3D Weaves as Filters for Low-Power Chemical Analysis Systems

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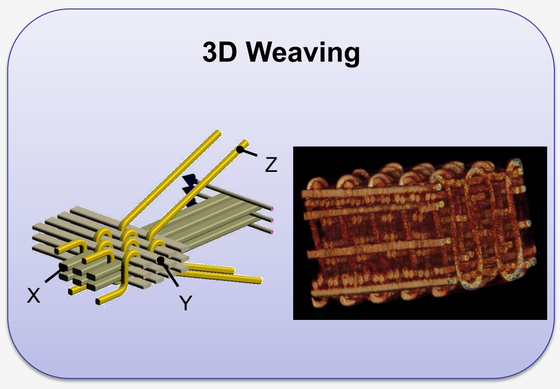
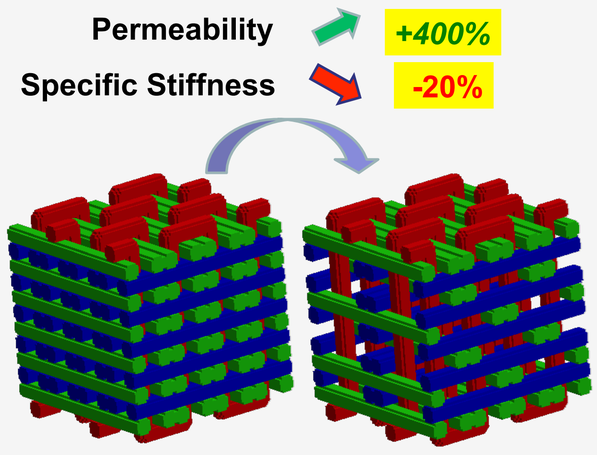
Summary of our Work

3D Weaves:
3D weaves are fabricated using metallic, ceramic or polymeric wires, and provide a broad design space and industrial scale manufacturing for creating novel cellular materials.

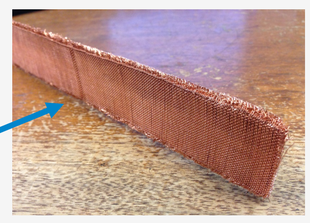




Topology optimization:
A powerful tool capable of generating new solutions to engineering design problems. Can be combined with specific manufacturing techniques to suggest practical or novel designs.

Large design space:
Can alter the weaving pattern, wire feedstock, surface finish, and post production treatment, providing the ability to optimize and tailor multiple properties, such as permeability (pressure drops), flow paths and surface area (adsorption rates), heating rates (for discharge), etc.

Possible metal wires: ***Stainless Steel, Cu, NiCr, NiTi, W***



Woven blocks made using layers of Cu weaves

Opportunities

3D Woven filters for low-power, tunable collection and rapid discharge of multi-phase chemical mixtures

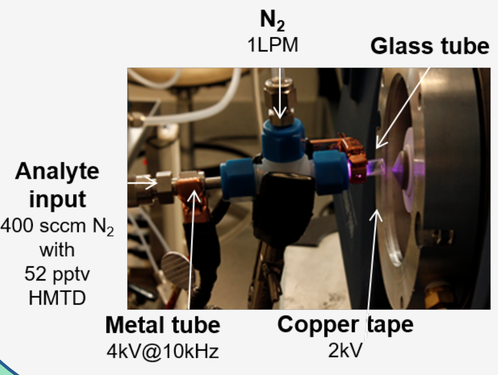
– Optimize weave architecture to
- minimize pressure drops
- maximize specific surface area
- vary flow paths for collection vs discharge

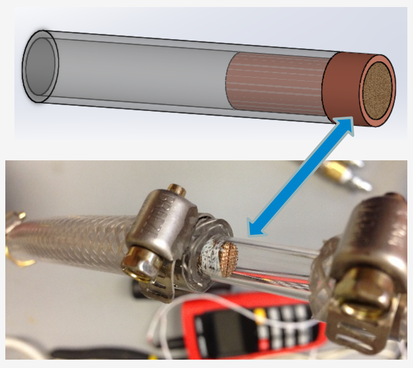
– Tune wire chemistry, diameter and surface finish
- enhance surface area and collection rates
- speed heating rates for discharge
- vary depending on gas species

