

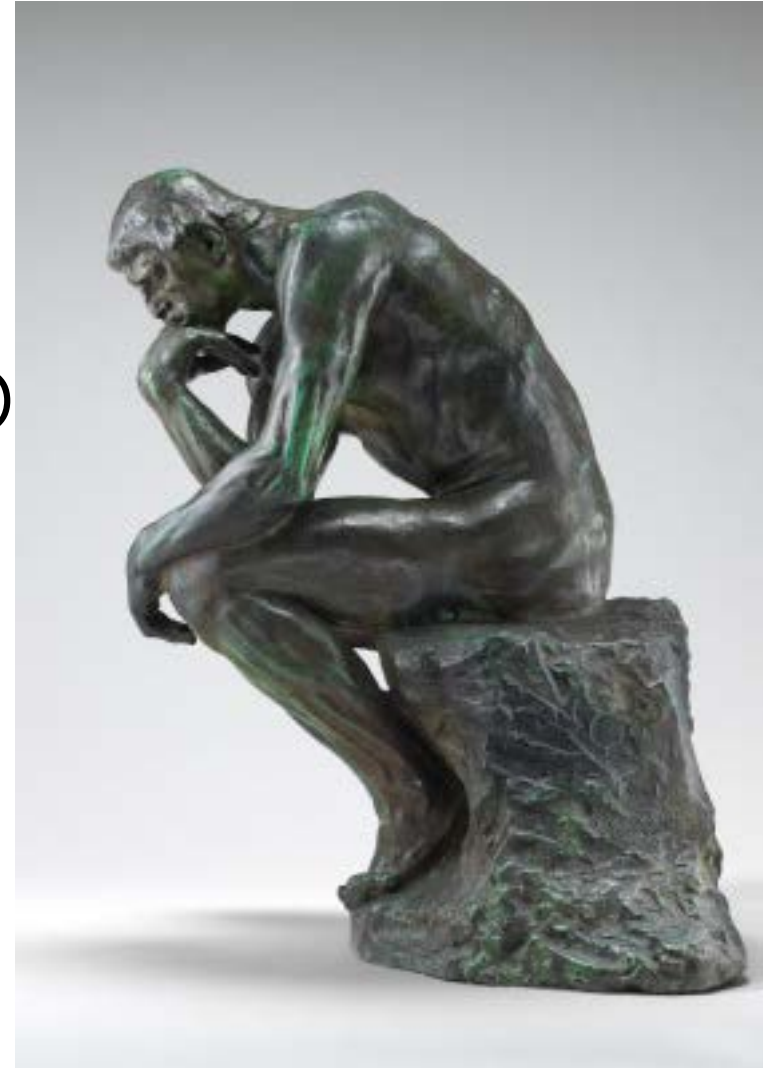
# Functional Printing

## Perspective of Tech Startup

Arkady Malakhov, CEO

Advanced Energy Conference 2018

- Prototyping (1980's)
- Early adopters & hobbyists (1990's)
- Beyond curiosity (2000's)
- Solution to everything? (2010's)
  - Production parts
  - On demand (no inventory)

