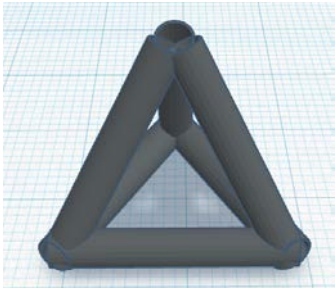
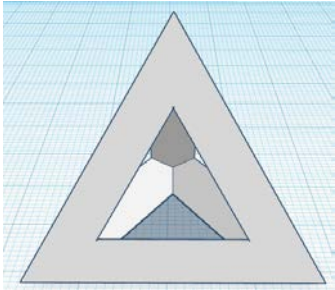
Zincblende Cuboidal



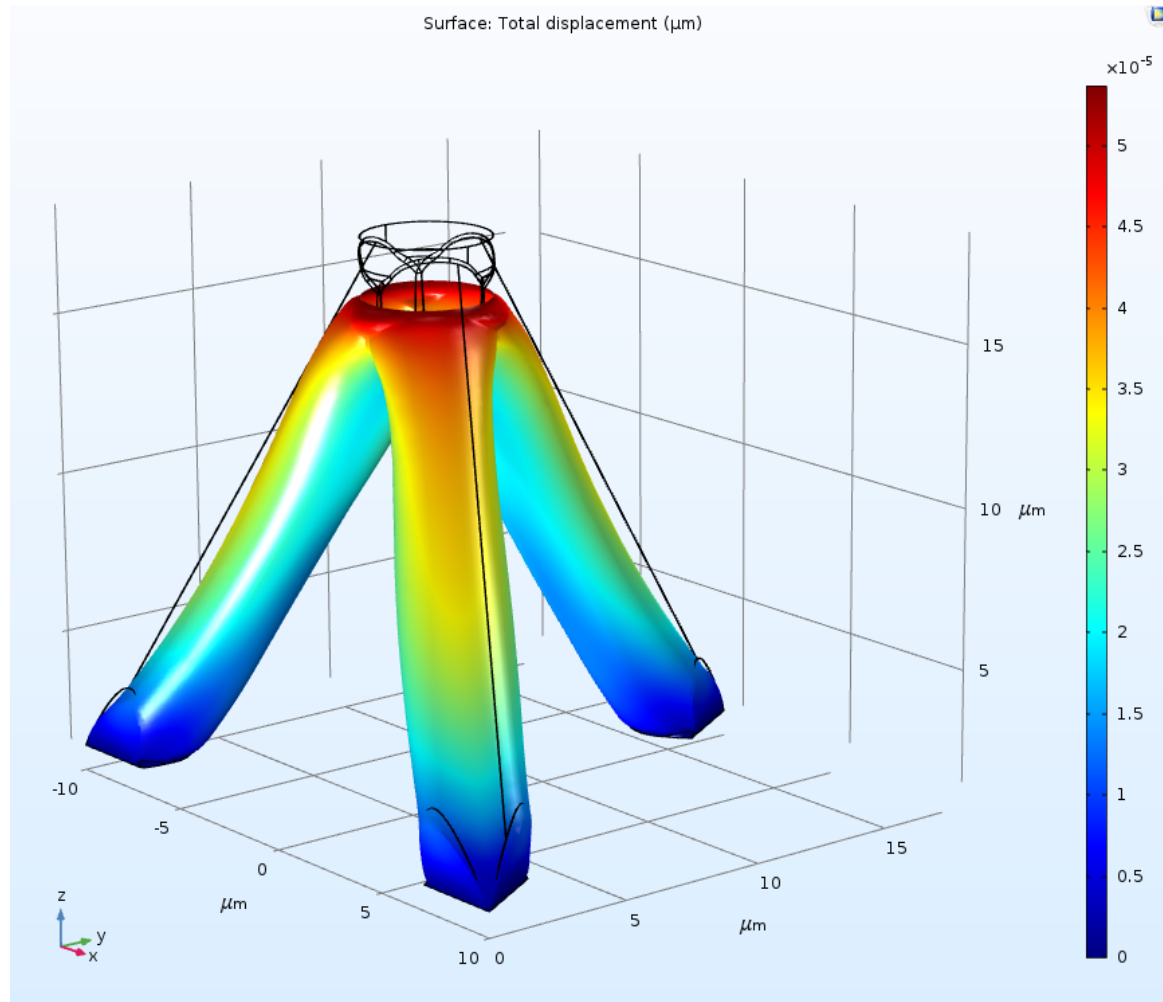
Model design



Model design

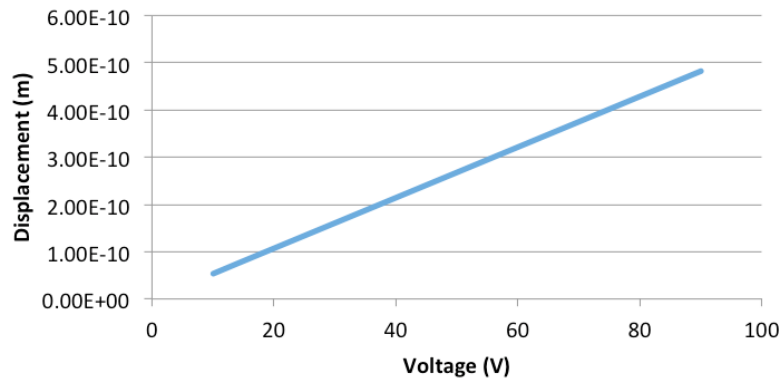


COMSOL Testing

