CAM-IES Industry Workshop:

Energy Harvesting for Wireless Sensors and IoT

Thermoelectric Energy Harvesting

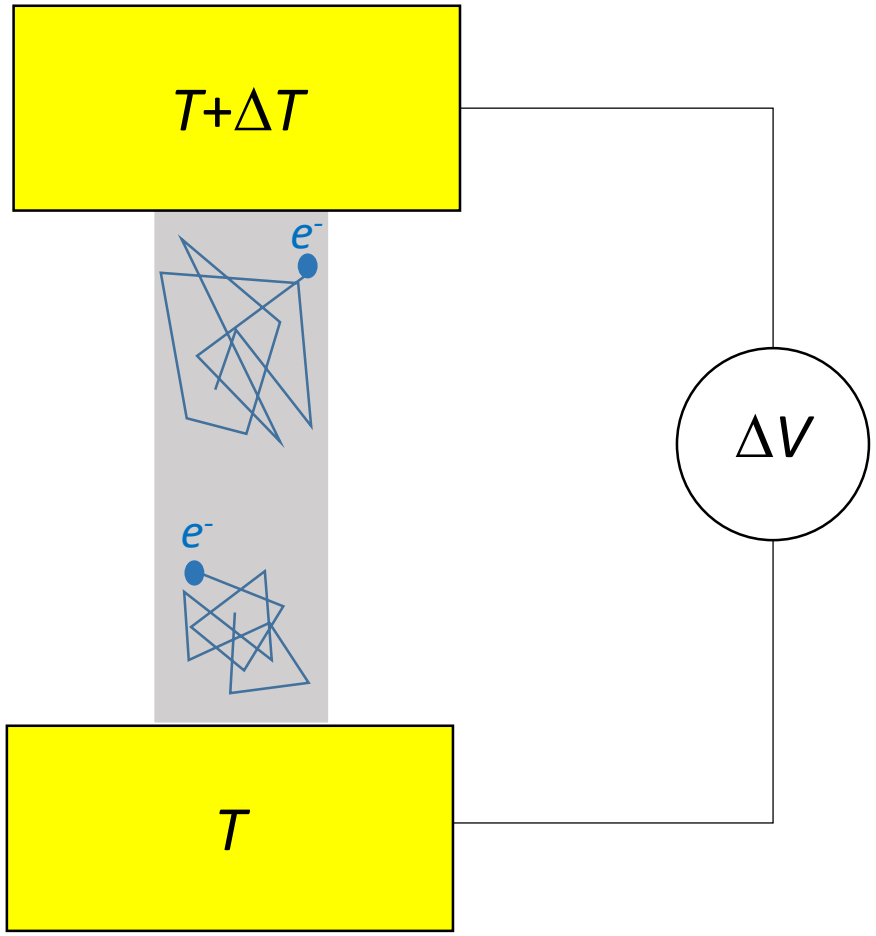