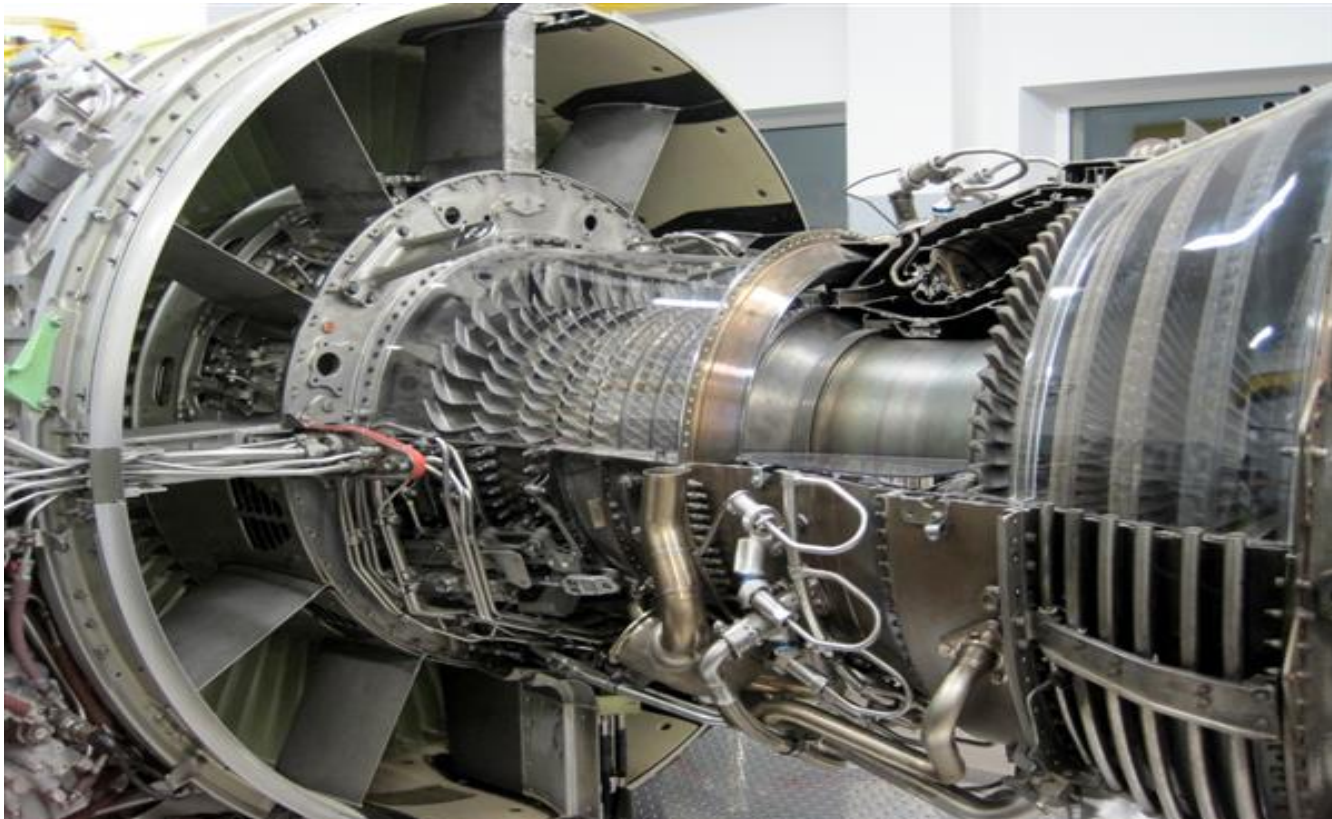


## Why AM Today?

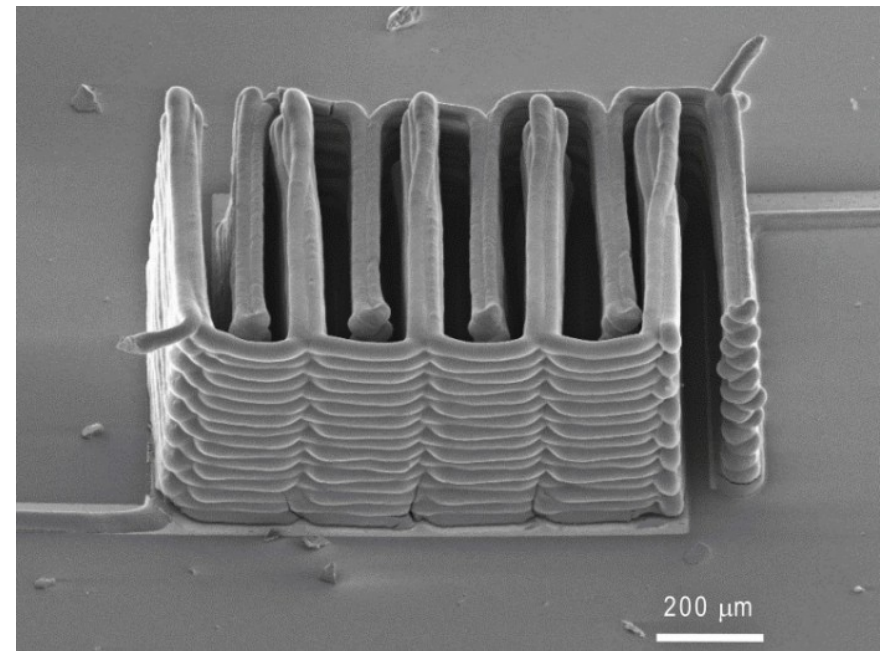
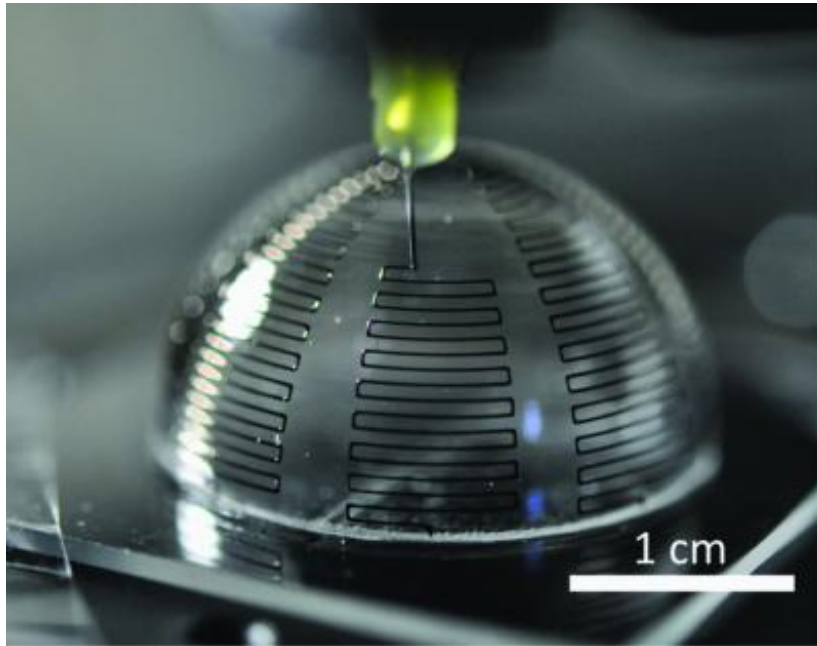
Perhaps not the solution to everything, but ...



