BOISE STATE UNIVERSITY
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Additive Manufacturing of Magnetostrictive Cobalt Ferrite Thin Films for Structural Energy Harvesting

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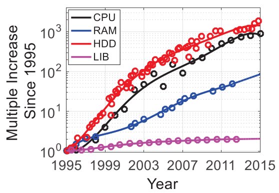
Penn Engineering

Introduction and Motivation


- Traditional lithium ion batteries frequently need to be charged or replaced.



- Structural vibration energy harvesters can replace finite power sources in portable and wearable electronic devices.

Background

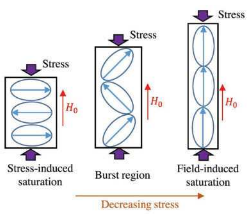


Figure 1: Magnetic domain rotation in magnetostrictive materials[1].

- Magnetostrictive materials convert mechanical energy into magnetic energy and vice versa.
- Additive manufacturing can be used to make thin films of this material for flexible energy harvesting devices.

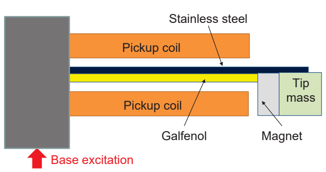


Figure 2: Cross-sectional view of a unimorph energy harvester.[2]

Smart Material | **Pickup Coil**

Mechanical Vibration ➡ **Magnetic Energy** ➡ **Electrical Energy**

Methods

Ink Synthesis	• Solvent + additives for dispersion • Ball milling, probe tip sonication
Characterization	• Transmission Electron Microscopy • Dynamic Light Scattering • Rotational Rheometer
Additive Manufacturing	• Inkjet Printing • Aerosol Jet Printing

First functional **ink** can convert **structural vibrations** into **electricity.**

Take a picture to view more information.

Results and Conclusions

Particle Description	Uncoated	Stearic Acid Coated	Stearic Acid Coated
Solvents	Isopropyl alcohol, ethylene glycol, glycerol	Isopropyl alcohol, ethylene glycol, glycerol	DI water, ethylene glycol
Particle Treatment	none	none	Ball milled: 300rpm, 1:20 ratio, 1.33hrs
Ink Treatment	Probe tip sonication (~5.5hrs, 95% amp)	Probe tip sonication (~5.5hrs, 95% amp)	Shear mixed (~4hrs) Probe tip sonication (4hrs, 95% amp)
Visual Observations	Well mixed ink	separated	Dispersed in solvent, visible agglomerations
DLS (approx. size)	~1400nm	~1100nm	~450nm

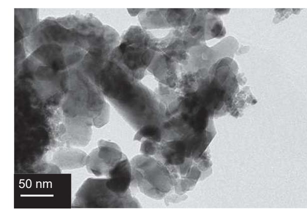


Figure 3: TEM image of as-received, uncoated Cobalt Ferrite nanoparticles.

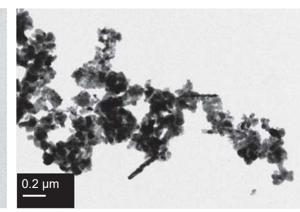


Figure 4: TEM image of ball milled stearic acid coated Cobalt Ferrite nanoparticles.

DLS of Stearic Acid Coated Cobalt Ferrite Nanoparticles

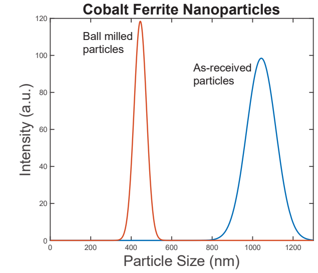


Figure 5: DLS data of stearic acid coated Cobalt Ferrite nanoparticles.

- Ball milling is a promising technique for reducing size of stearic acid coated particles.
- The stable suspensions synthesized have large agglomerations, but may be viable using N-script.

Future Work

Characterize surface ➡ **Heat treatments:** • Sintering 900° C • Magnetic annealing 300° C ➡ **Effects on magnetostrictive properties**

References:
1. Deng, Z., & Dapino, M. J. (2017). Review of magnetostrictive vibration energy harvesters. *Smart Mater. Struct.* 26 103001
2. Deng, Z., & Dapino, M. J. (2016). Influence of electrical impedance and mechanical bistability on Galfenol-based unimorph harvesters. *Journal of Intelligent Material Systems and Structures*, 1045389X16666176

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