Mark Baxendale

School of Physics and Astronomy, Queen Mary University of London

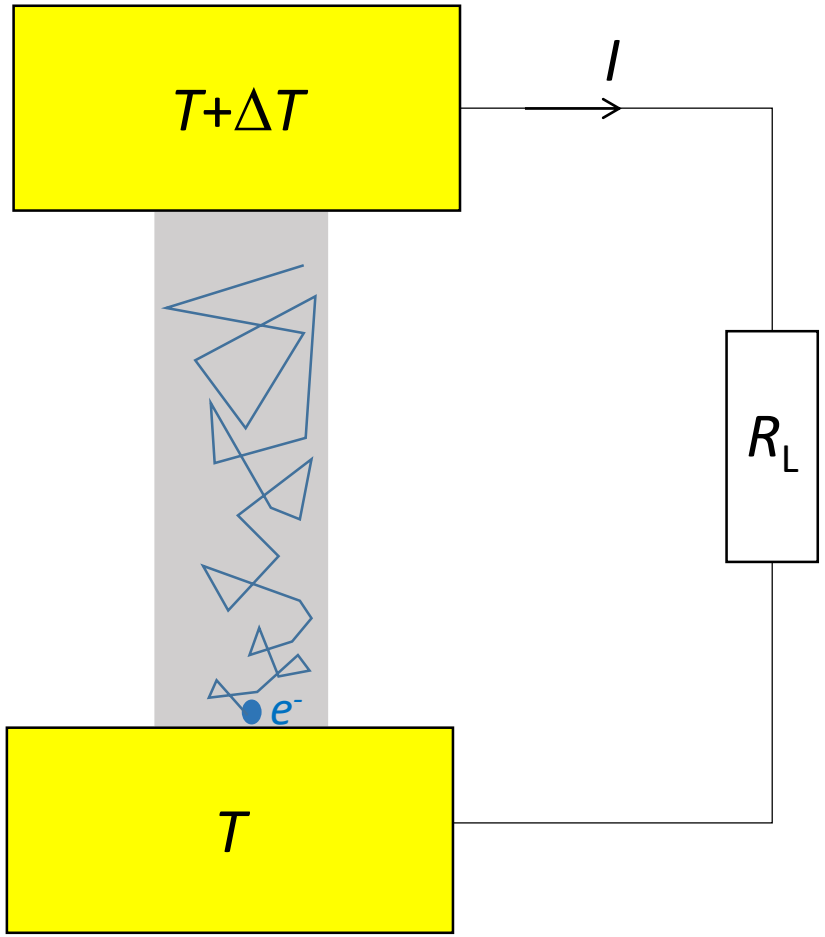
CAM-IES

