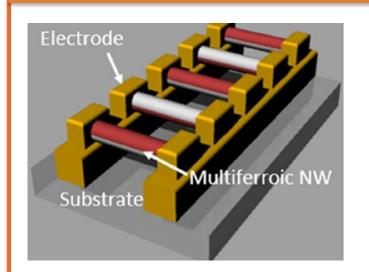
Development of a Passive Magnetic Field Sensor Utilizing Magnetoelectric Nanowires

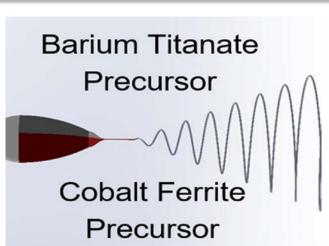
Herbert Wertheim College of Engineering UNIVERSITY of FLORIDA

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Passive Magnetic Field Sensor



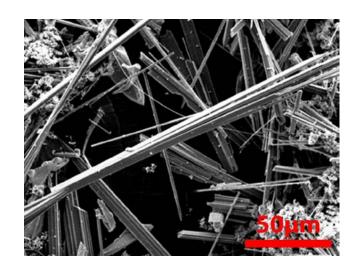


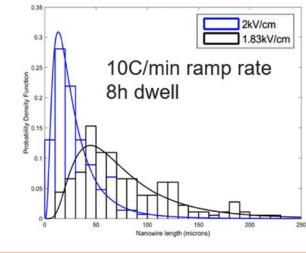


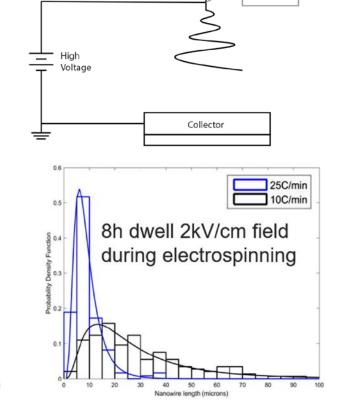
- Synthesis of biphasic cobalt ferrite and barium titanate nanofibers via electrospinning
- Janus nanowire (NW) formation via the controlled break up of nanofibers during a salt calcination
- Assembly of nanowires to form ordered arrays on inter-digitated electrodes using dielectrophoresis
- Characterization of the magnetoelectric property of the nanowires

Nanowire Fabrication

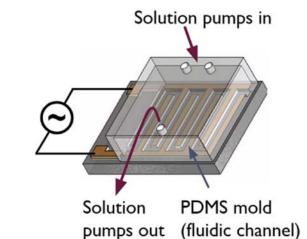
- We synthesized magnetoelectric Janus nanofibers via sol gel electrospinning
- A subsequent salt calcination with a fast ramp rate was used to quickly burn off the polymer from the fibers, shrinking them axially and breaking them apart into shorter nanowires
- Nanowire dimensions can be controlled by the electrospinning field and calcination ramp rate

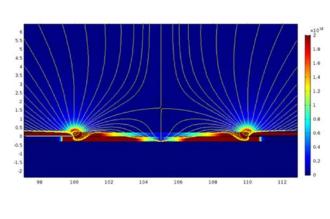


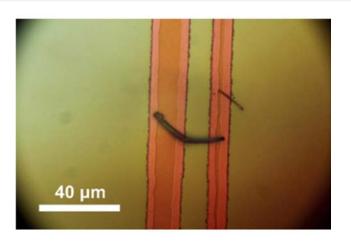




Electrical Assembly

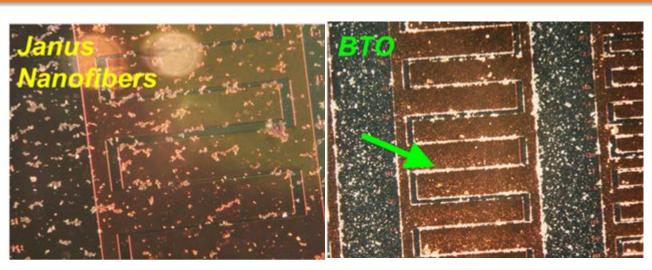


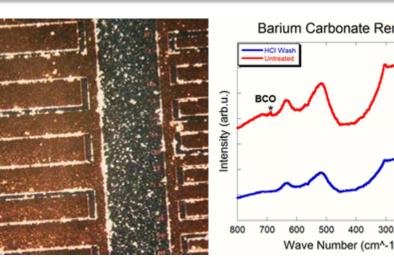


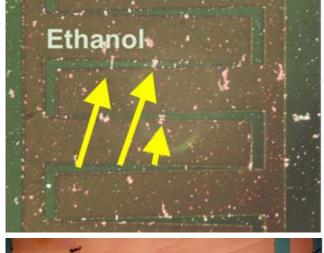


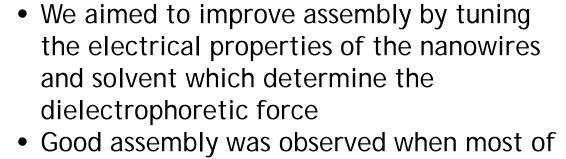
- We performed electrical assembly with water to arrange the nanowires across the electrode gap using the dielectrophoretic force, however in water this force appeared weak
- As the dielectrophoretic force is determined by the electrical properties of the nanowires and solvent used, we sought to improve assembly by adjusting these properties

