Laboratory for Alternative Energy Conversion

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Canada-Germany Workshop at HPC

Sept. 16, 2018

SFU
SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

LAEC
Laboratory for Alternative Energy Conversion

Simon Fraser University

Laboratory for Alternative Energy Conversion

SFU Laboratory of Alternative Energy Conversion (LAEC)

SFU Surrey campus

LAEC Laboratory for Alternative Energy Conversion

SFU

New program: Sustainable Energy Engineering

- Program launch in 2019
- 320 undergraduate and 100 graduate students

Now Hiring!

Sustainable Manufacturing, Clean Power Generation, Smart Cities, Transportation, Cleantech, Renewable Energy, Sustainable Food and Water Solutions

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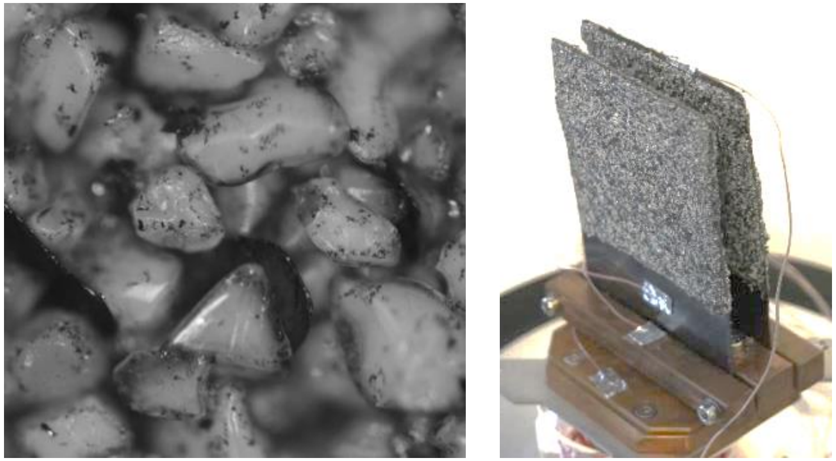
- Sorption chillers (systems, low pressure evaporators, heat exchangers, materials)
- Thermal energy storage
- Fuel cells (CL, GDL, transport phenomena, ex-situ testing of thermal conductivity and gas diffusivity of thin films)
- Power electronics cooling (e.g. light electric vehicle battery changers)
- Greenhouses (sustainable temperature and humidity control, upcoming installation of small solar thermal and PV)
- District heating
- Graphite heat sinks, heat exchangers, and thermal interface materials
- Heat and humidity recovery modules for building ventilation
- Dehumidification
- Atmospheric water harvesting
- Waste heat recovery
- Thermal management of batteries