Centre of Advanced Materials for Integrated Energy Systems

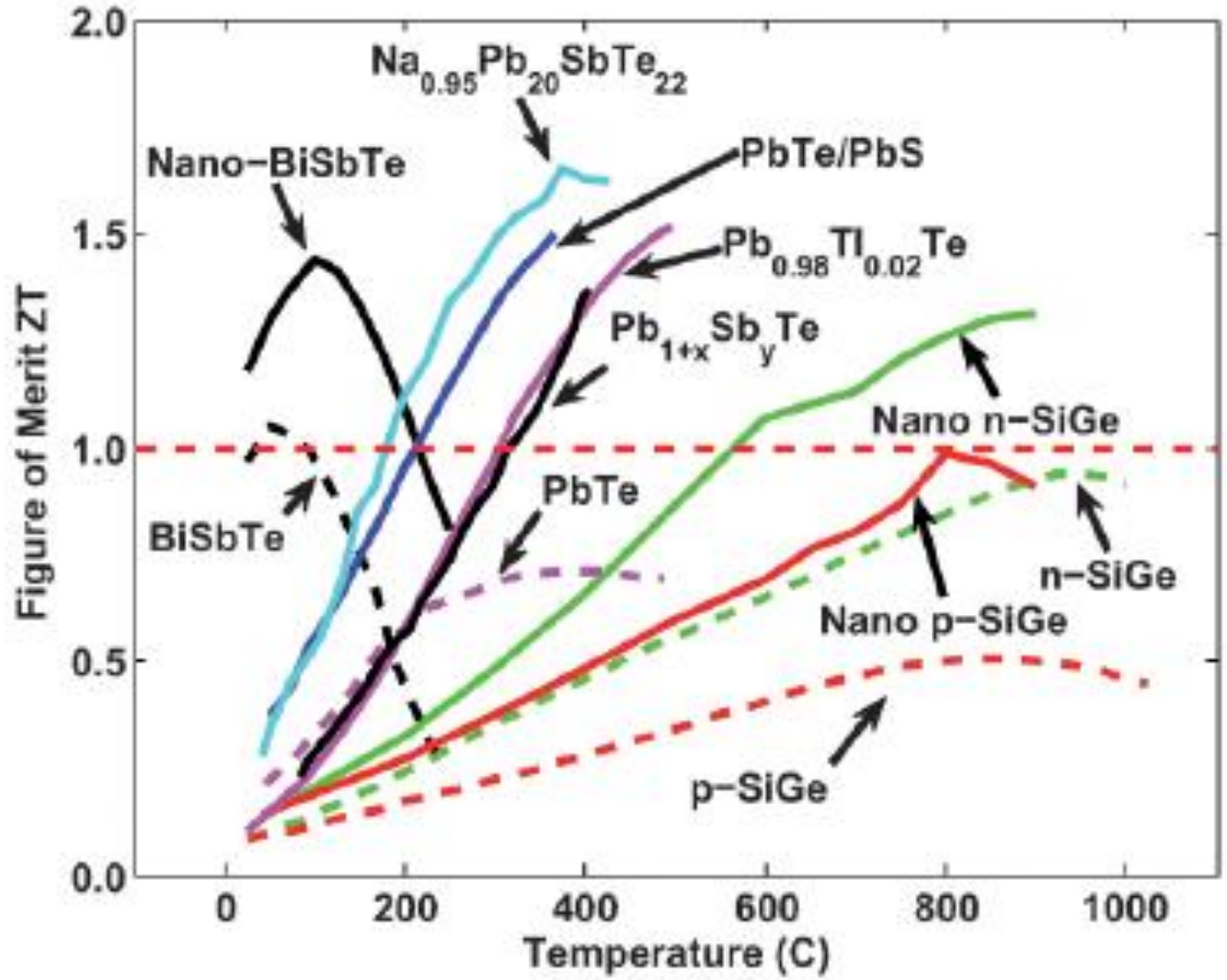
Queen Mary University of London



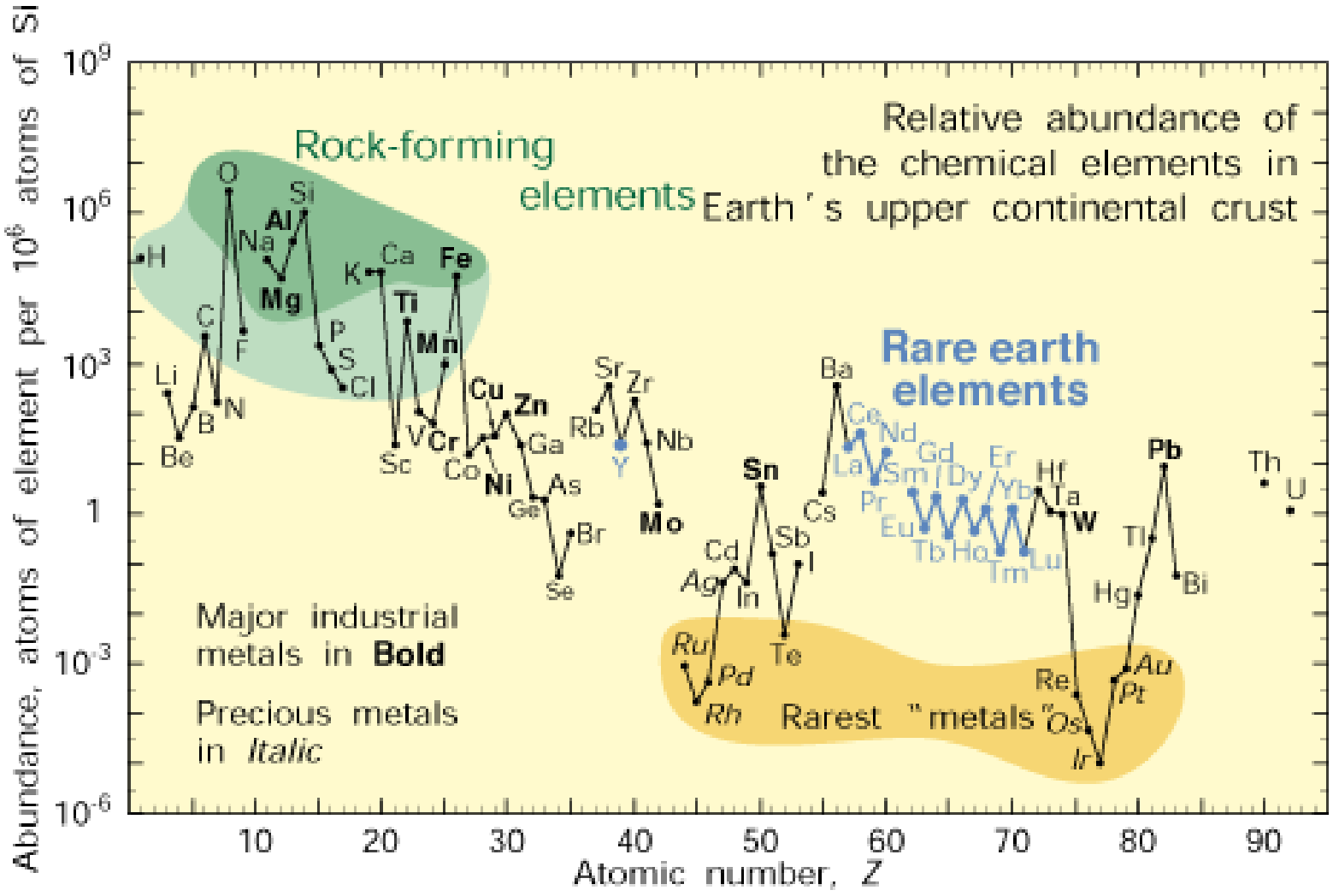