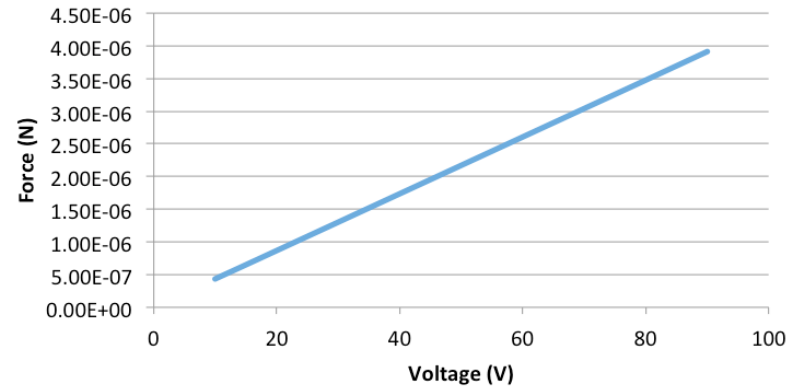


COMSOL Results

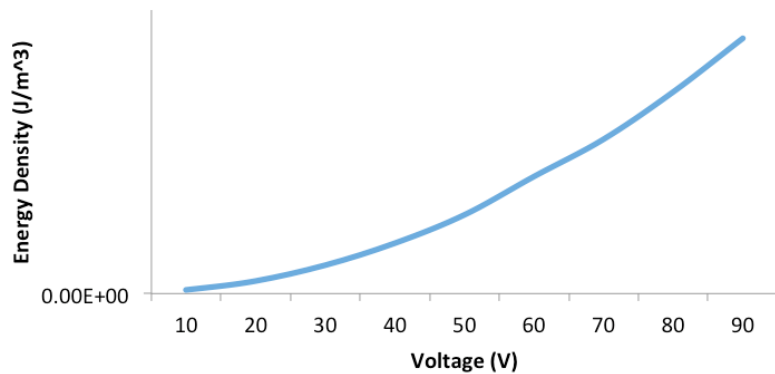
Displacement (m)



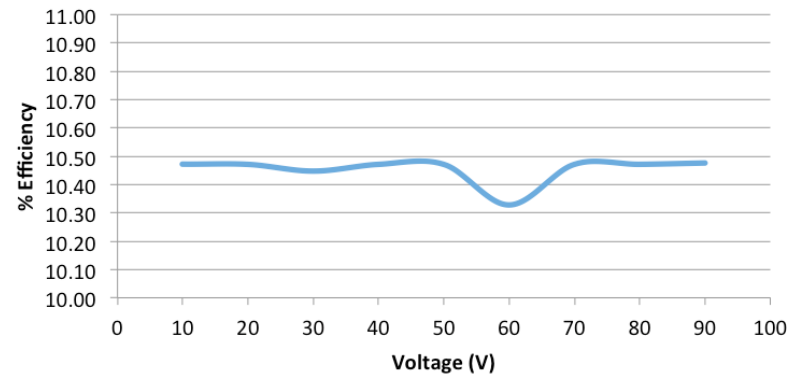
Force (N)



Energy Density

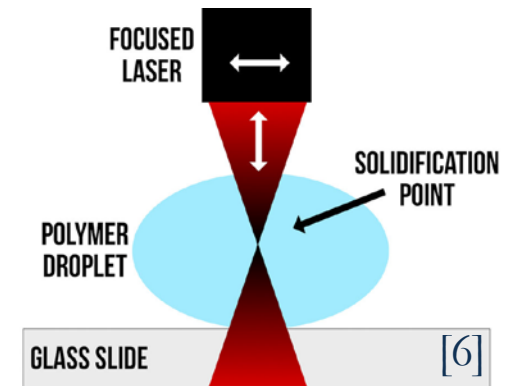
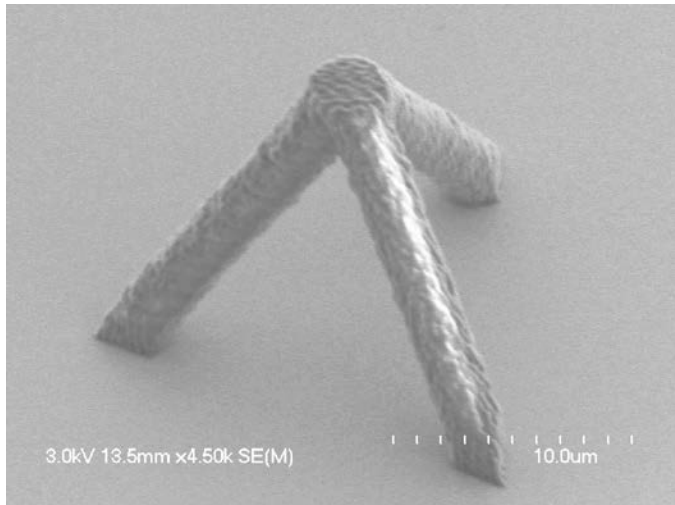