The Lab

The Lab

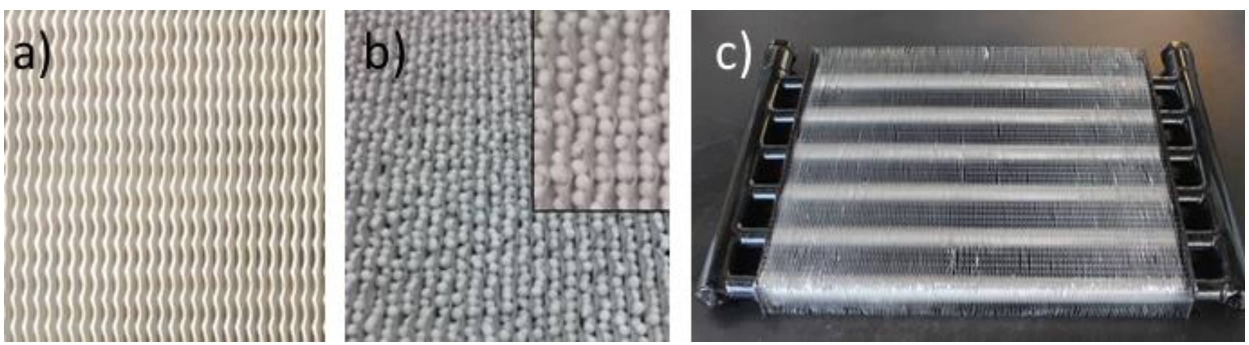
Sorbent materials



Composite sorbent coated on graphite substrate for heat transfer test

Sorbent for “VENTIREG” cold climate ventilation heat and humidity recovery tests

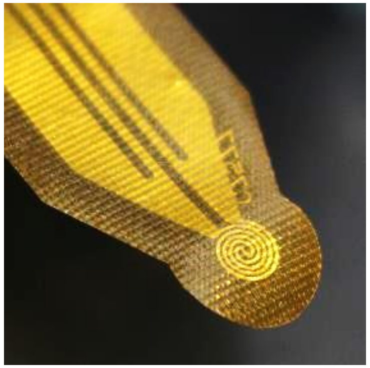
$CaCl_2$ composite sorbent for dehumidification



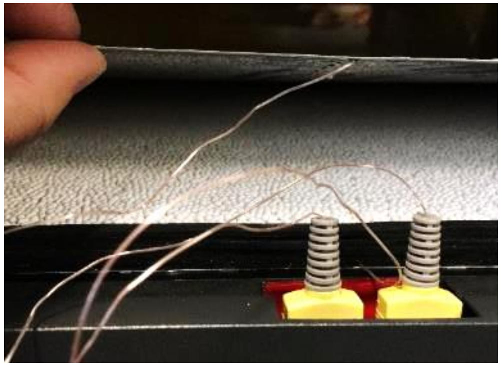
Sorbent on heat exchangers for sorption chiller tests: Z02 coating, Z02 pellets, empty heat exchanger and $CaCl_2$ composite

Material characterization

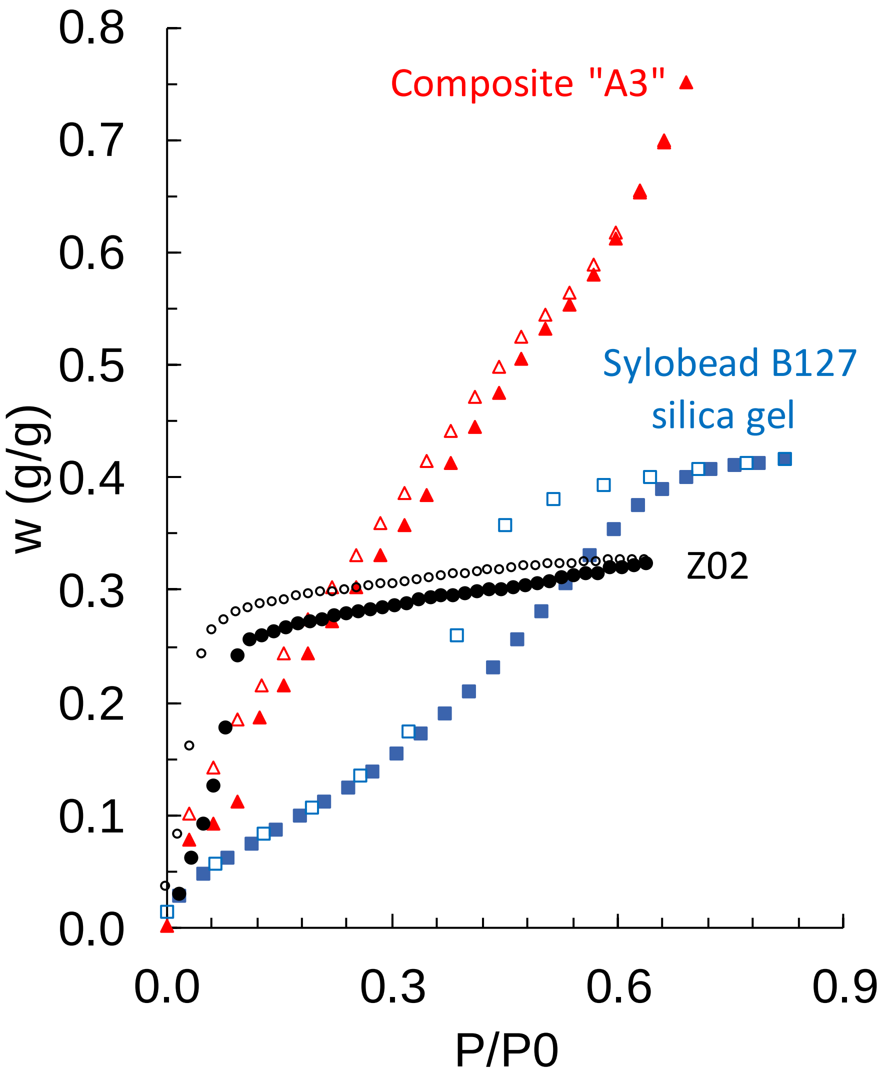
- Salt, silica gel, binders and thermally conductive additives are combined to create sorbents for a range of applications
- Water vapor sorption (isotherms, heat of adsorption), pore structure, thermal properties (dry & wet), and pressure-jump sorption dynamics



