

Department of Electrical and Computer Engineering

# High Temperature, Flexible, Piezoelectric Transducers Based on Nylon-11 Nanowires

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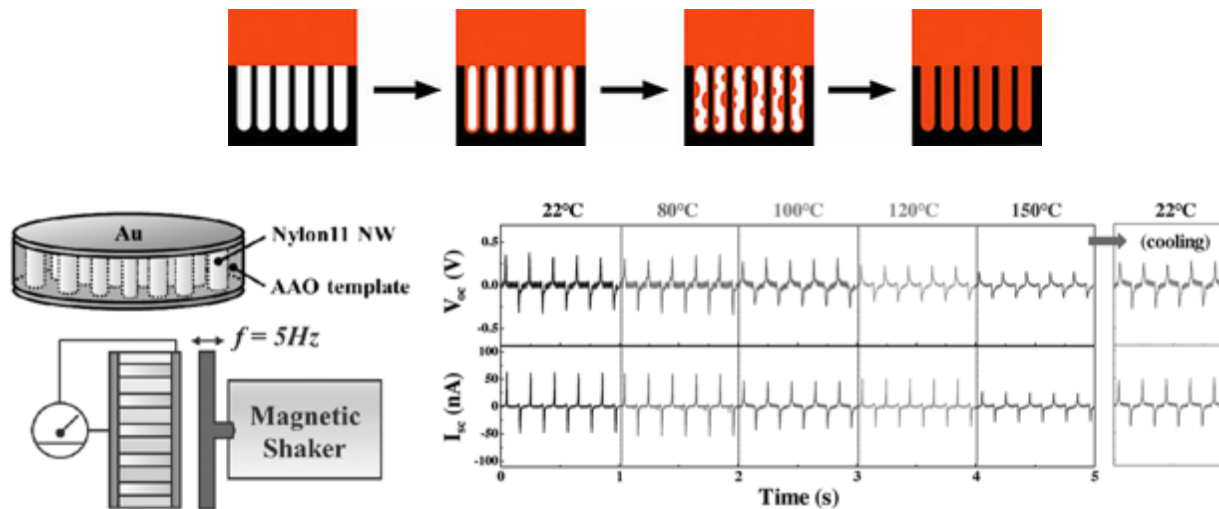
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The University of Akron  
College of Engineering

# Background

## Nylon-11 Nanowires via Template Wetting



# Initial Experimentation

Nylon-11 Nanowires using chemical etching



# NT1: Design & Construct Apparatus for Nanotemplate Synthesis of Nylon-11 Nanowires

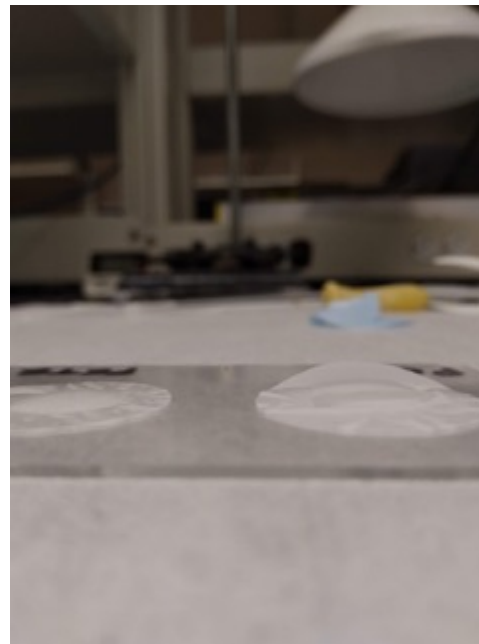
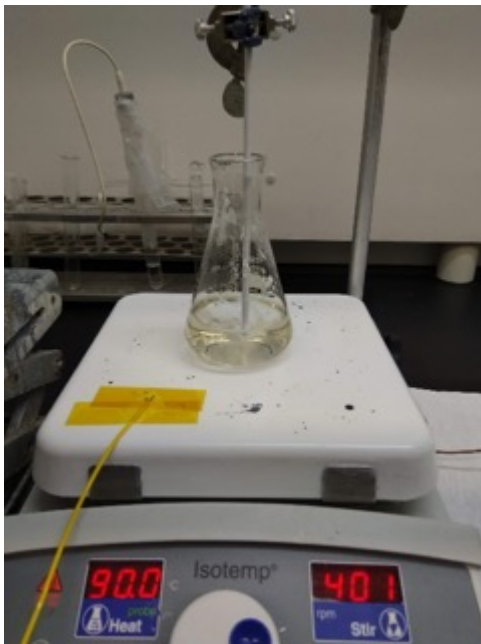
- Details of Nylon-11 Solution Procedure/Recipe:
  1. Put 50 mL of formic acid (>88.0% ACS, VWR BDH4554-500ML) on a hotplate in a 125-mL Erlenmeyer flask (which reduces loss of solution to evaporation by collecting condensation on slanted walls).
  2. Place tip of hotplate probe (a type K thermocouple) about 1 cm below surface of solution and set temperature to 70 °C. Actual hotplate surface temperature will be much higher ~135 °C.
  3. Place 1" x 5/16" spinbar in solution and set cyclic frequency to 300 RPM.
  4. Wait for temperature to stabilize, then slowly mix in 12.2 g of nylon-11 pellets (3mm, Aldrich 181153-250G) to attain a 20 wt% solution. Adding too many pellets at one time will lead to "clumping." Mixture should be homogenized after about 2 hours.
  5. Pipet about 1 mL of solution into a shallow petri dish.
  6. Place template on top of solution and let dry (with or without laminar flow of air—depending on desired crystalline phase).