Optimizing Assembly



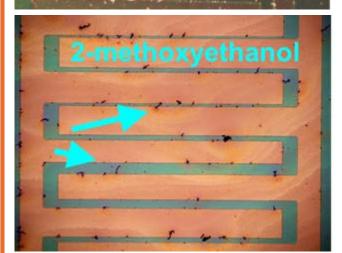




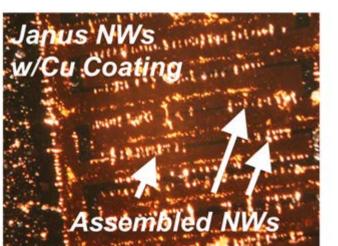


the nanowires received a sufficiently thick

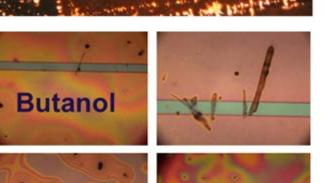
Cu coating along each section of their



lengths on one side, but achieving this was unreliable via sputter coating • Removing a barium carbonate ($\varepsilon_r \approx 8.5$) impurity from the Janus nanofibers/wires slightly improved assembly, and greatly improved assembly of single phase barium



• Ethanol ($\varepsilon_r \approx 24.5$) appeared to improve assembly, but its fast evaporation rate gave little time for the fibers to assemble



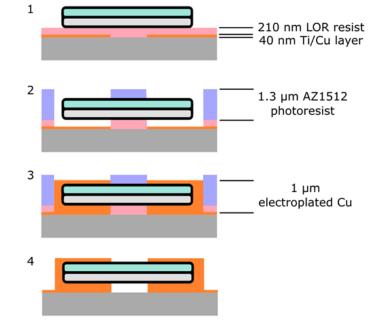
Currently the best assembly has been seen with 2-methoxyethanol ($\varepsilon_r \approx 16.9$) and butanol ($\varepsilon_r \approx 17.8$) which have low dielectric constants and evaporate slowly

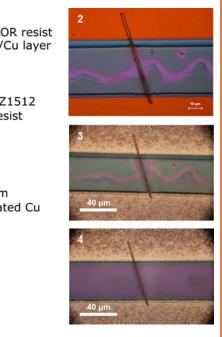
$$F_{DEP} \propto arepsilon_{solvent} Re \left(rac{arepsilon_{NW}^* - arepsilon_{solvent}^*}{arepsilon_{NW}^* + 2arepsilon_{solvent}^*}
ight)
abla ig|_{ec{E}}^2$$
 $arepsilon^* = arepsilon + rac{i\sigma}{\omega}$

Upper Contacts

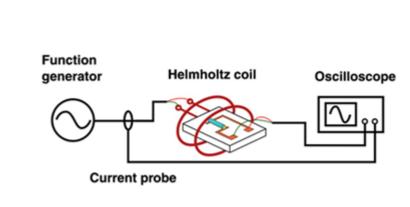
titanate fibers

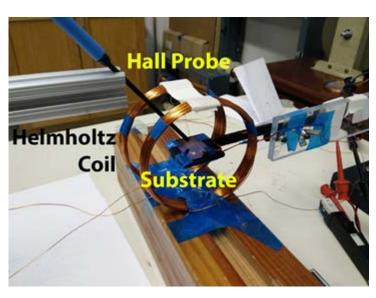
- AZ1512 was spun on the wafer to hold the nanowires in place
- Lithography was used to expose the ends of the NWs which were then coated in copper to form upper contacts
- The remaining photoresist was stripped from the wafer



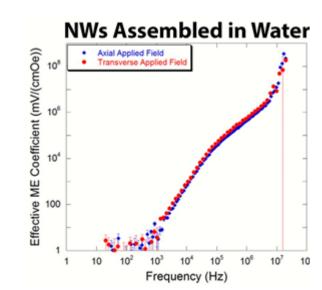


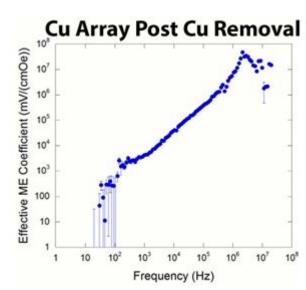
Magnetoelectric Measurements





- Applied an AC magnetic field with varying magnitude and frequency to the nanowire array
- Measured the voltage output and found the effective magnetoelectric coefficient of the nanowire arrays (dE/dH)





• Identified the voltage signal from nanowire arrays, which deviated from a linear relationship that would occur with pure electrical induction

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