

Sorption Chillers and Thermal Storage: Materials, components, models, and systems

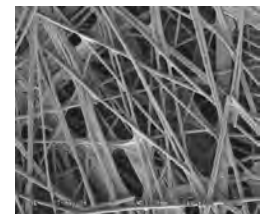
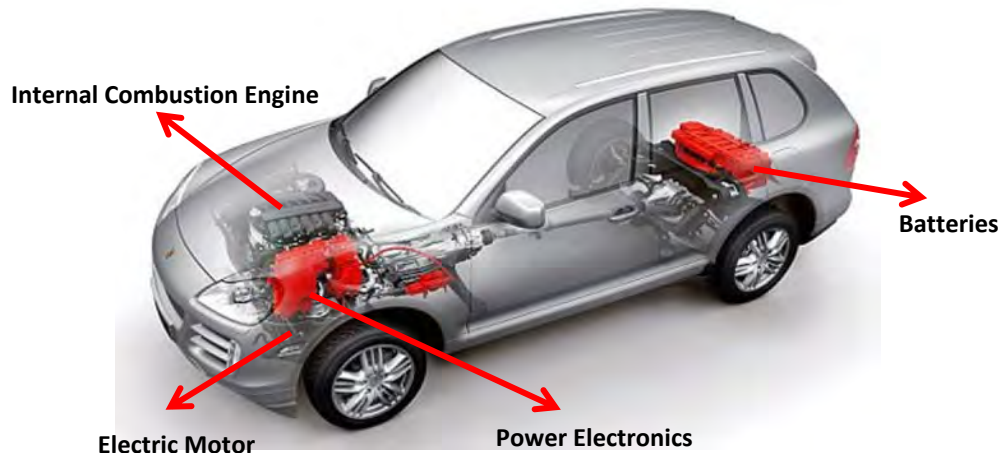
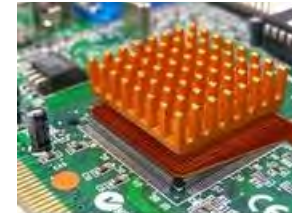
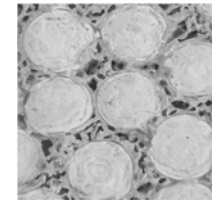
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LAEC seeks to understand and solve fundamental problems at multiscale levels for improved energy conversion efficiency in devices such as compact heat exchangers, fuel cells, batteries, and thermal energy storage systems.

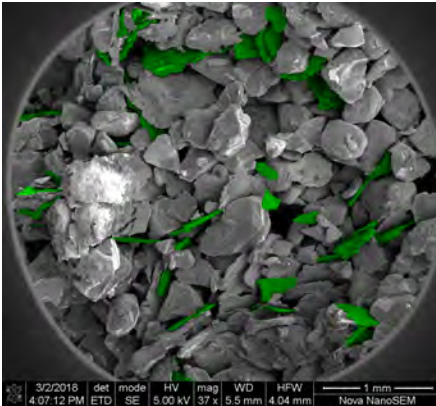
Some of active research topics:

- Sorption A/C and thermal storage systems
- Graphite heat exchangers and heat recovery
- Transport phenomena in PEM fuel cells porous media
- Electronics cooling solutions, Li-ion battery systems
- Energy and water management in greenhouses



- Composite sorbents
- Lab-scale single chamber sorption chiller
- Sorber bed heat transfer modeling
- Compact capillary-assisted evaporators
- Graphite heat exchangers
- Sorption heat and cold storage
- RH control and TES for greenhouses
- District heating energy with TES with City of Surrey, BC
- Hybrid heat sinks (HHS) featuring PCM for power electronics with Delta-Q