“Hot disk” sensor



Heat flow meter test sorbent pellets



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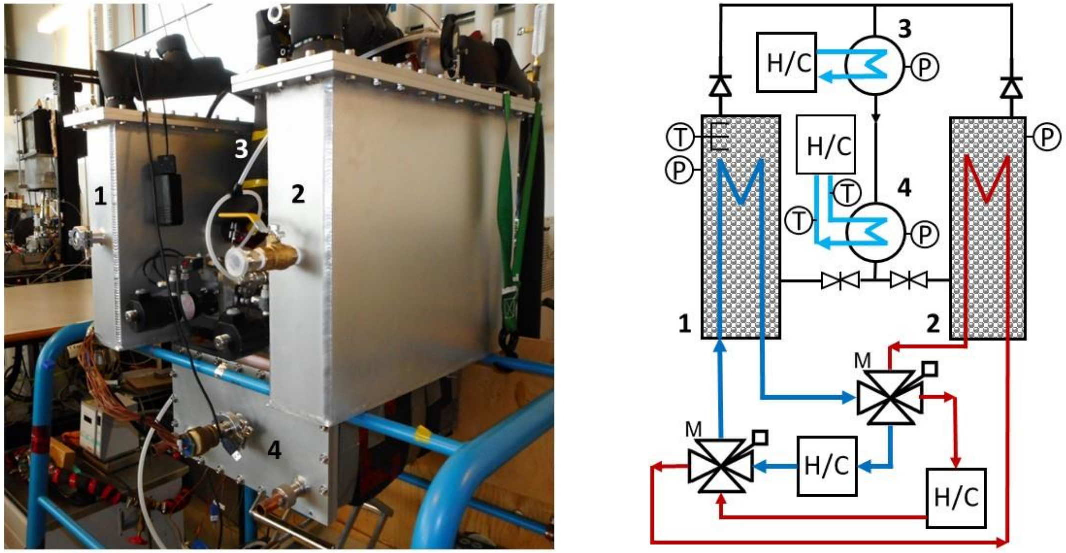
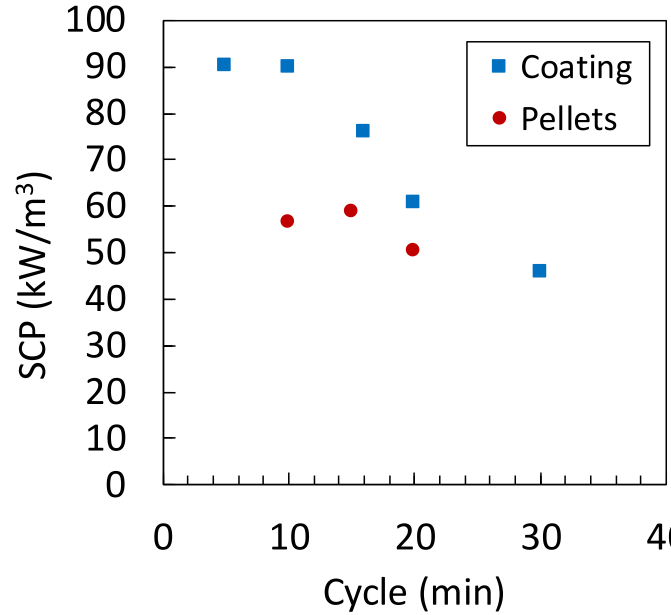
Lab-scale sorption chiller



Lab-scale sorption chiller with two sorber beds (1,2), condenser (3), CALPE evaporator (4), valves, sensors and heating/cooling (H/C) circulators.



