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

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Background

Nylon-11 Nanowires via Template Wetting
Initial Experimentation

Nylon-11 Nanowires using chemical etching
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

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## Phase 1 Transducer R&D Task List:

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<th>Planned Actions</th>
<th>Key Results</th>
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<td>Retool electrospinning apparatus for nylon-11 nanofiber synthesis.</td>
<td>Synthesize nylon-11 nanofibers.</td>
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<td>Scanning electron microscopy analysis.</td>
<td>Determine length and diameter of nanowires and nanofibers.</td>
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<td>X-ray diffraction analysis.</td>
<td>Verify crystal direction aligned along major axis of nanowires and nanofibers.</td>
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<td>Sputter gold electrodes in contact nylon-11 nanowires in flexible, track-etched polycarbonate membranes.</td>
<td>Realize a nanowire-based transducer with a parallel-plate configuration.</td>
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<td>Electroplate coplanar electrodes in direct contact with electrospun nanofibers.</td>
<td>Realize a nanofiber-based transducer with a coplanar electrode configuration.</td>
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<td>Construct apparatus for characterizing piezoelectric response to applied force.</td>
<td>Verify accurate application of force measured in units of Newtons.</td>
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NT1: Design & Construct Apparatus for Nanotemplate Synthesis of Nylon-11 Nanowires

Design of Drying System:
Laminar-Flow Dryer (Physical Realization)
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