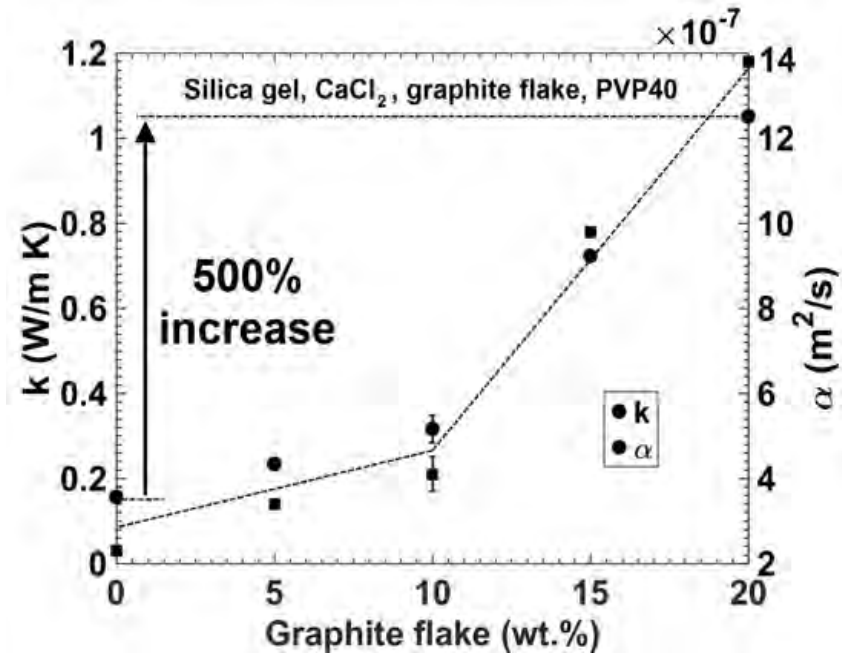




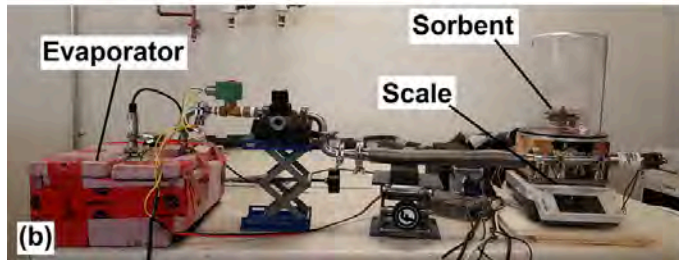
Graphite flake additive to increase sorbent thermal diffusivity



Transient plane source



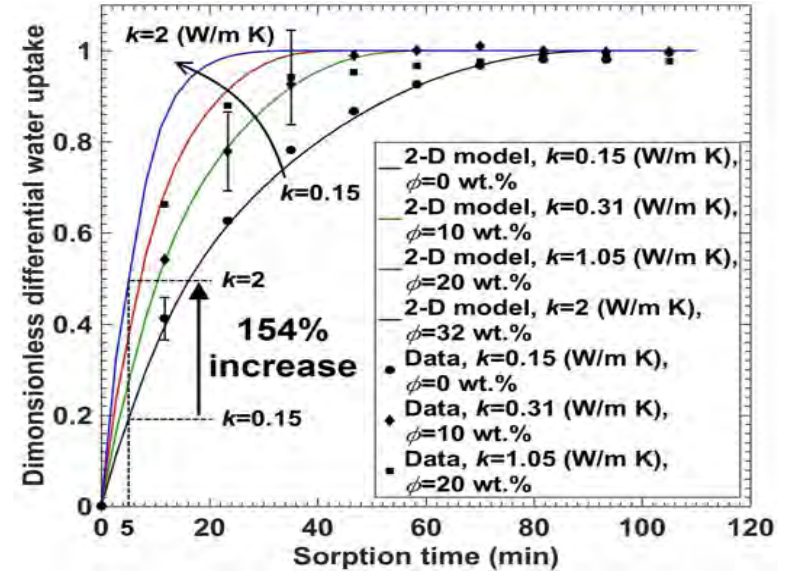
- Significant increase in thermal diffusivity
- “hockey-stick” behaviour suggests potential breakthrough in heat transport properties
- Development of “functional” sorbents



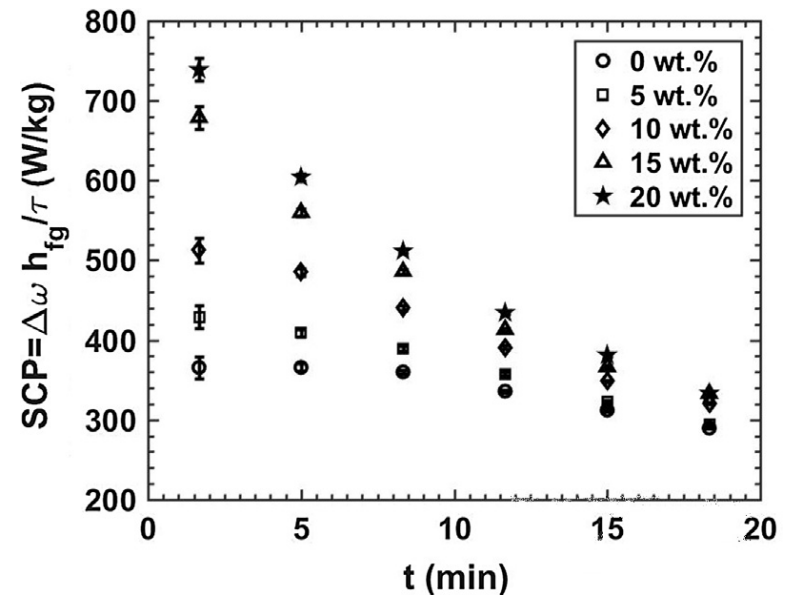
Custom-built Gravimetric large pressure jump (G-LPJ)