% Efficiency

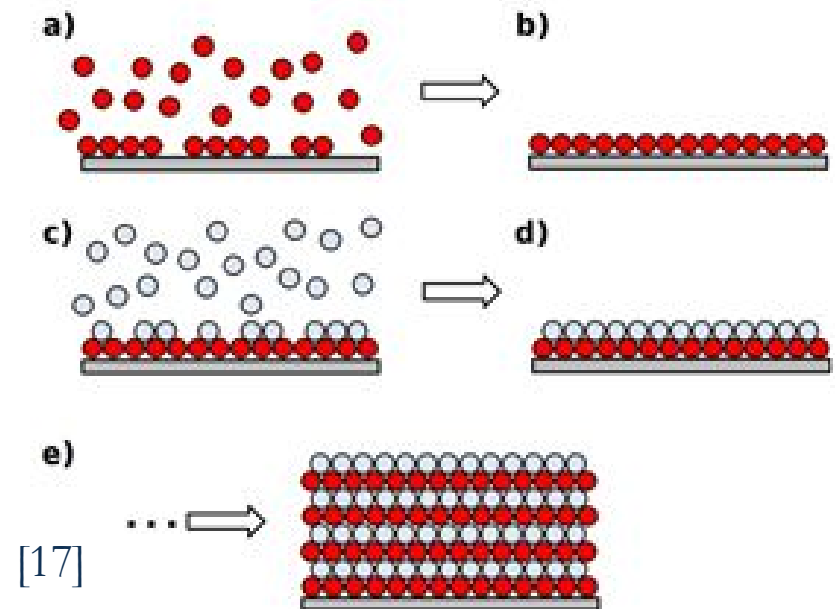
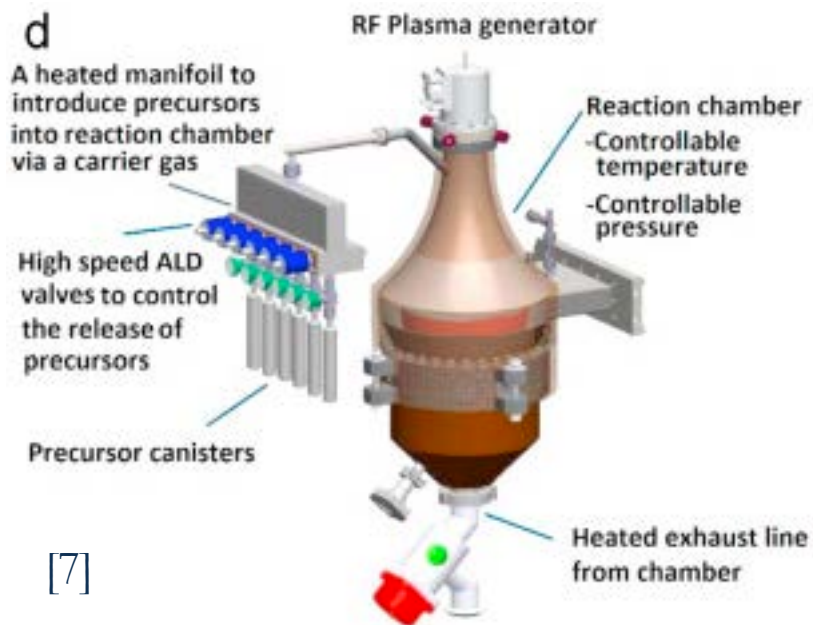


Model print

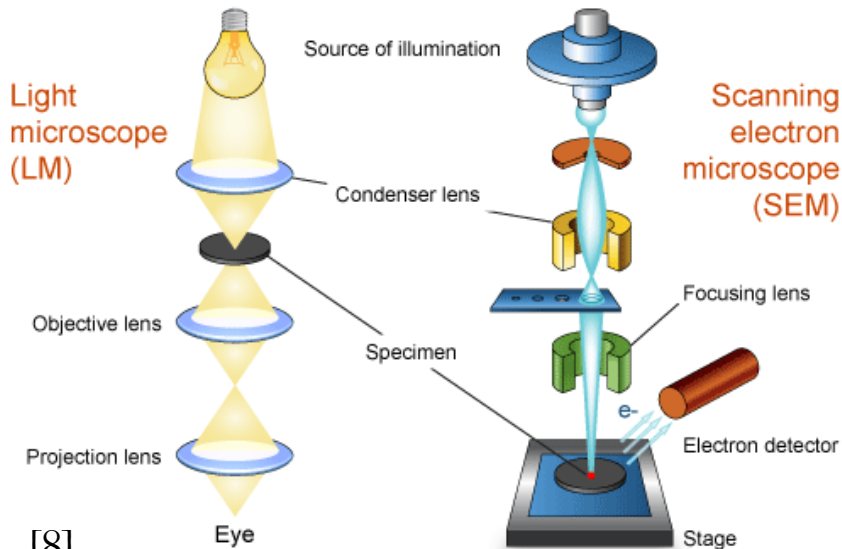
- + Nanoscribe: Two-photon lithography polymerization.
- + IP-Dip photoresist on 0.7mm ITO Glass substrate.



Atomic Layer Deposition (ALD)



Scanning Electron Microscopy (SEM)