$$S = -\frac{\Delta V}{\Delta T}$$



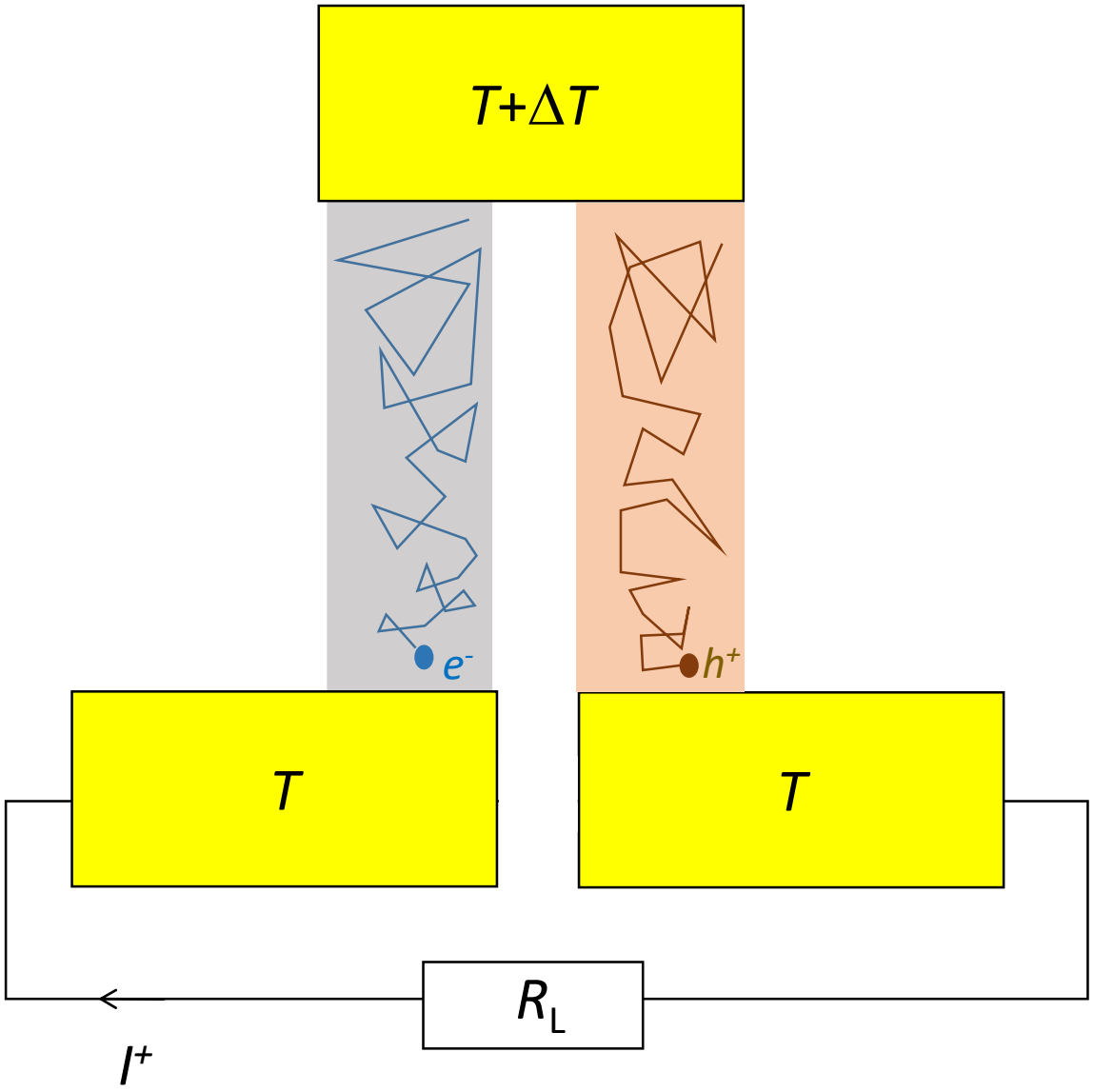
$$ZT = \frac{S^2\sigma}{\kappa_{\mathrm{el}}+\kappa_{\mathrm{ph}}}T$$