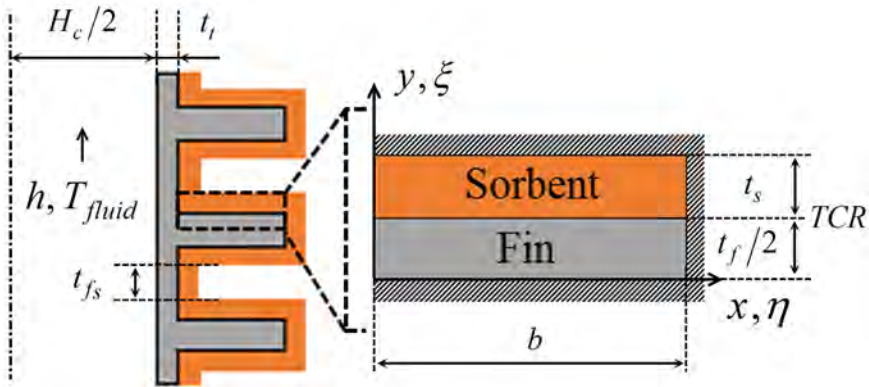


Thermogravimetric sorption analyzer

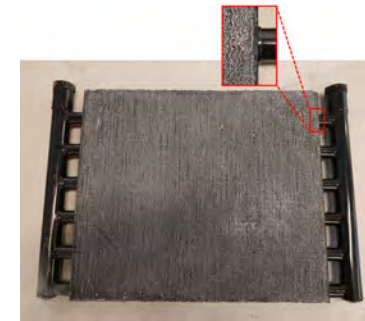
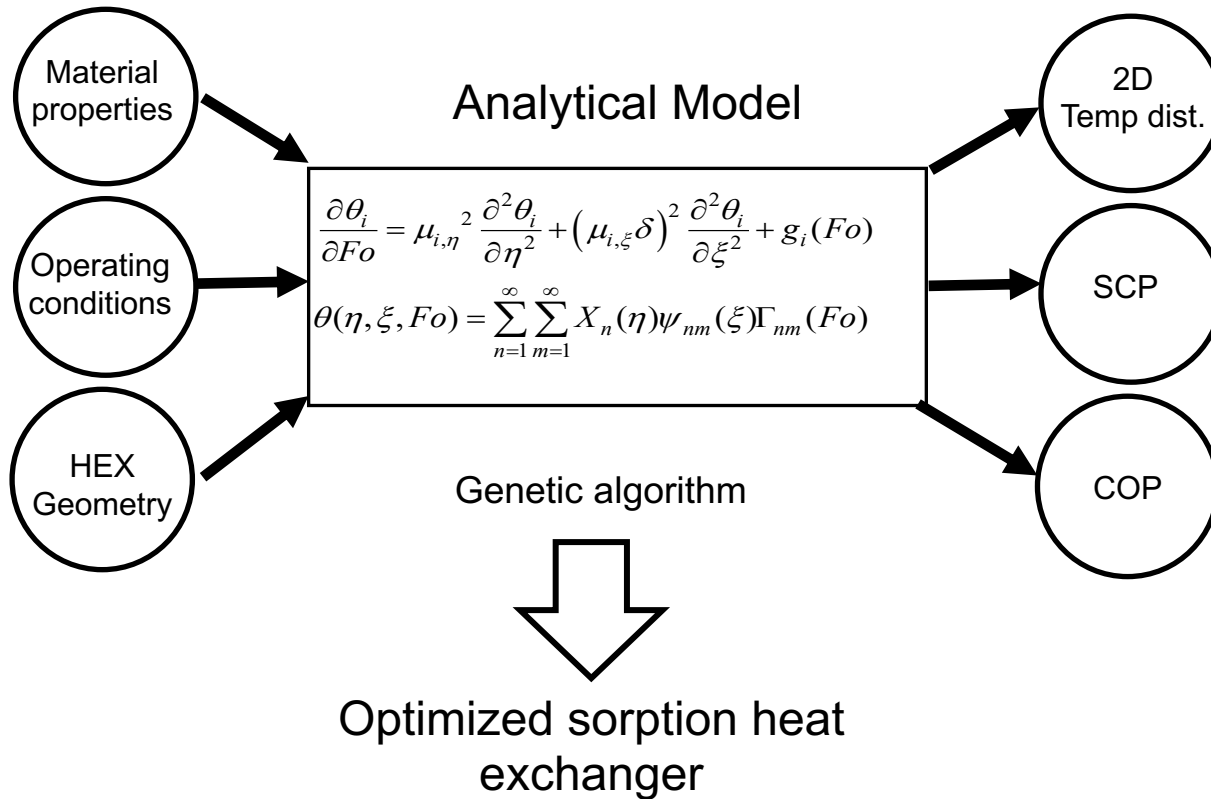