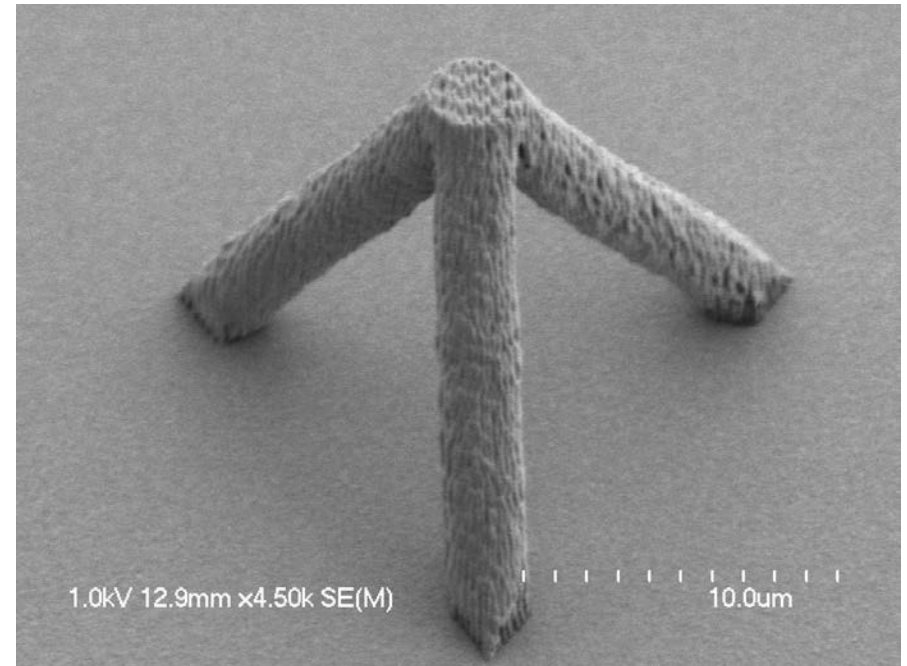
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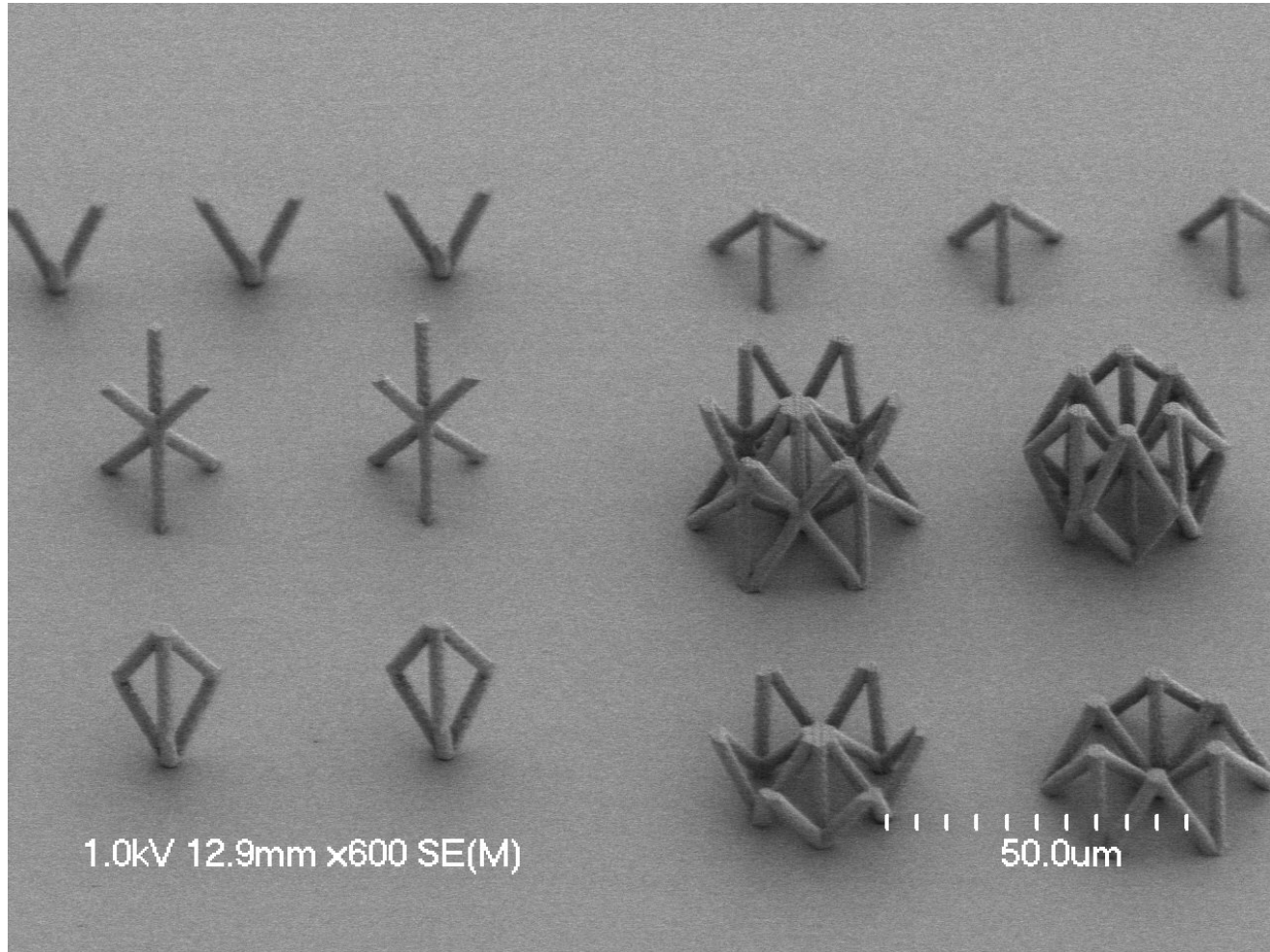
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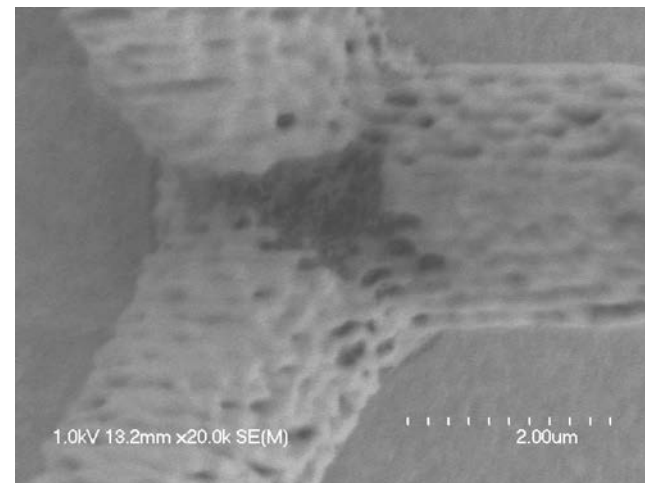
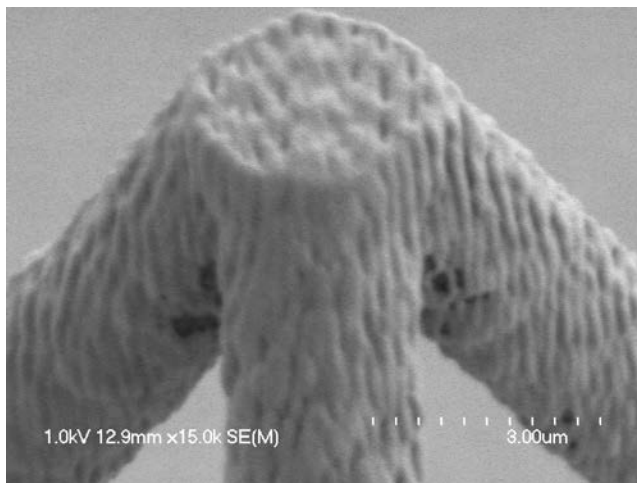