Volumetric SCP of sorption chiller for Z02 coating and pellets; T_{evap}= 15 °C, T_{cond}=T_{ads}= 30 °C, and T_{des}= 90 °C

<u>Z02 Coating (0.8 kg per HEx, 10 min cycle)</u>

SCP = 472 ± 8 W/kg, COP = 0.27

<u>Z02 Pellets (1.97 kg per HEx, 15 min cycle)</u>

SCP = 130 ± 10 W/kg, COP = 0.28

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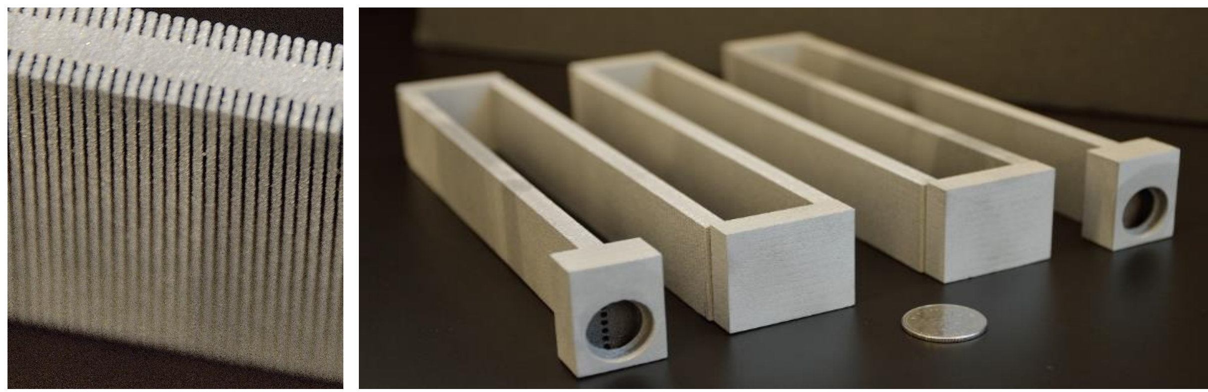
Capillary-assisted low pressure evaporator

- Water-based sorption systems operate at low pressure and require thin film evaporators
- Developed low pressure evaporators and custom-built apparatus for measuring their heat transfer performance
- Developed method to determine porosity and surface roughness of metal coatings

Thermal spray porous copper coating on finned tube heat exchanger



Direct metal sintering of finned aluminum microtube heat exchanger

	Cooling Power
Porous copper evaporator:	0.3 kW/kg
Sintered aluminum evaporator:	1.2 kW/kg

Manufacturing heat sinks and heat exchangers from natural flake graphite

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Low cost Material

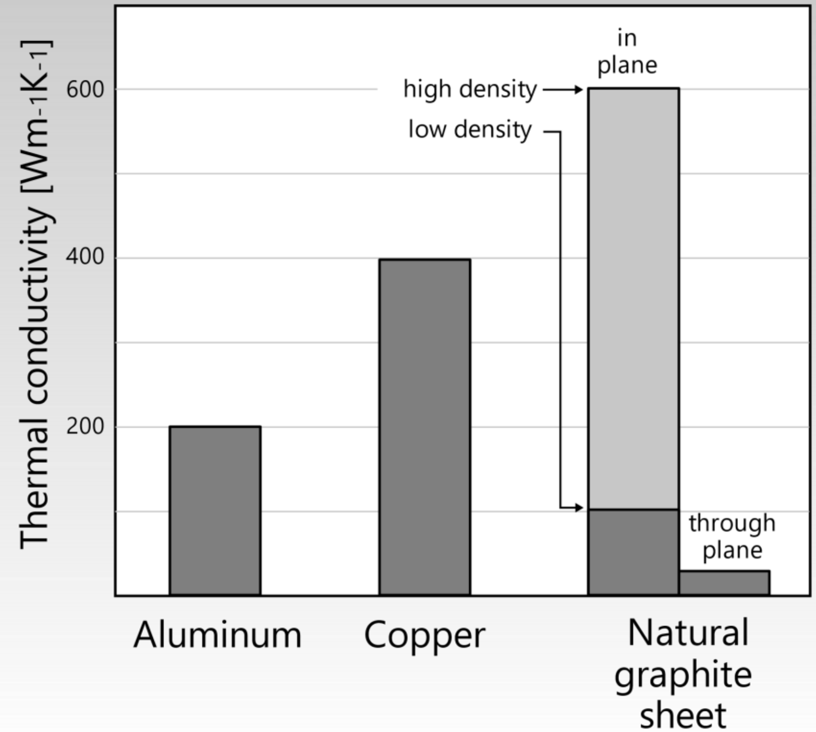
Roll embossing (mass production)