Thermal conductivity vs uptake: our analytical 2-D model vs and data G-LPJ

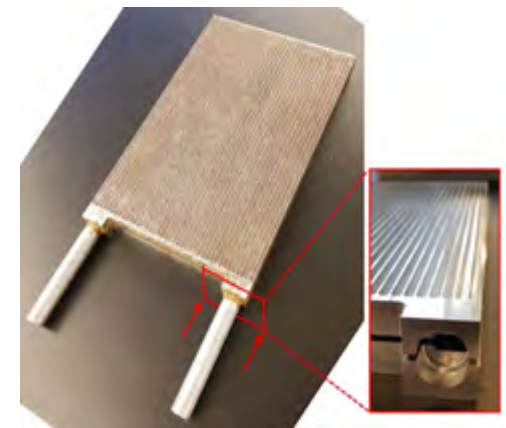




- Assuming decoupled heat and mass transfer
- Solved 2-D transient heat transfer (energy eq) **analytically** in coated sorber bed heat exchanger

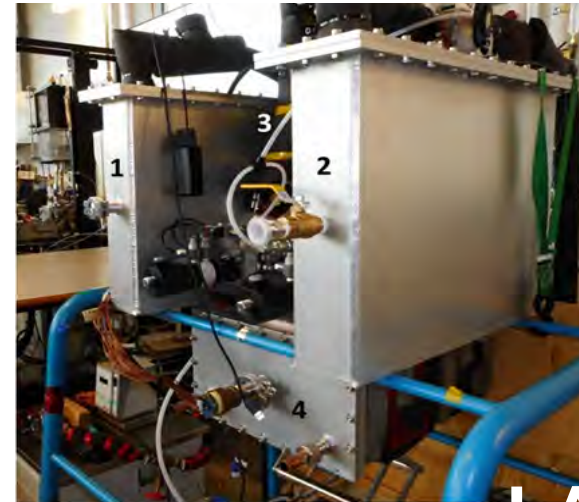
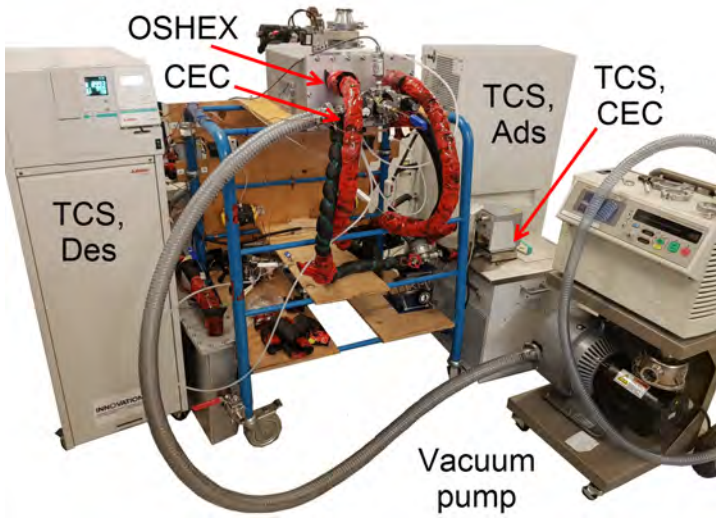