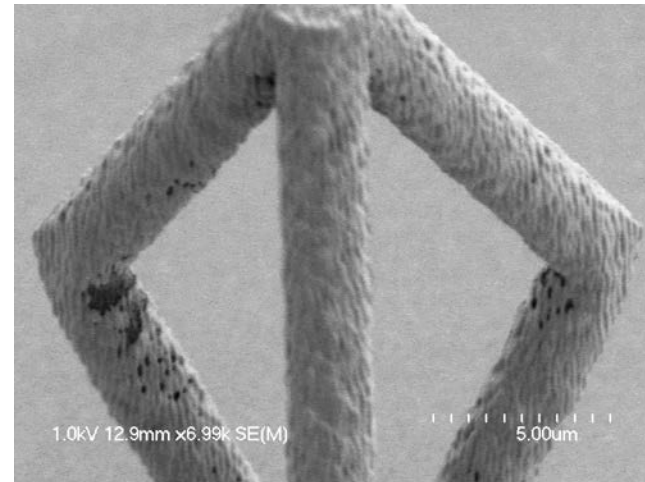
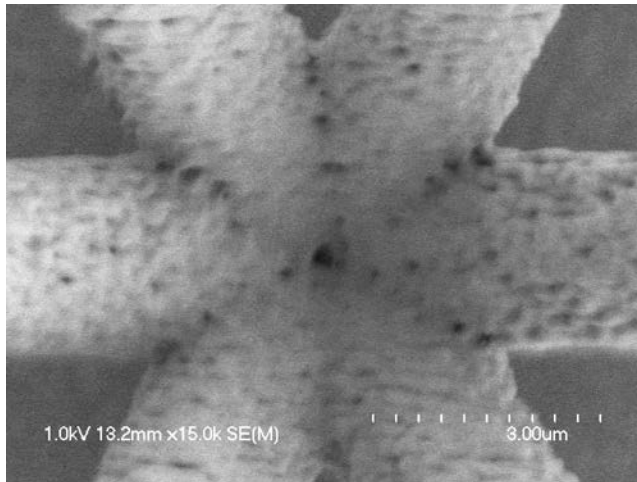
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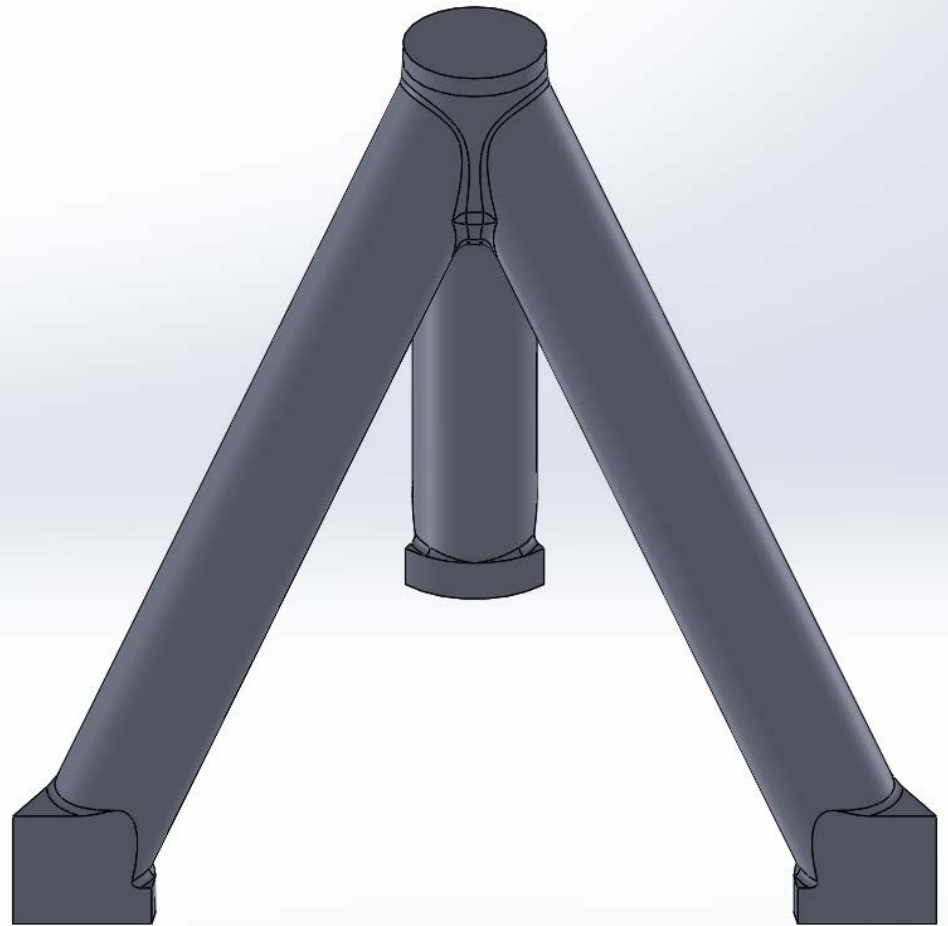
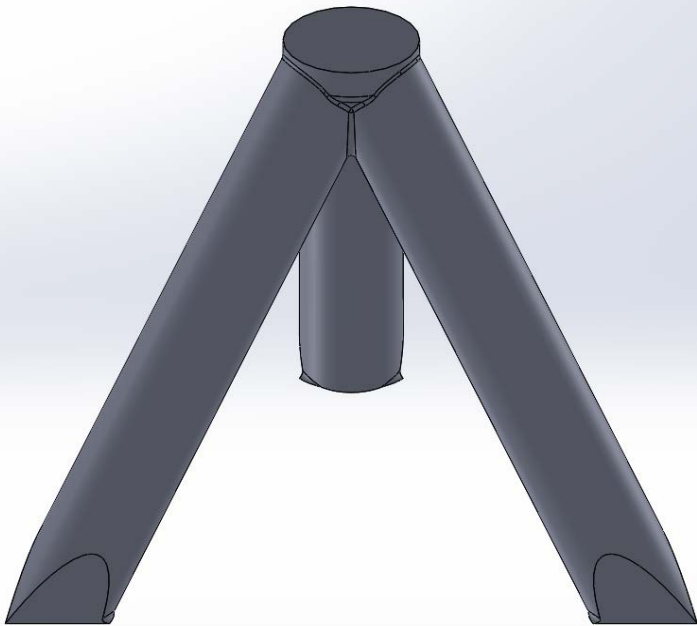
Possible Structures