Light weight

Good cooling performance

Corrosion resistant

High thermal conductivity



Graphite heat sink had comparable performance to aluminum + TIM

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Terrella Energy Systems Ltd.

SFU

Greenhouse Research Collaboration

Three year project (2017-2018):

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

KWANTLEN POLYTECHNIC UNIVERSITY
SCHOOL OF HORTICULTURE

ARGUS CONTROLS

BC GREENHOUSE GROWERS' ASSOCIATION

core
ENERGY RECOVERY SOLUTIONS

QuantoTech

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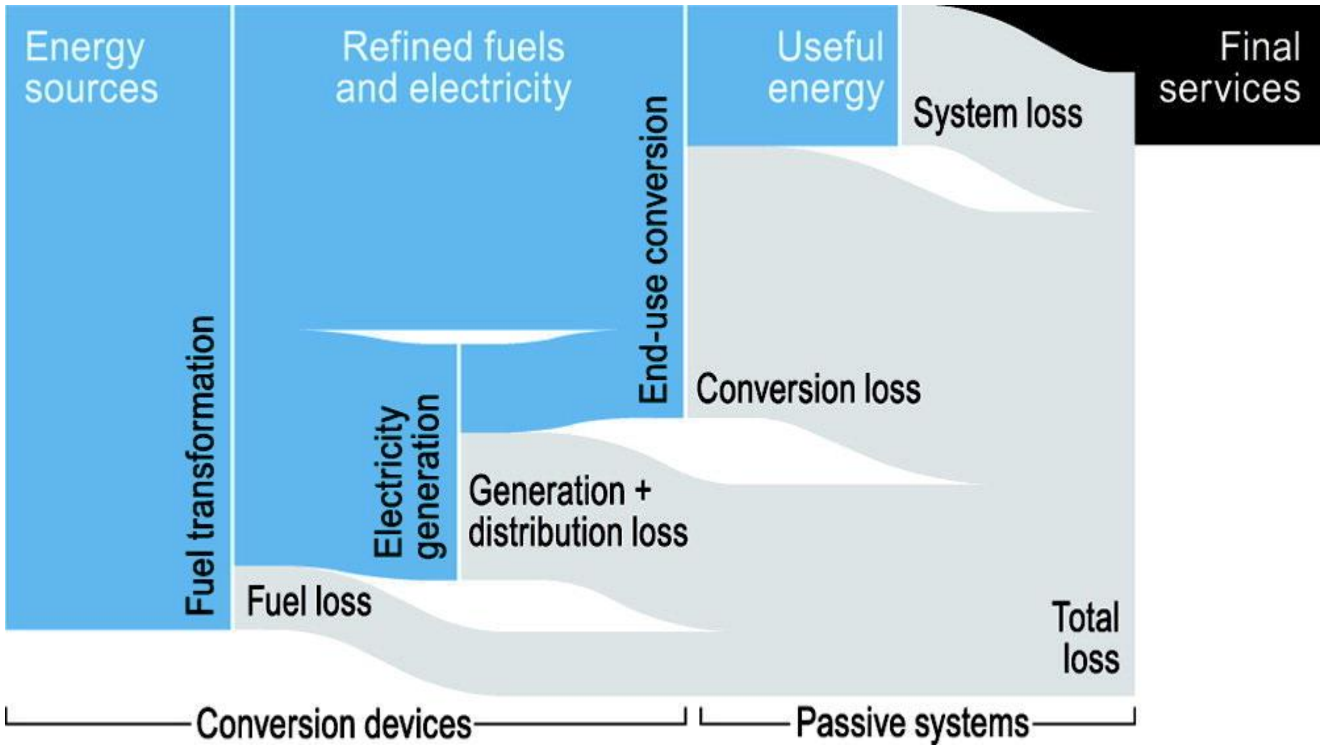
The LAEC has developed new composite sorbents, adsorber beds, capillary-assisted low pressure evaporators and a modular lab-scale sorption chiller