Off-the-shelf HEX

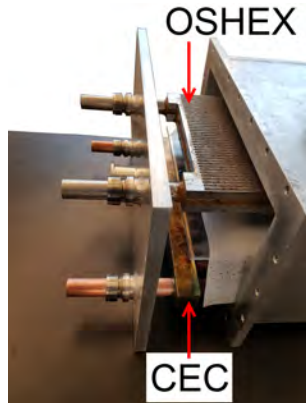


Optimized sorption HEX

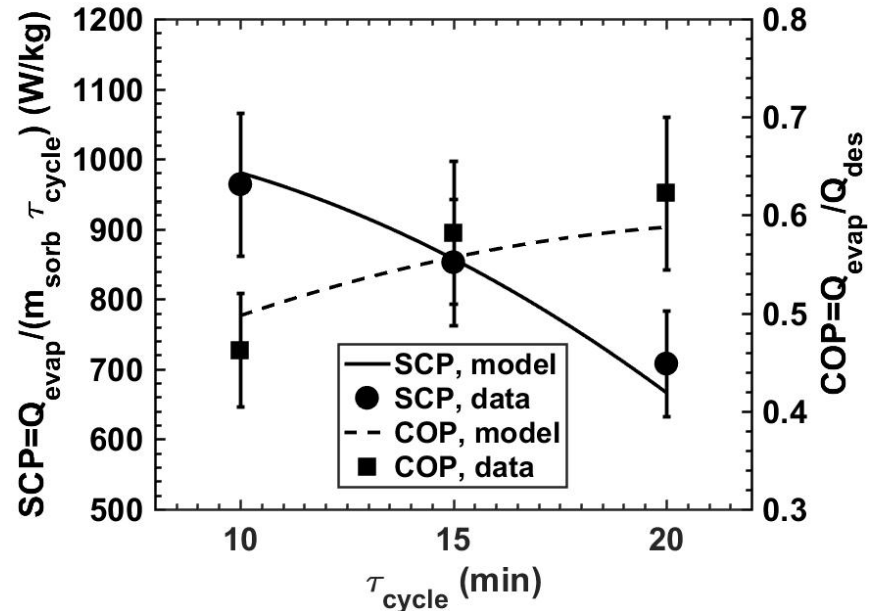
Optimized Sorber bed: Validation

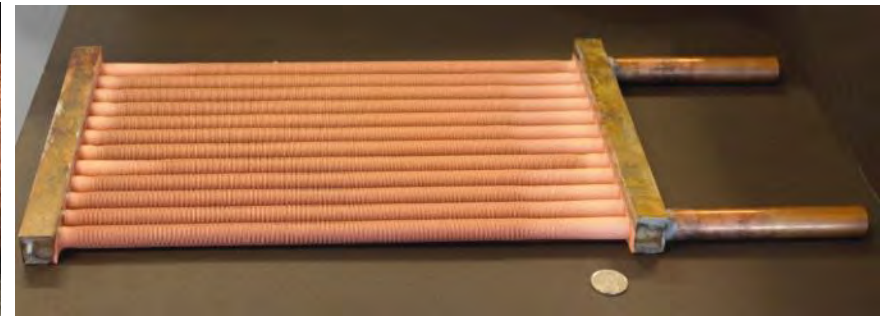
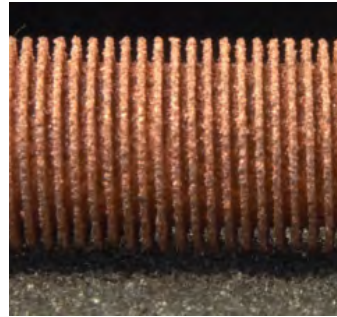
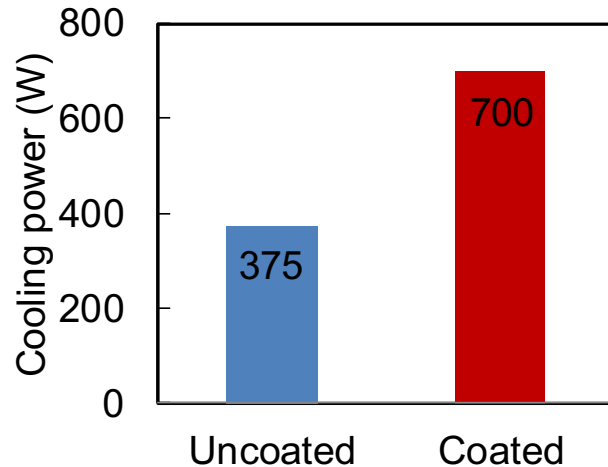