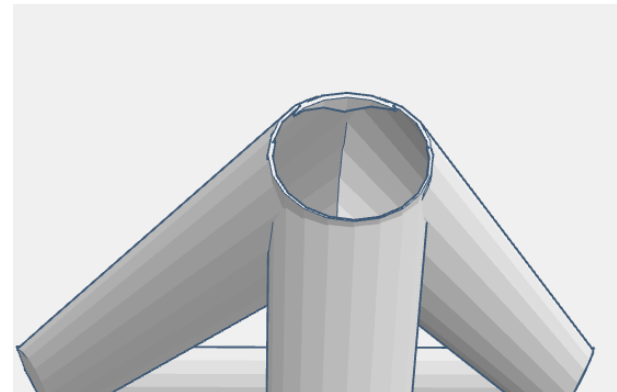
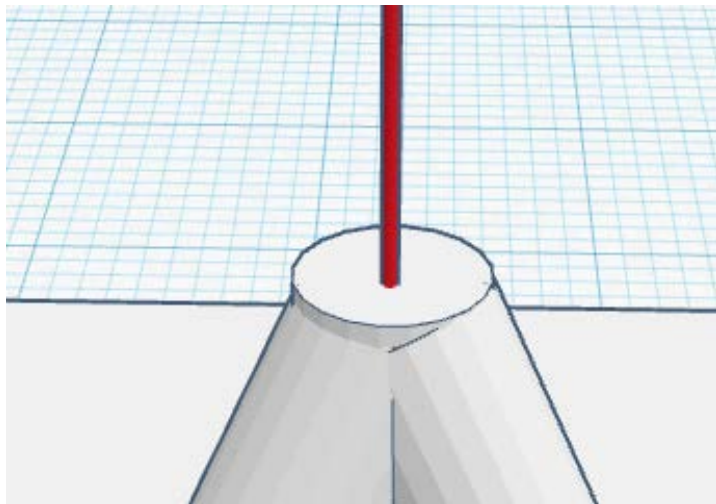
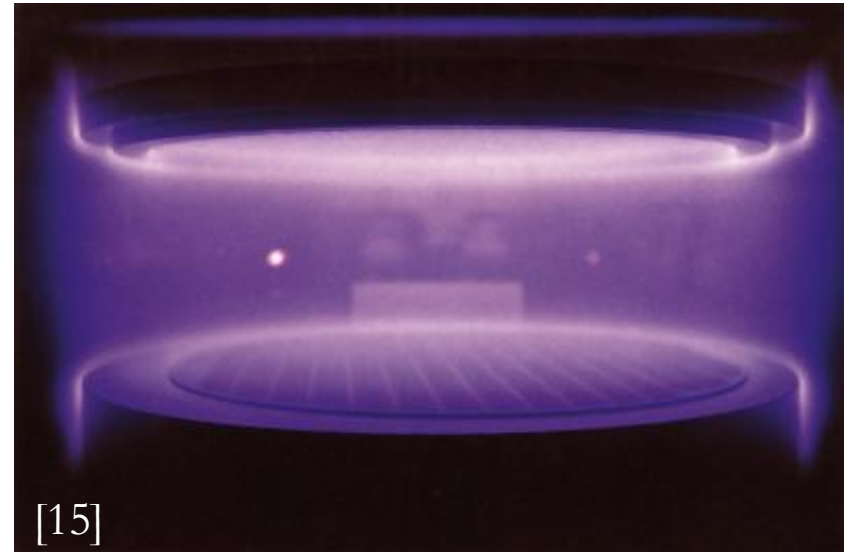
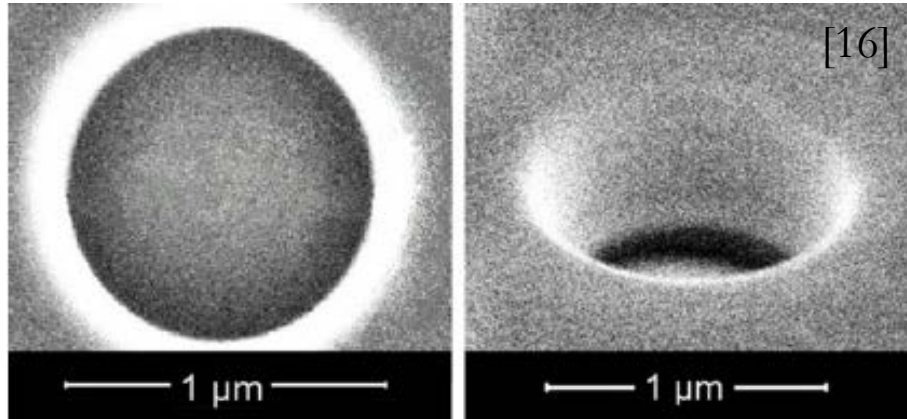
ALD Results



