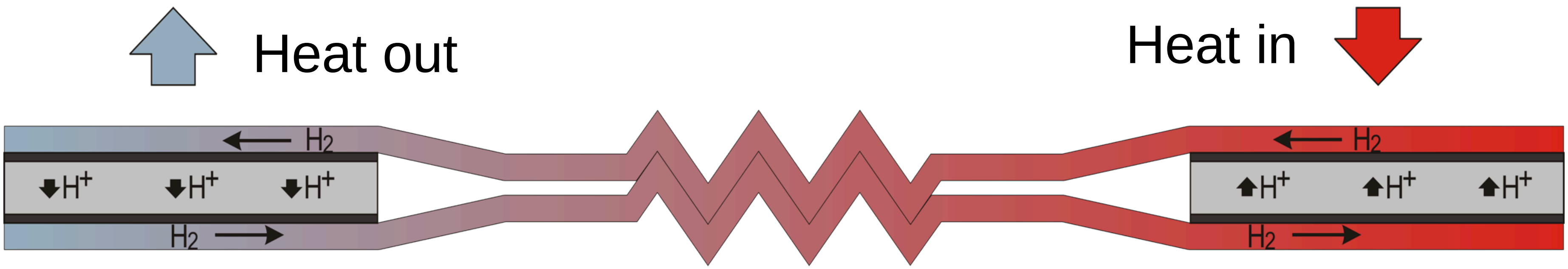
JTEC: A Hydrogen Thermoelectric Converter

parc
A Xerox Company



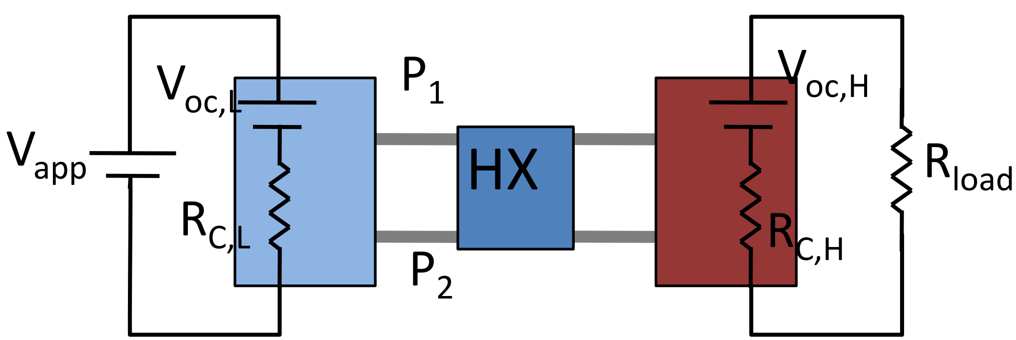
Electrochemical compression stack

Regenerative heat exchanger

Electrochemical expansion stack

- No-moving parts electrochemical heat engine
- The working fluid, hydrogen, completes an approximate Brayton cycle
- Potential for competitive power density to free-piston Stirling engines

Electrical model:

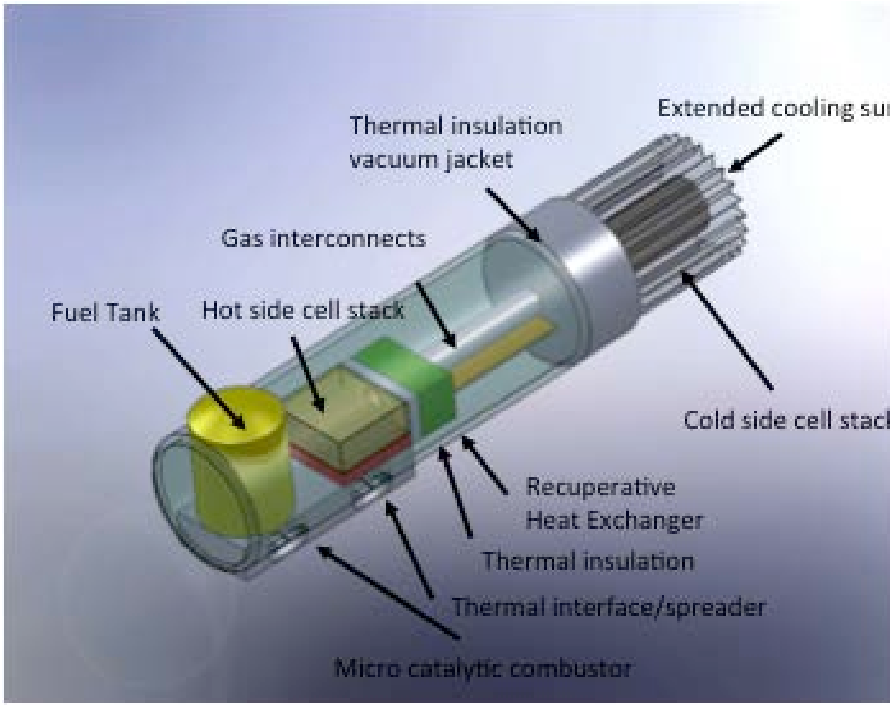


$$V_{oc} = \frac{RT}{2F} \ln\left(\frac{P_2}{P_1}\right)$$

Voltage is linear in temperature but only logarithmic in pressure ratio

JTEC continued

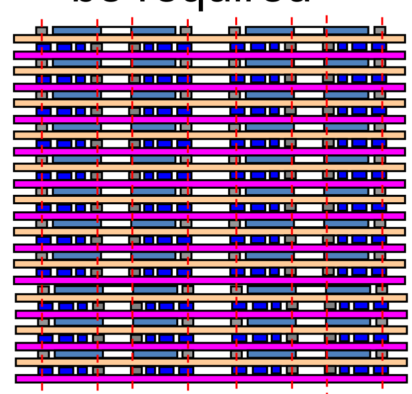
PARC small-scale generator concept



Burns liquid or gaseous hydrocarbons efficiently for distributed power generation. Hot side ~1100C.