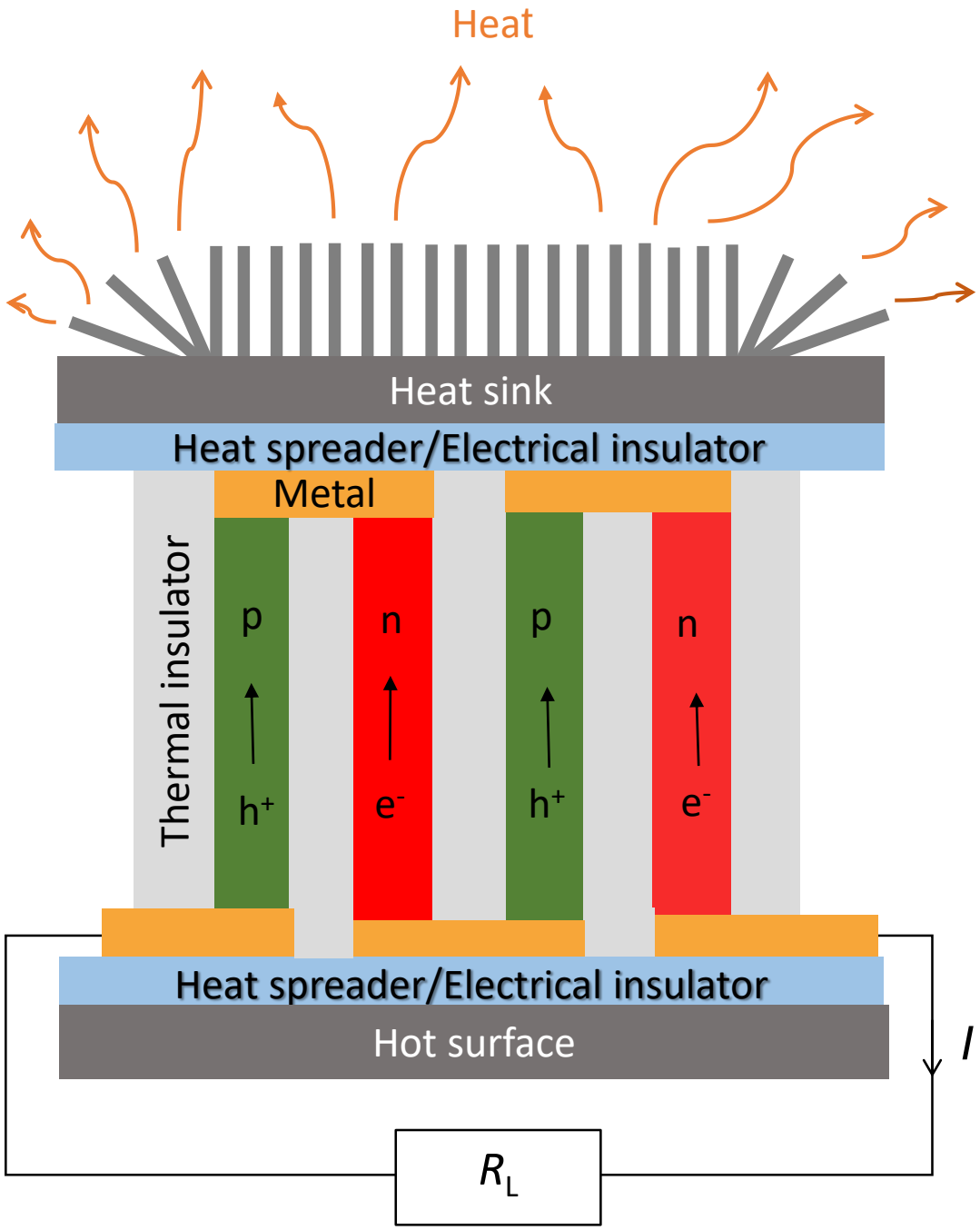


Energy & Env. Sci. **2**, 446 (2009)