Model Refinement

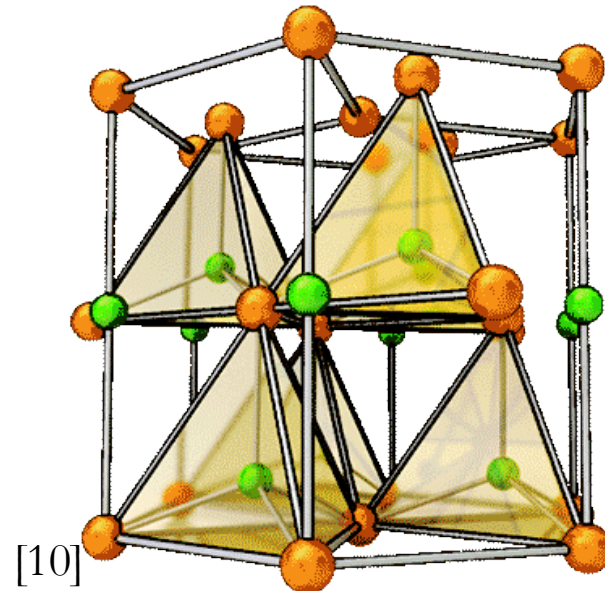
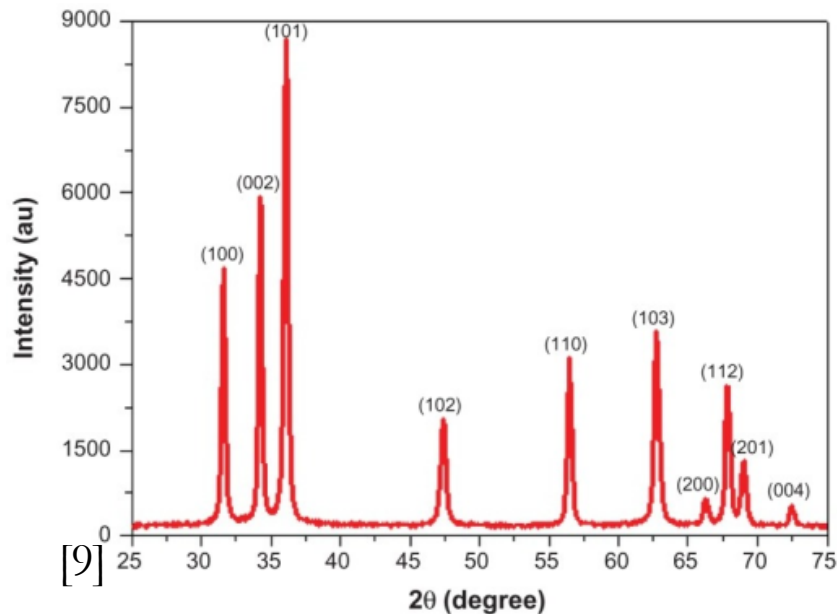


Focused Ion Beam (FIB) and Plasma



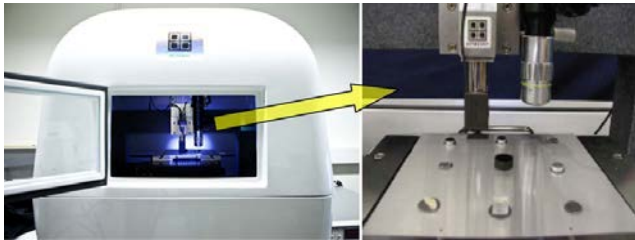
X-Ray Diffractometer (XRD)

- + Ensure the crystalline structure of ZnO to be Wurtzite.
- + Crystal normal to surface of model.

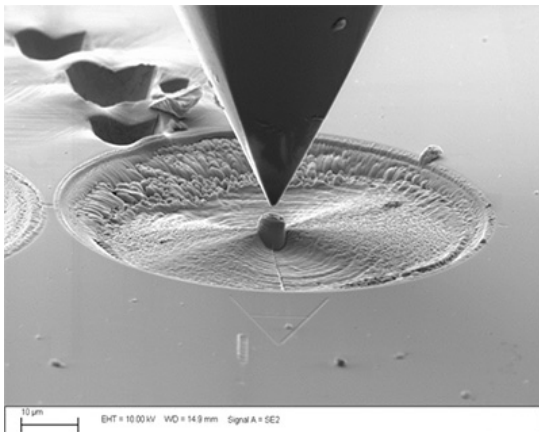


Passive stress test

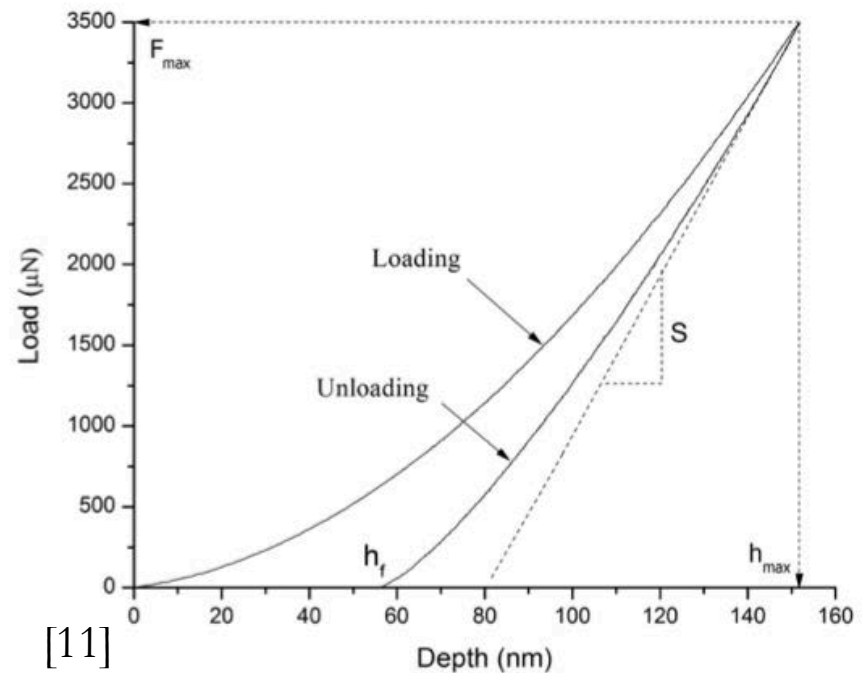
- + Hysitron Triboindenter: stress, displacement and structure resilience.
- + Experimental Young's modulus



[12]



[13]