Future research includes:

- Lab-scale single chamber sorption chiller
- Sorber bed heat transfer modeling
- Composite sorbents
- Compact capillary-assisted evaporators
- Graphite heat exchangers
- Testing systems for sustainable temperature and humidity control in greenhouses

Thanks

Extra slides



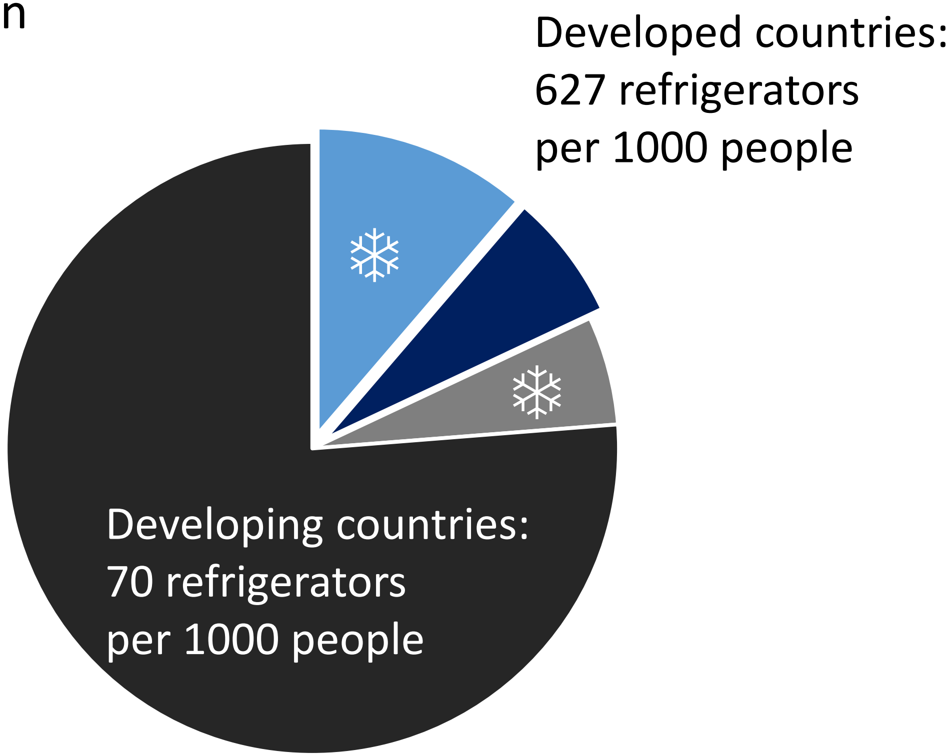
J. M. Cullen, et al., “Reducing energy demand”,
Environ. Sci. Technol., **45** (2011) p. 1711

The food cold-chain

World population: 7.3 billion

Food losses due to
lack of refrigeration: 25%

Projected population:
8.5 billion by 2030



How much power would be required to provide cold storage to this portion of the world population?