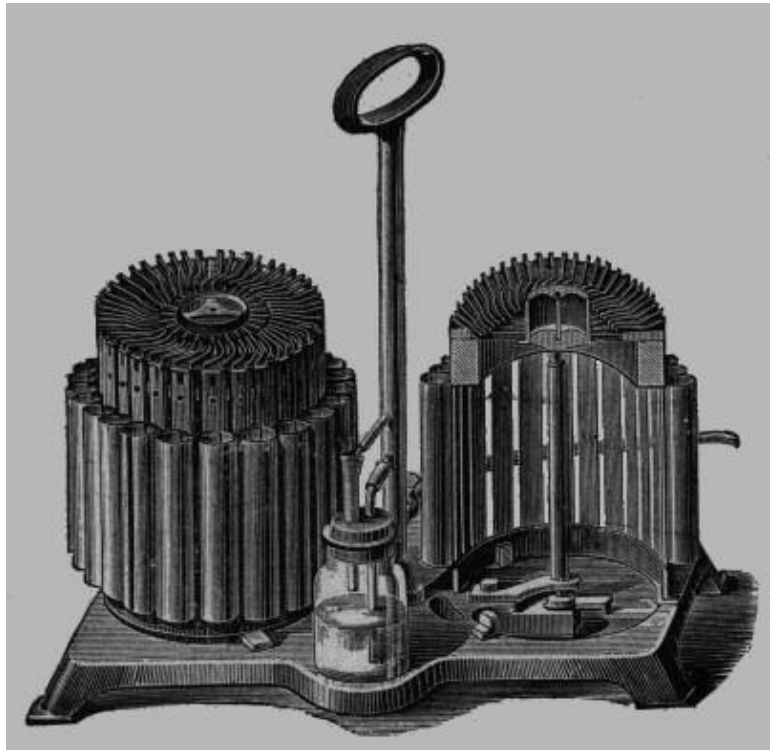
U.S. Geological Survey Fact Sheet 087-02, 2005


T+ΔT
e-
h+
T
T
R_L
I+



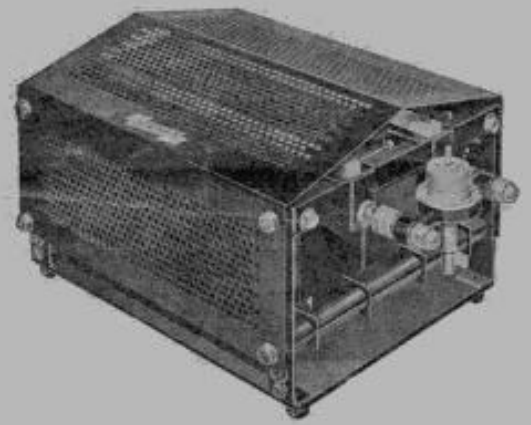
$$\frac{P_{\max}}{A} = \frac{F \times (S\Delta T)^2 \sigma}{4L}$$

1821 1870 1930 1956



GAS Operated RADIO!