No cost penalty for manufacture of complex features with improved properties beyond the limits of conventional technologies.



3D printing using inks based on functional materials.



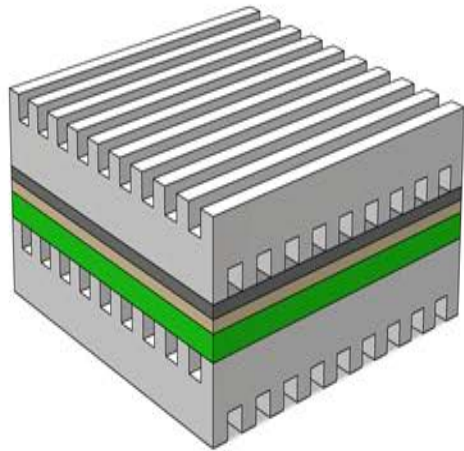
**Conformal Electrically Small Antenna**

**Anode & Cathode of Li-Ion Microbattery**

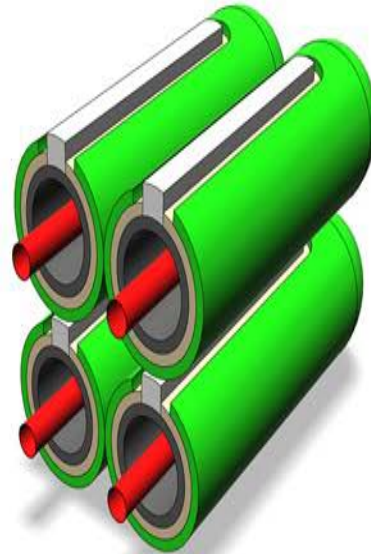
Image Credits: Jennifer A. Lewis, Harvard University