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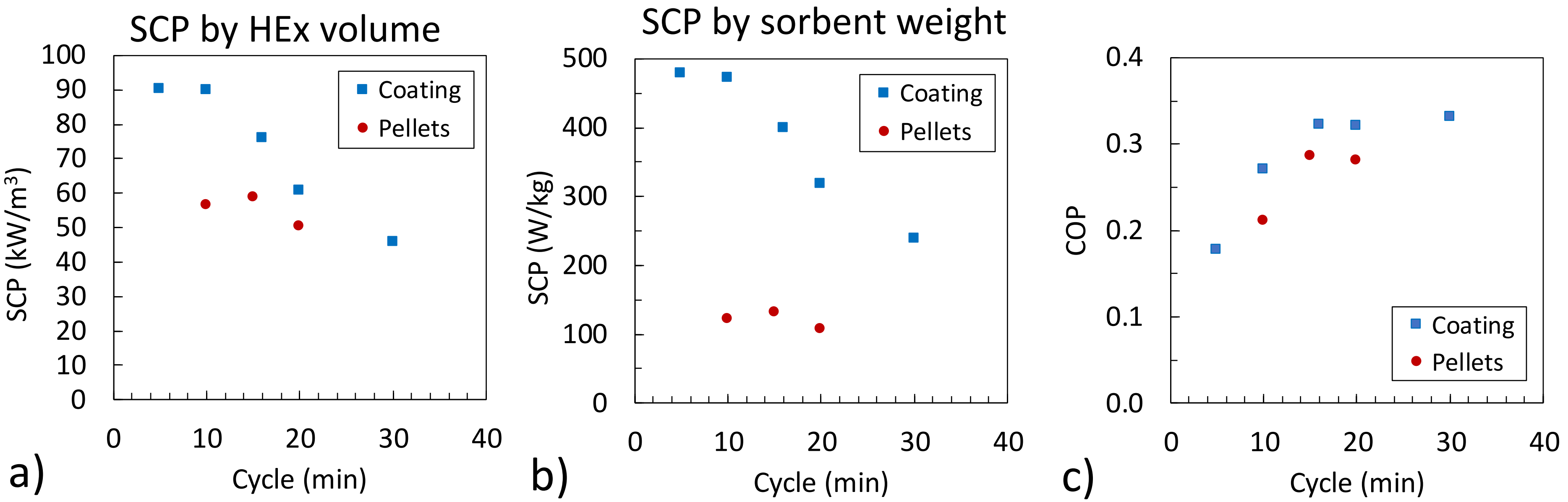
S.J. James, C. James, "The food cold-chain and climate change", *Food Res. Int.*, **43** (2010) p. 1944

Sorption Chiller: Comparison of AQSOA™ FAM-Z02 sorbent coatings and pellets



Operating conditions: T_{evap}= 15 °C, T_{cond}=T_{ads}= 30 °C, and T_{des}= 90 °C

Z02 coating 0.8 kg per HEx   Z02 pellets 1.97 kg per HEx

Heat transfer measured at the evaporator

$$Q_{evap} = \int_0^{\tau} \dot{m} c_p (T_{\text{in}} - T_{\text{out}}) dt$$

Coefficient of performance

$$COP = Q_{evap}/Q_{heat}$$

Specific cooling power

$$SCP = Q_{evap}/(m_{ads} \cdot t_{cycle})$$

Volumetric cooling power

$$VSCP = Q_{evap}/(V_{ads} \cdot t_{cycle})$$

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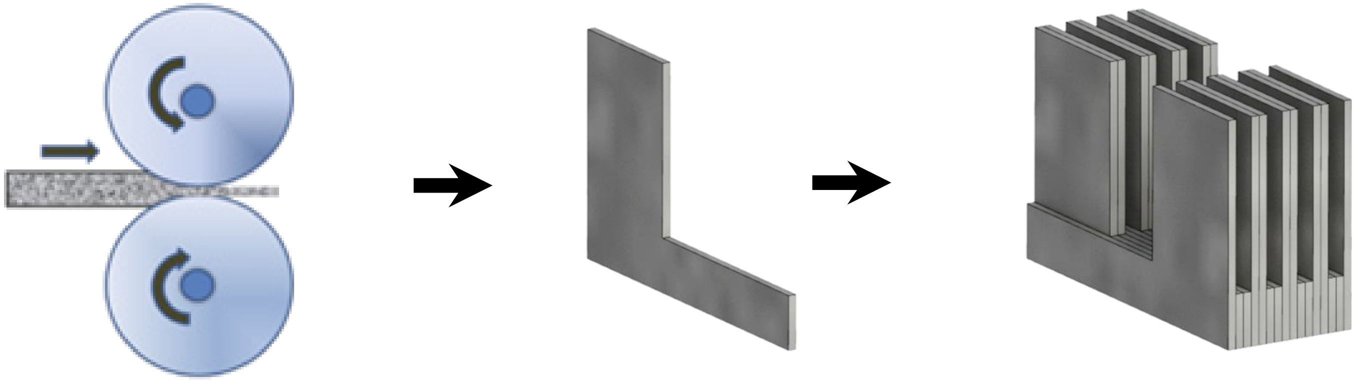
Manufacture of heat sinks from natural graphite sheets



Roll embossing and cutting

Basic shape

Stacked and glued basic shapes

Terrella Energy Systems Ltd.