# Nanotemplate Synthesis of Nylon-11 Nanowires Procedure

Nylon-11  
Solution

Template  
Wetting

Response  
Measurement

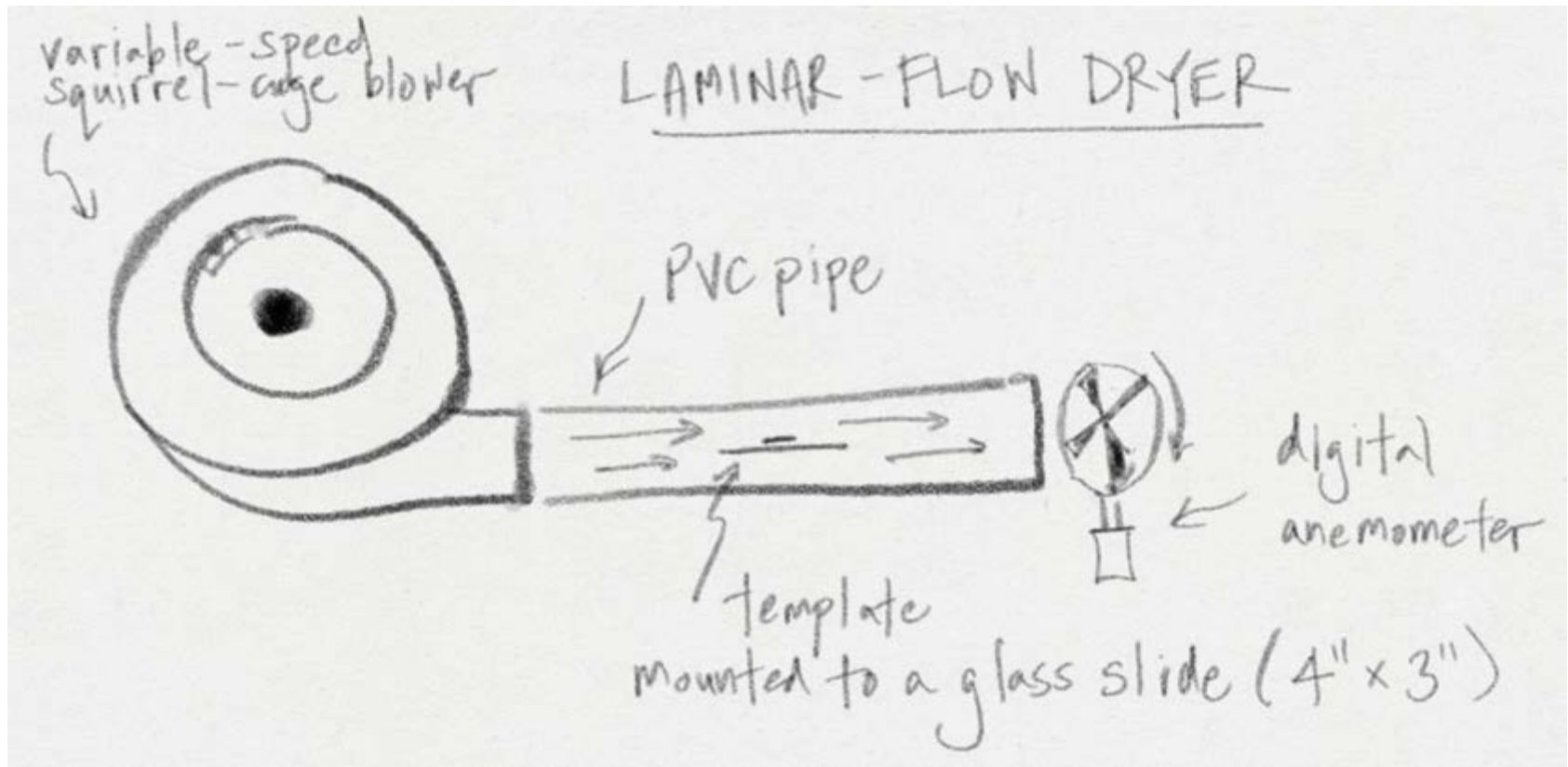


# Phase 1 Transducer R&D Task List:

Planned Actions	Key Results
Construct apparatus for template-wetting synthesis of nylon-11 nanowires.	Synthesize nylon-11 nanowires in flexible, track-etched polycarbonate membranes.
Retool electrospinning apparatus for nylon-11 nanofiber synthesis.	Synthesize nylon-11 nanofibers.
Scanning electron microscopy analysis.	Determine length and diameter of nanowires and nanofibers.
X-ray diffraction analysis.	Verify crystal direction aligned along major axis of nanowires and nanofibers.
Sputter gold electrodes in contact nylon-11 nanowires in flexible, track-etched polycarbonate membranes.	Realize a nanowire-based transducer with a parallel-plate configuration.
Electroplate coplanar electrodes in direct contact with electrospun nanofibers.	Realize a nanofiber-based transducer with a coplanar electrode configuration.