Active stress test

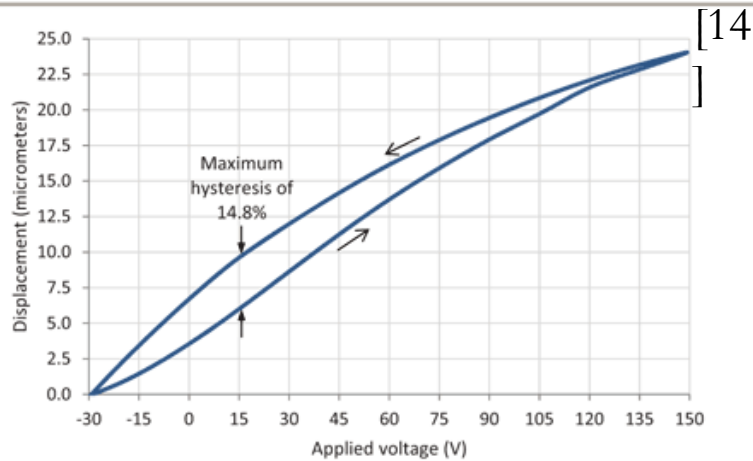


Figure 2. Typical hysteresis curve of a piezoelectric stack actuator operating from -30 V to +150 V.

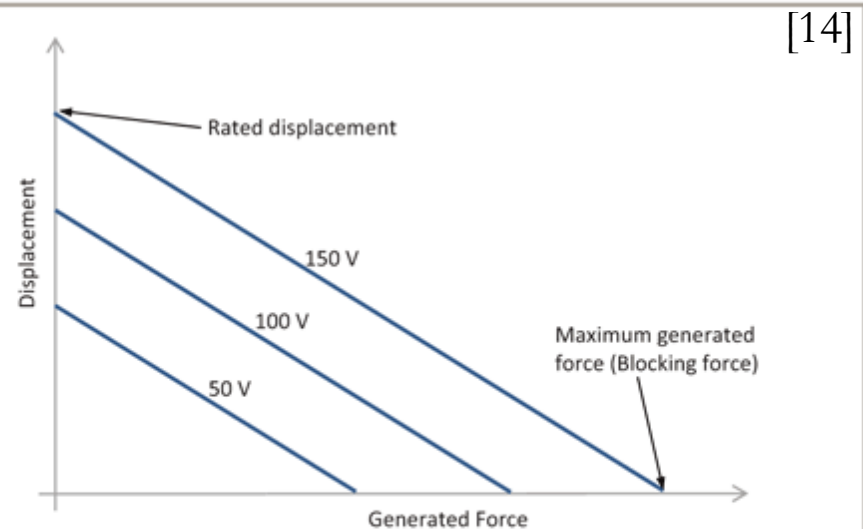
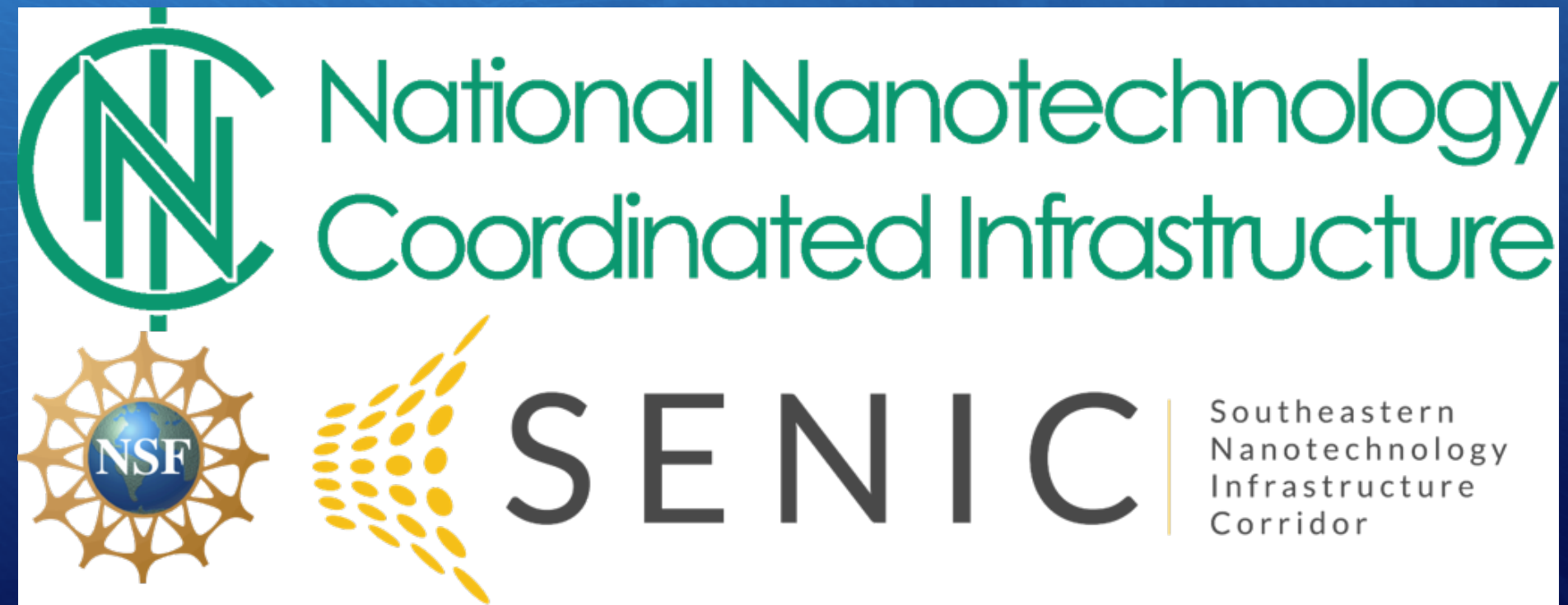


Figure 3. Force vs. displacement output of a piezo actuator at various applied voltages.

Questions

Thank you



Sources

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