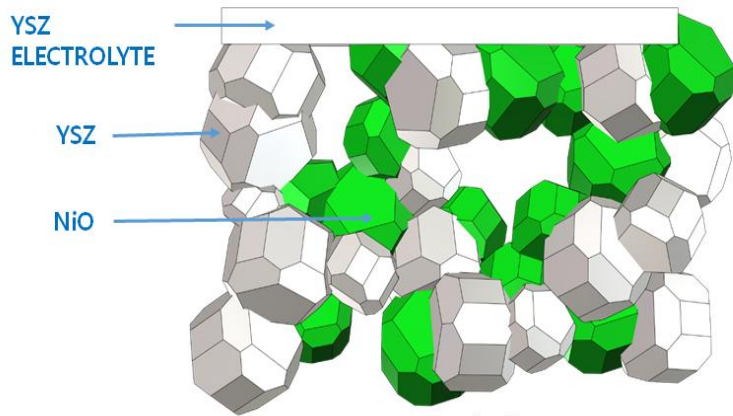
**Planar**



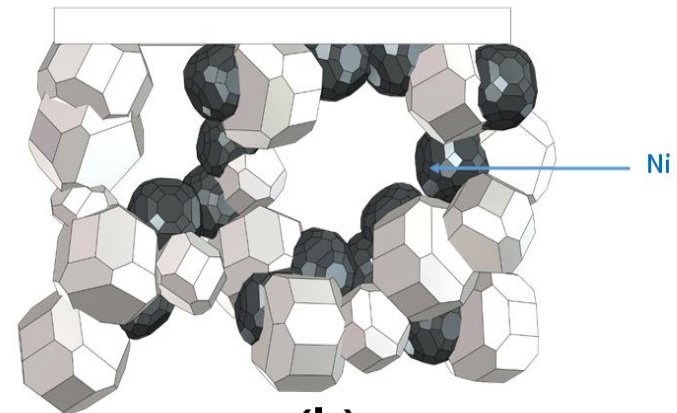
**Tubular**



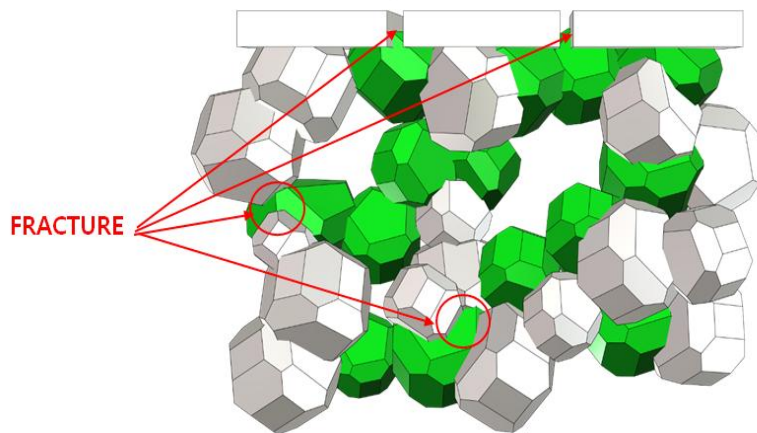
**Segmented-Cells-in-Series**



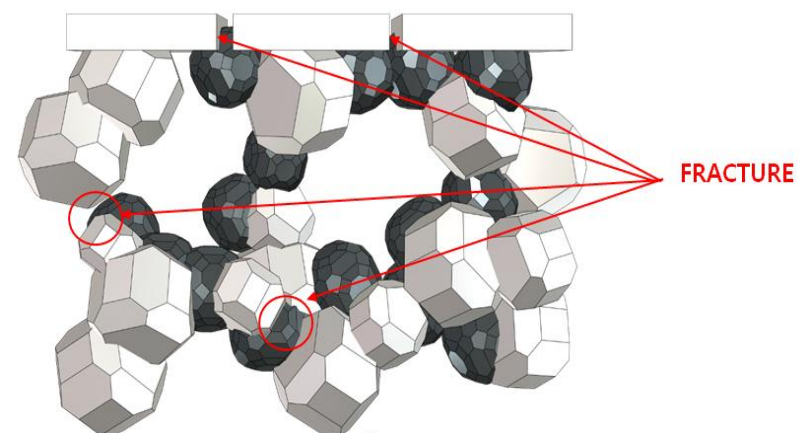
(a)



(b)

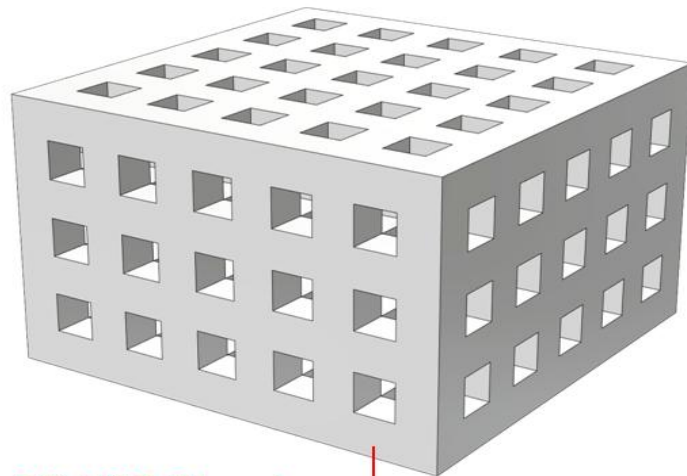


(c)