PARC also performed design trade study on 700C hot-side stack.
Most significant sources of loss: Fluid flow resistance in stack and membrane electrical resistance.
Conclusions:

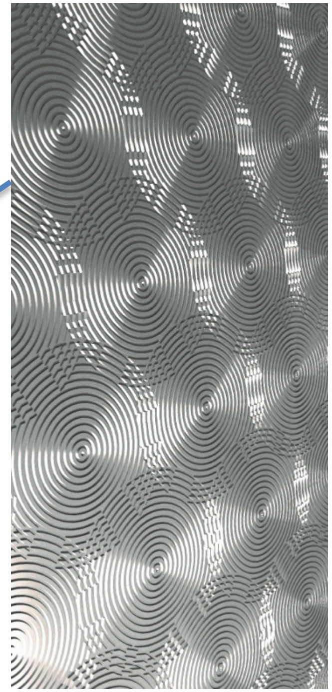
- Efficiency depends strongly on stack design
- Key to cost is tradeoff b/w stack performance and manuf. complexity
- PARC concept (below)could be economical, requires some process development
- Cold-side materials development may be required

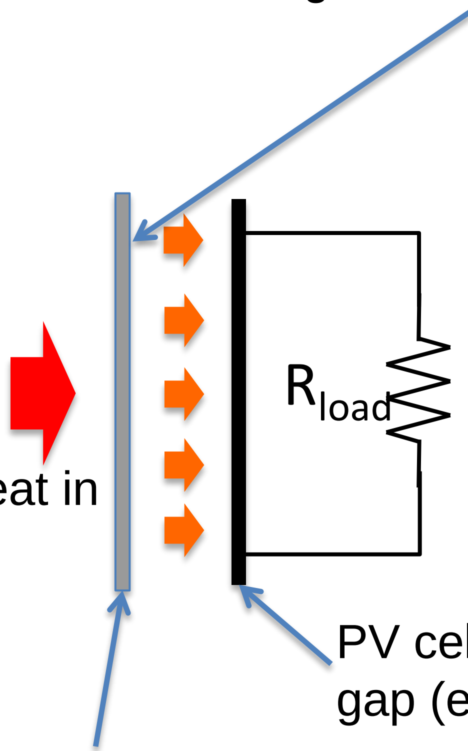


PARC hot-side stack concept: can create high-performance stack with high-throughput manufacturing process (Details are proprietary)

Metamaterials-enhanced TPV

Key enabling technology: overlapping bull's eye metamaterial design

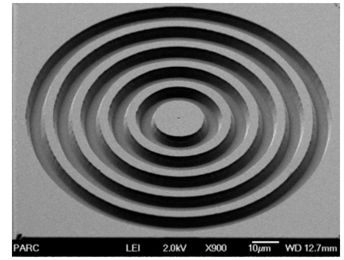




PV cell with IR band gap (e.g. GaSb)

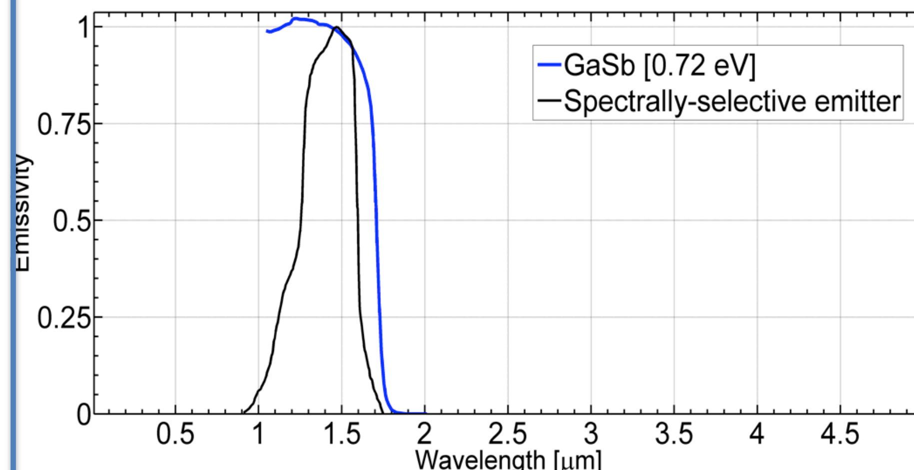
Tuned thermal emitter

The emissivity of a thermal radiator is tuned using metamaterials techniques to match the band gap of a PV cell, increasing conversion efficiency.



Single bull's eye fabricated at PARC

Simulated spectrum shows good match to GaSb band gap:



TPV is a well-known type of no-moving-parts heat engine but suffers from low effciency (~10%). Initial estimates show PARC metamaterials approach can increase efficiency to 20-30%.