– Integrate heating elements to enable rapid discharge

External testing:
MIT Lincoln Lab (Roderick Kunz, Patrick Wen)

Preliminary test setup:

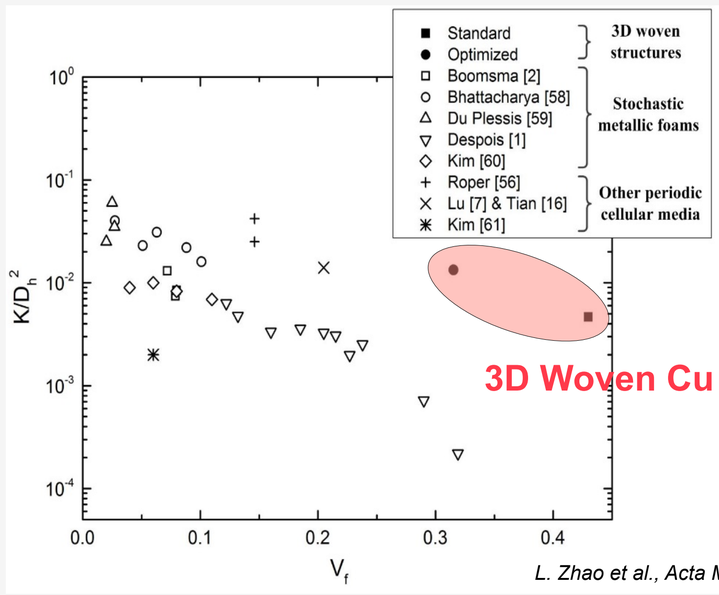




Research Interests

Materials for a ultra-low-power chemical analysis system

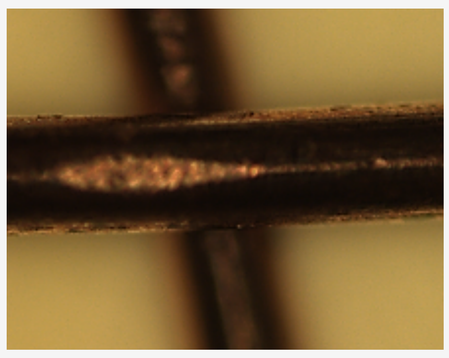
Very high permeability at high material fraction:
Novel 3D woven architectures with wire diameters from 160 to 202 µm were designed using topology optimization to possess very high permeability at high material volume fraction. This leads to low pumping powers for driving high volumetric flow rate.



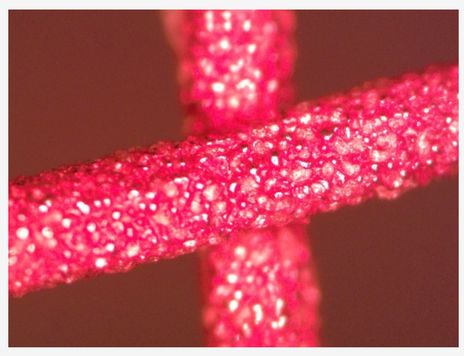
L. Zhao et al., Acta Mater. 81 (2014) 326-336

Tune surface roughness to enhance gas phase collection:

Various techniques have proven successful:
- Vary wire diameter
- Electroplate metals onto wires
- CVD coating of wires
- Oxidation of metallic wires



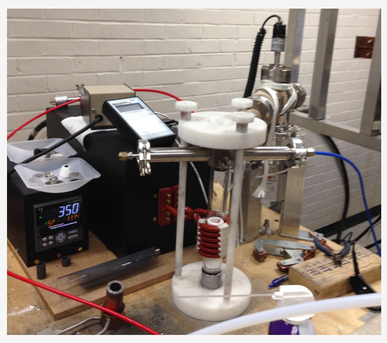
Unplated Cu wires



Electroplated Cu wires

Methods for fast discharging:

– RF heating of most metallic and metal coated wires
– Resistance heating for NiCr wires



RF heating setup

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