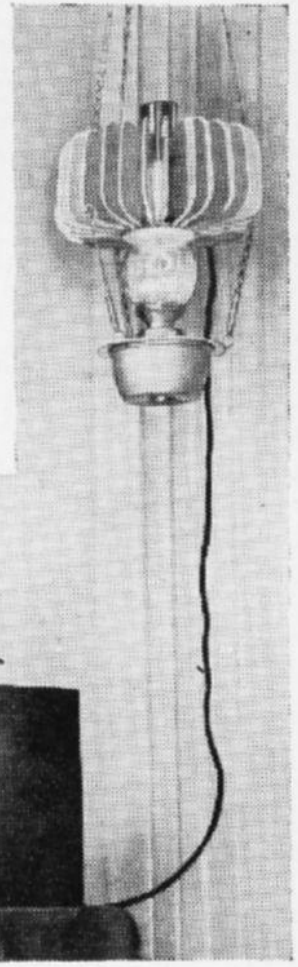
THE INVENTION OF A GENERATION

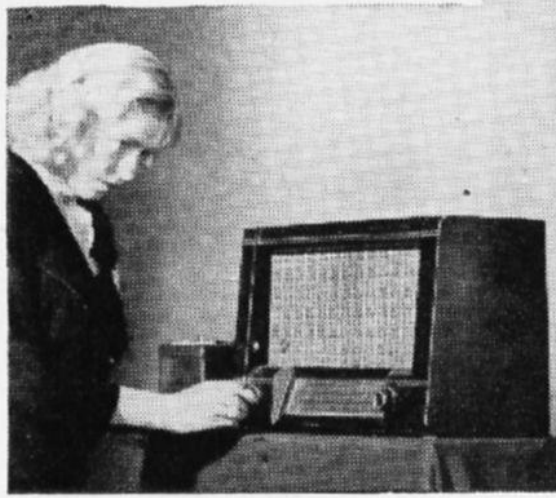


THIS IS
THE THERMO-ELECTRIC GENERATOR
which makes your Battery Set Independent of Batteries of any kind. Dispense with Accumulator charging and uncertainty of Reception. Gas, unfailing in supply will definitely improve your listening

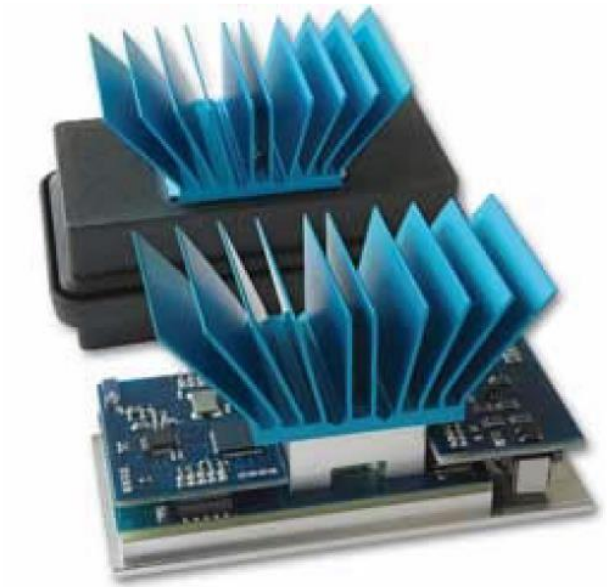
THERMO-ELECTRIC RECEIVER

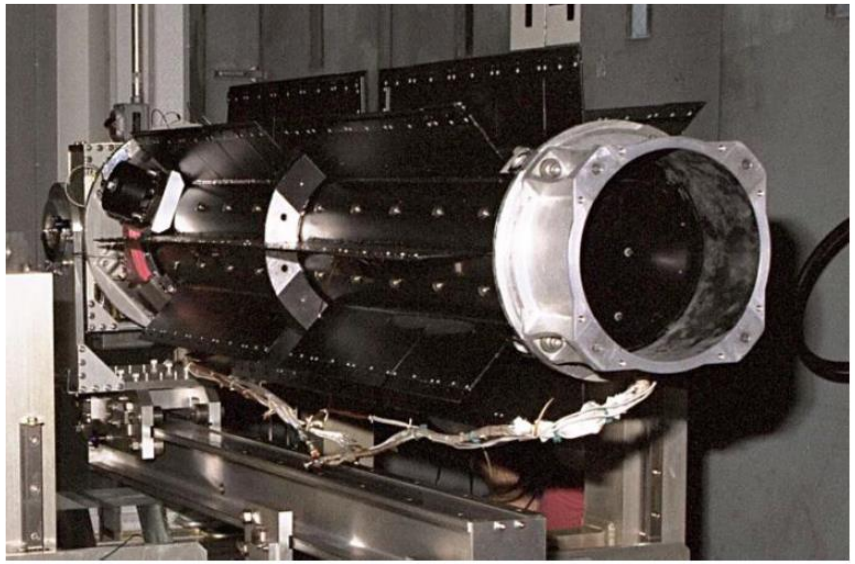
Heated by an ordinary paraffin lamp, this thermal generator was exhibited by the U.S.S.R. at the Leipzig Fair. Consisting of a number of bi-metallic thermocouples backed in asbestos and mounted on the glass chimney, it is heated to 300°C and cooled by the radial fins to 30°C, the temperature differential causing a current to flow. Its output operates a vibrator for the receiver's h.t. supply.