Custom-built sorption testbed

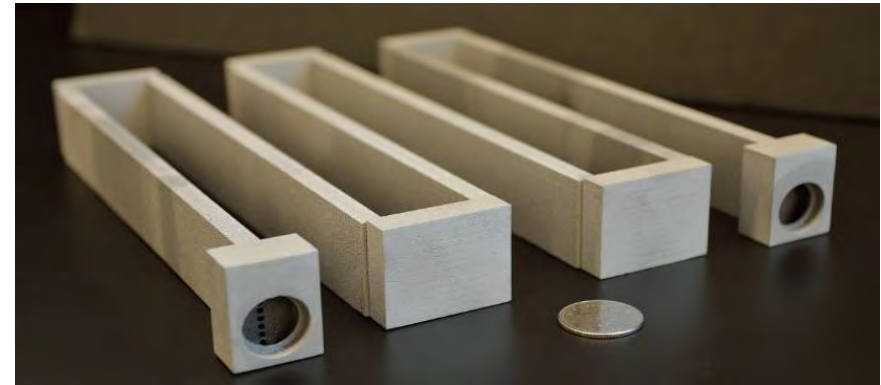
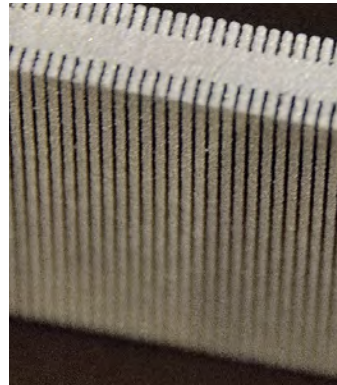


Optimized sorption HEX and combined evaporator/condenser





Thermal spray porous copper coating on finned tube heat exchanger



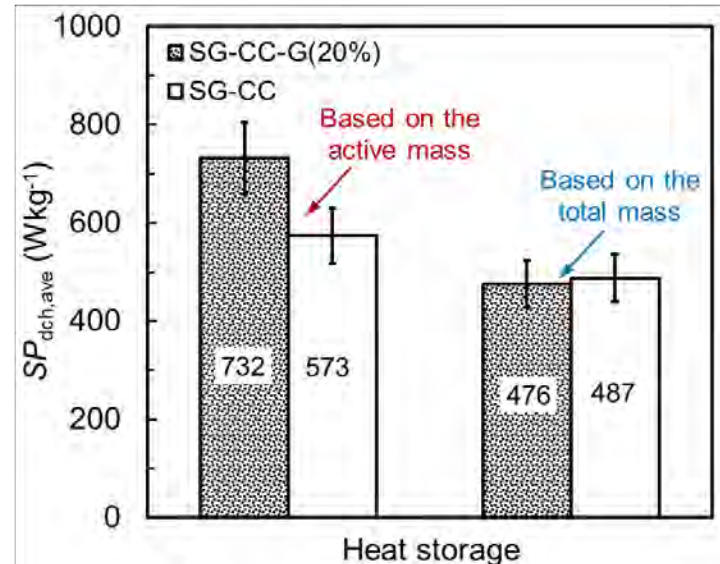
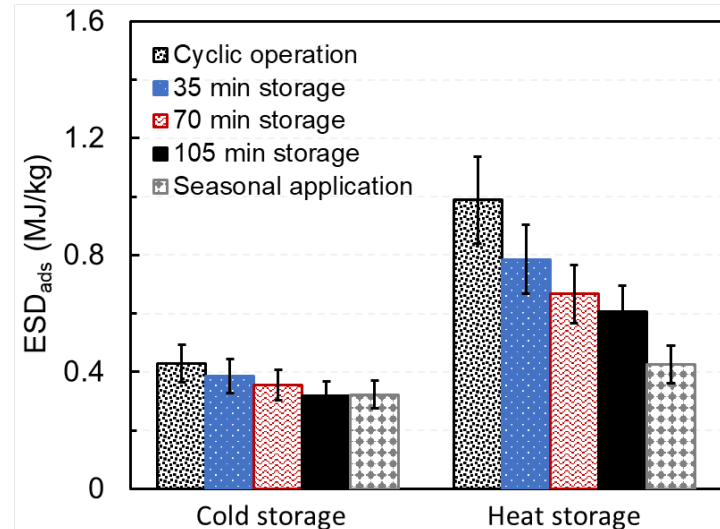
Direct metal sintering of finned aluminum microtube heat exchanger

- Custom-built apparatus for measuring CALPE performance
- Developed method to determine porosity and surface roughness of metal coatings

Cooling Power

- Porous copper evaporator: 0.3 kW/kg
- Sintered aluminum evaporator: 1.2 kW/kg

- ESD_{heat} of 1.1 GJm^{-3} achieved, lab-scale silica gel+ CaCl_2 storage
- ESD_{heat} decreased from 1.03 for cyclic operation (no storage-time) to 0.43 MJkg^{-1} for seasonal applications.
- Adding 20% graphite flakes to silica gel+ CaCl_2 increased the initial SP from 1.25 to 1.30 kWkg^{-1} for the first 10 min.