Construct apparatus for characterizing piezoelectric response to applied force.	Verify accurate application of force measured in units of Newtons.

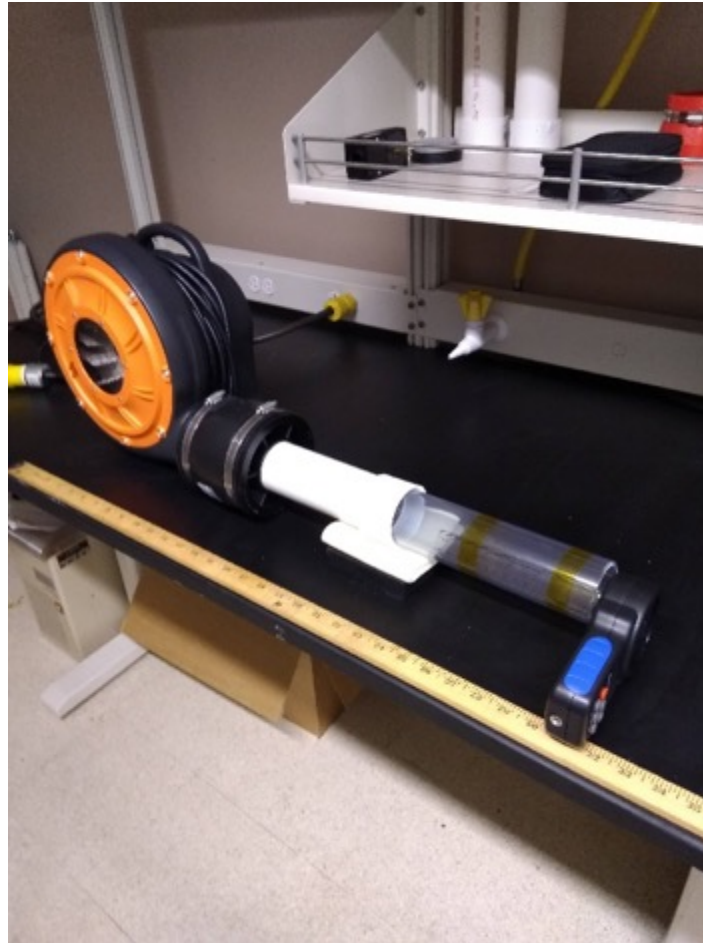
# NT1: Design & Construct Apparatus for Nanotemplate Synthesis of Nylon-11 Nanowires

Design of Drying System:





# Laminar-Flow Dryer (Physical Realization)





# **NT1: Design & Construct Apparatus for Nanotemplate Synthesis of Nylon-11 Nanowires**

## Other Efforts:

- Chemicals obtained (from Transene) for electroless plating – roughly 200 nm of gold plated copper
- Two separate fume hoods set-up: one for nylon-11 nanowire template synthesis and one for electroless plating
- Two new Scanning Electron Microscopes (SEMs) on same floor as our chemical laboratory Tescan FE-SEM (\$60/hr) and Hitachi Tabletop SEM (\$35/hr, lower resolution for magnification up to 10,000x)

## Other Ideas:

- Use desktop laser cutter for trimming templates after electroless plating.

# Acknowledgement

**Sincere gratitude to my advisor**  
**Dr. Ryan Toonen**



# References

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