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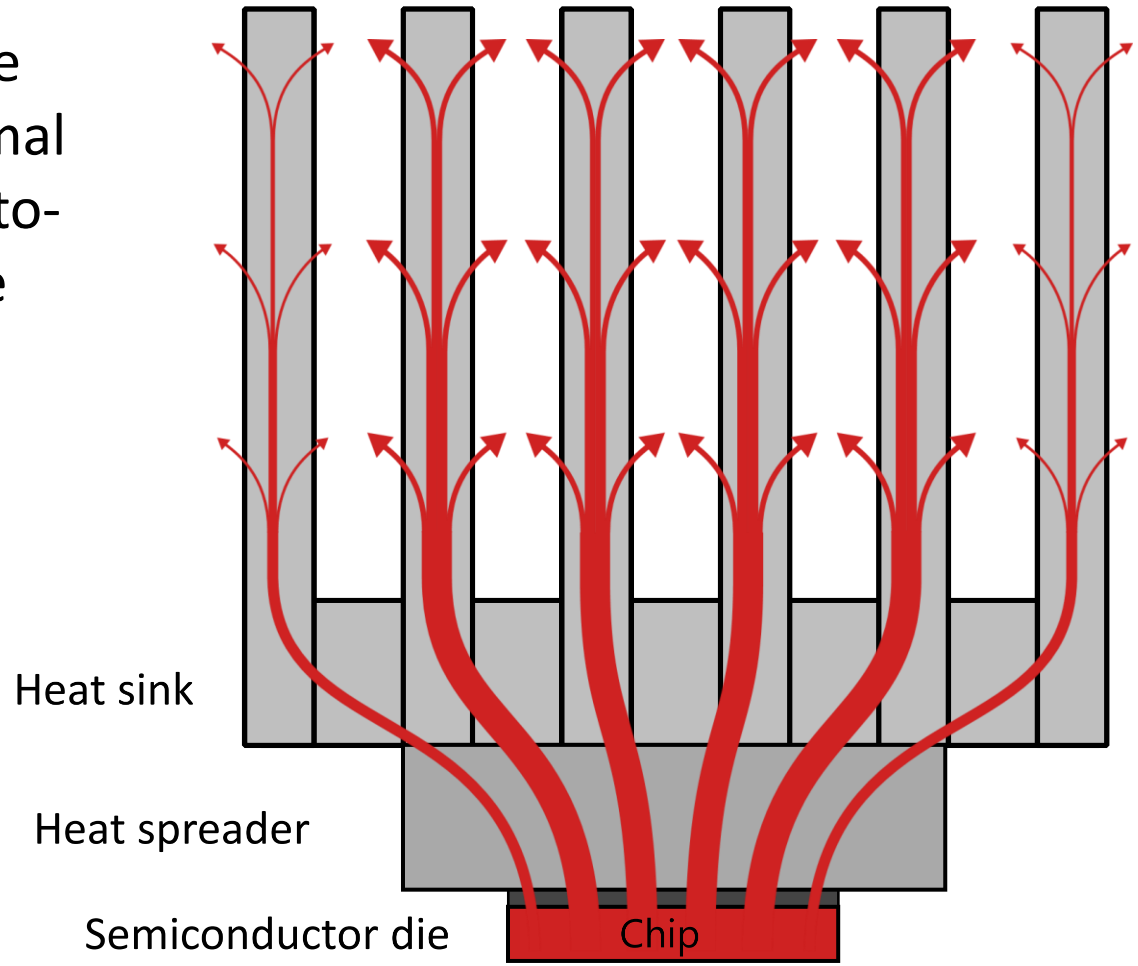
M. Cermak, et al, (2018) "Natural-graphite-sheet based heat sinks", *34rd Thermal Measurement, Modeling & Management Symposium (SEMI-THERM)*: 310-313.

Heat transfer: Anisotropic graphite sheet heat sinks

Heat transfer in the base limited by the low thermal conductivity and sheet-to-sheet contact resistance

Optimal geometry for a graphite heat sink will differ from metal



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