Low cost
Material

Roll embossing
(mass production)



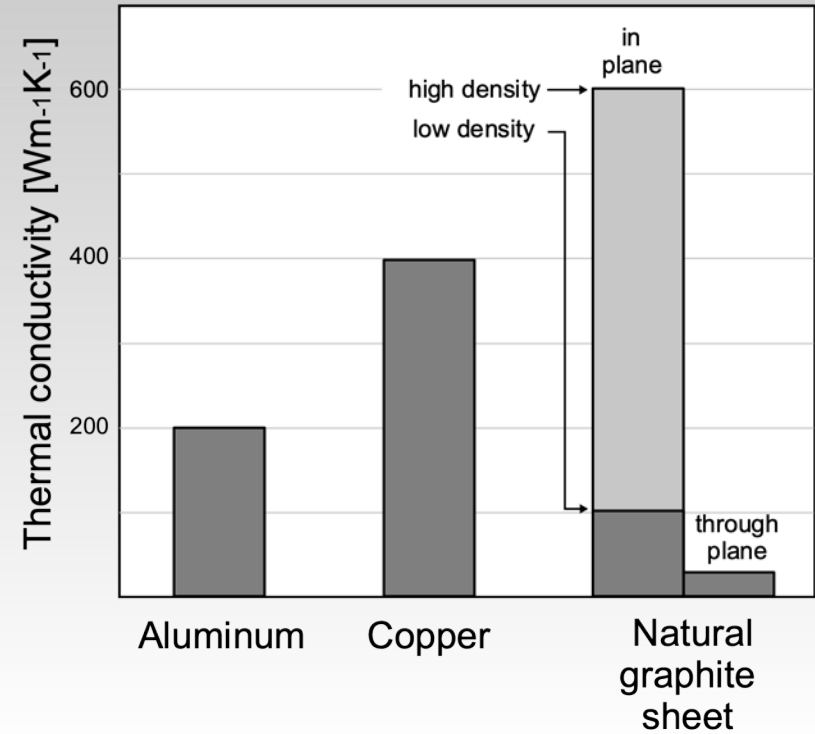
Light
weight

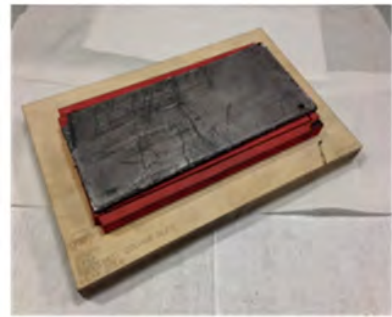
Good cooling
performance

Corrosion
resistant

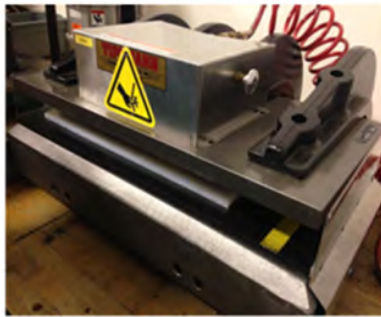
Graphite HEX comparable performance to Al

High thermal conductivity





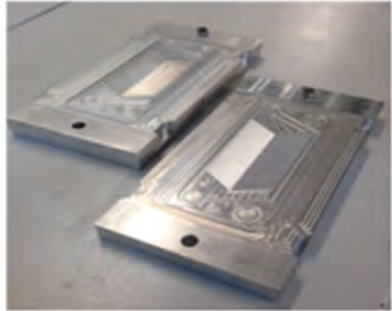
(a)



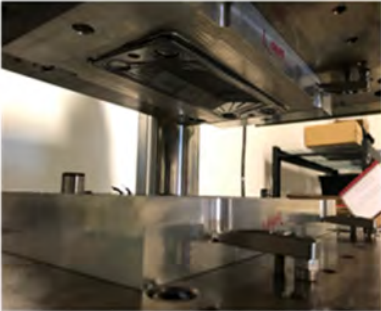
(b)