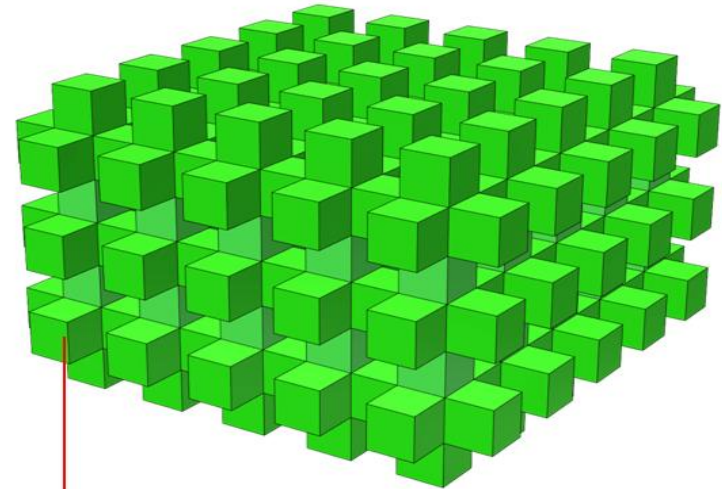


(d)

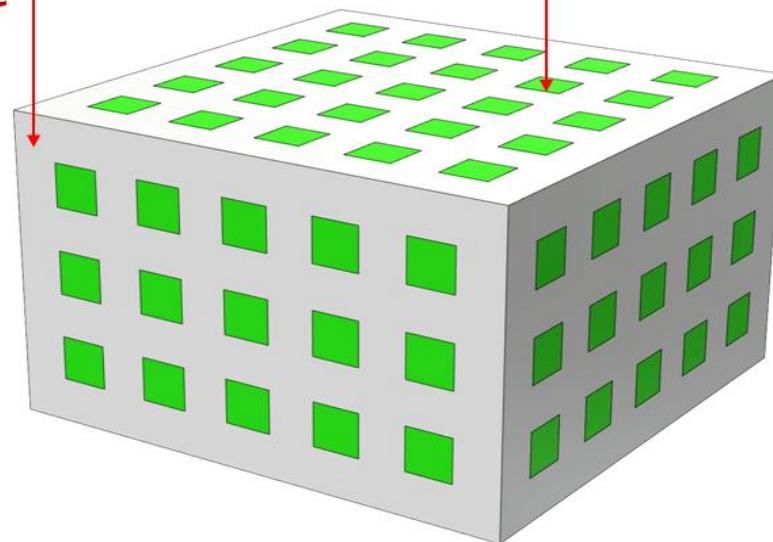




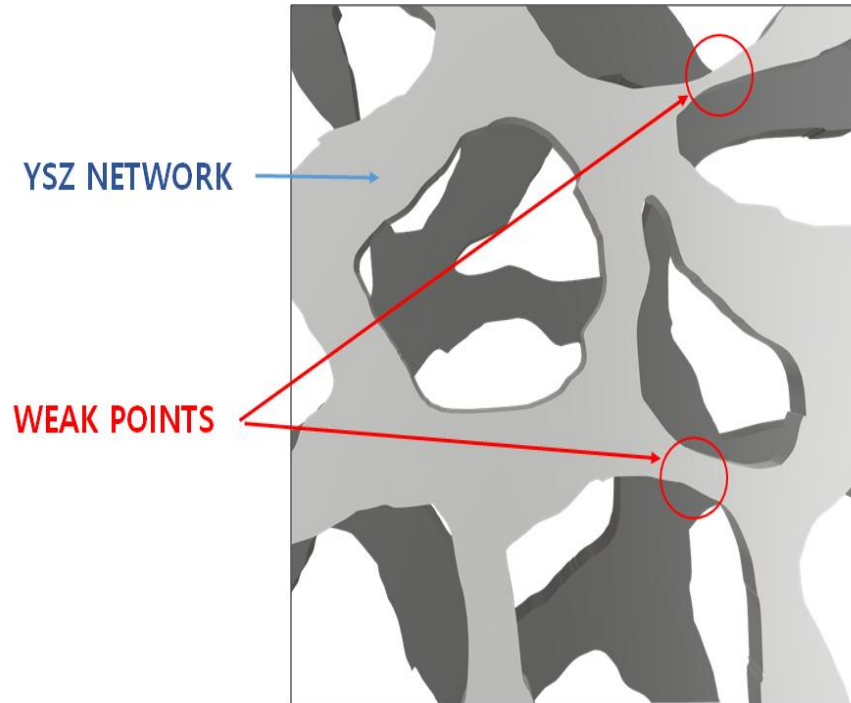
**3D YSZ Structure**



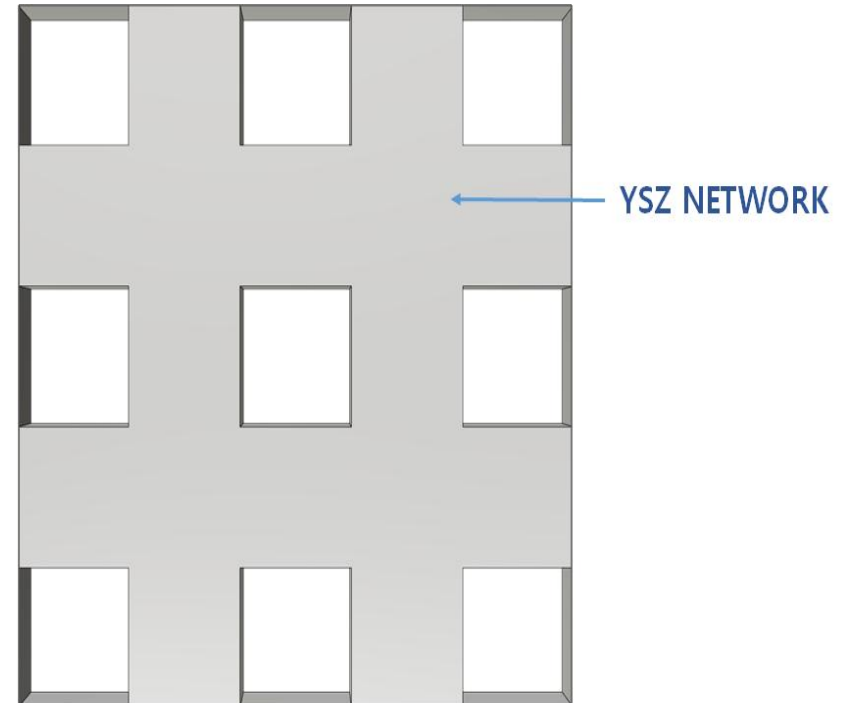
**3D NiO Structure**



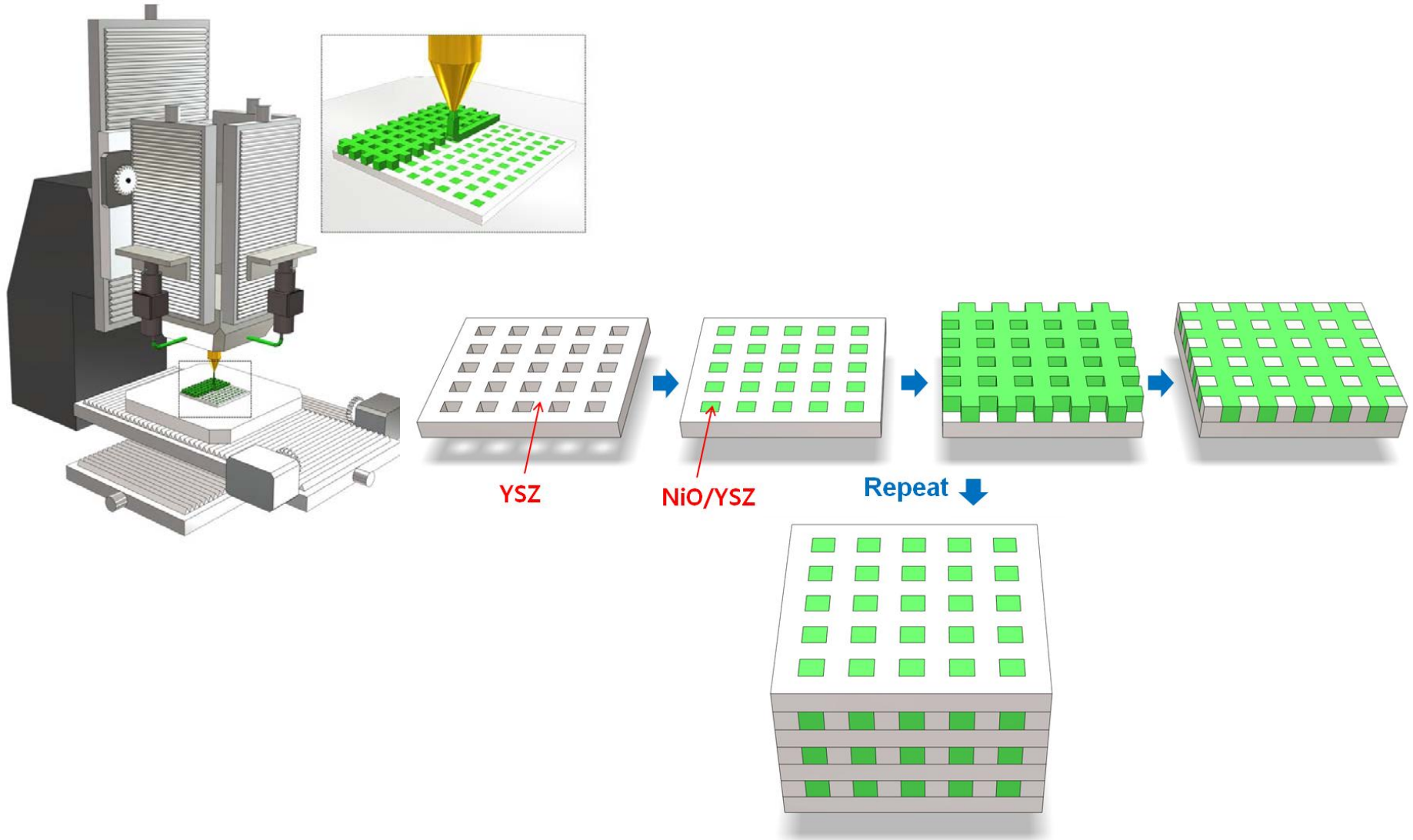
Concept Credit: Nguyen Minh, UCSD



CONVENTIONAL ANODE STRUCTURE

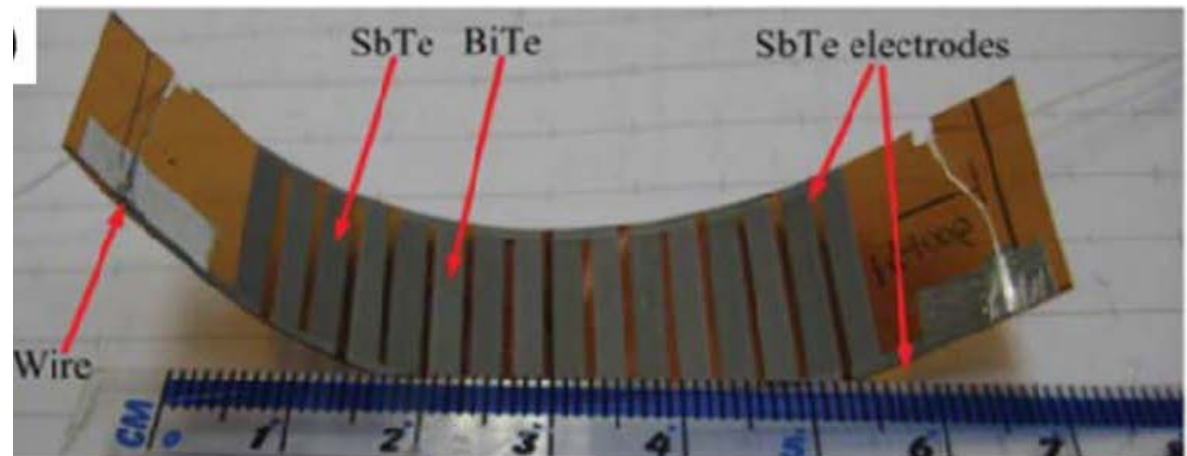


ENGINEERED ANODE STRUCTURE



Other application:

## Integration of Flexible Thermoelectric Modules into Heat Exchangers



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