(c)



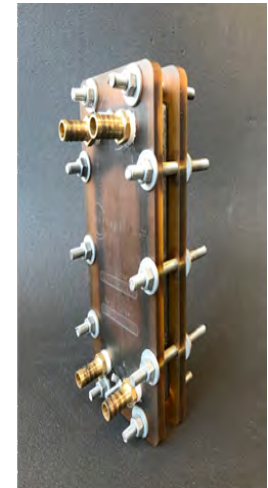
(d)



(e)

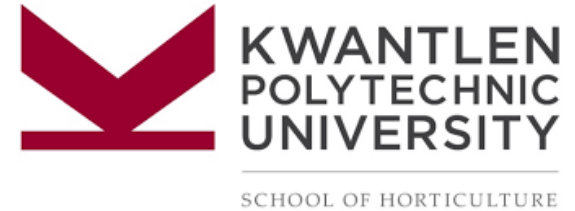


(f)



Three year project (2015-2018):

- Assess energy consumption of local greenhouses
- Model greenhouse climate control
- Test energy efficient climate control systems in a research greenhouse compartment





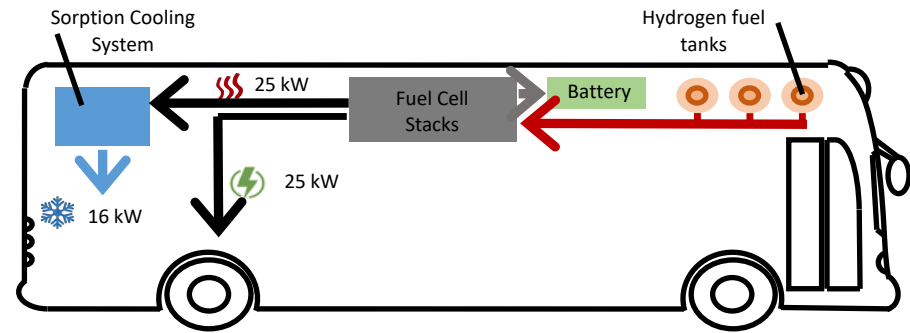
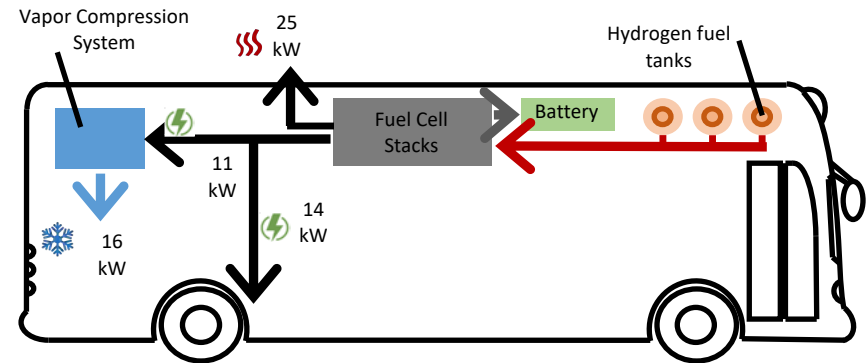
25 kW electrical energy



25 kW low-grade waste heat at 60 – 70 °C



Water



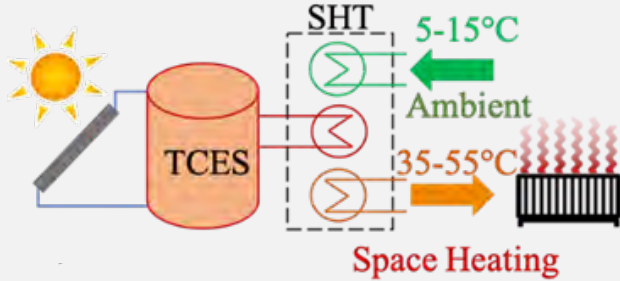
BALLARD®



NEW FLYER

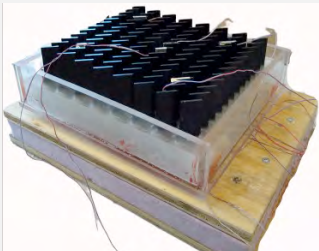
Solid Sorption

Scalable, Modular Sorption Heat Transformer (SHT)



Phase Change
Material

Hybrid passive heat sink (HPHS)



Liquid Sorption

Mobile thermal energy storage (M-TES)