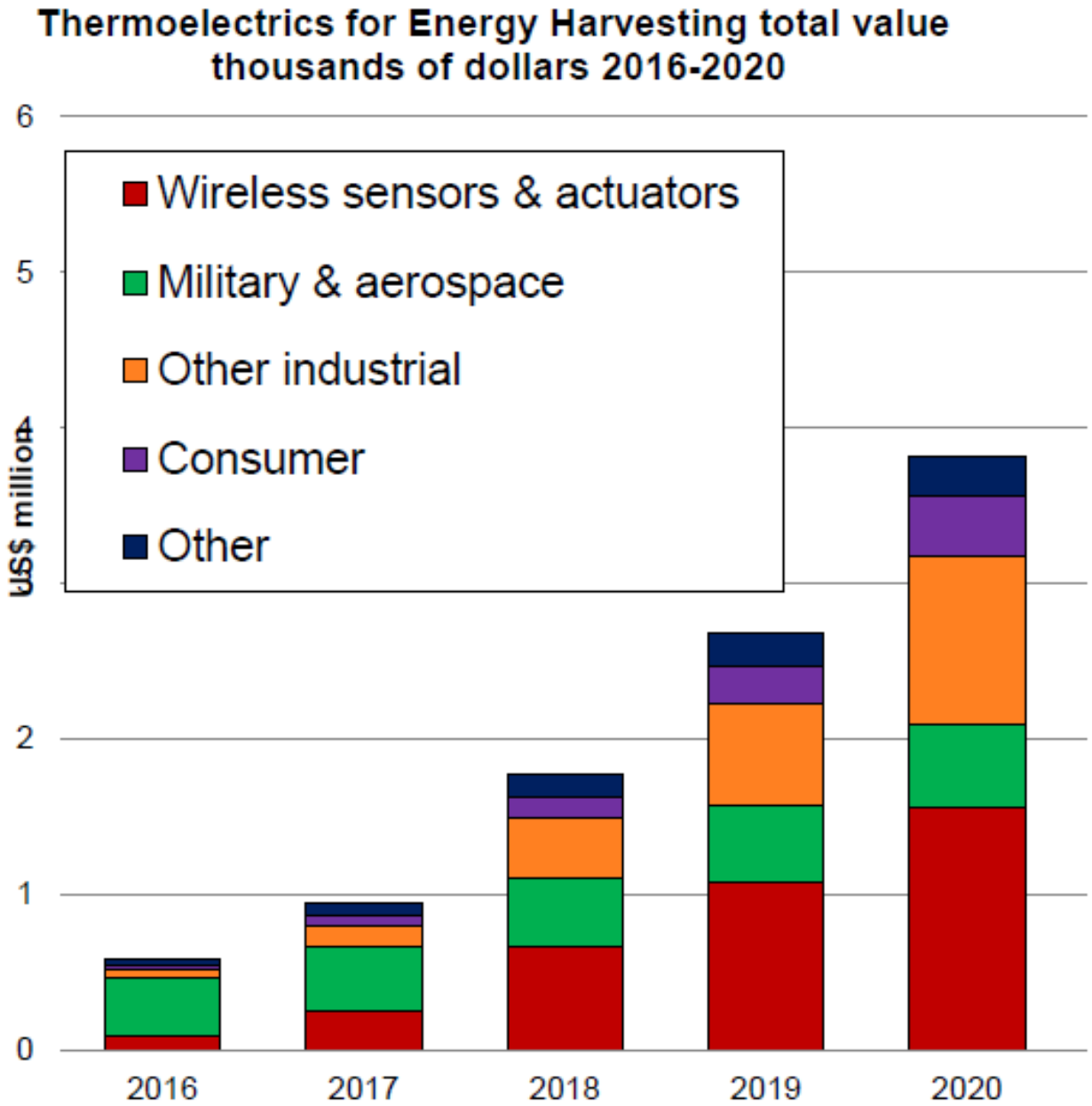




2011 2012 2013







IDTechEx.com/thermo

Internet of things
Internet of everything
Smart objects
Industrial internet
Machine to machine
Ambient intelligence
Operational technology
Wireless sensor networks
Cyber-physical systems
Ubiquitous computing
Pervasive sensing
Cooperating objects

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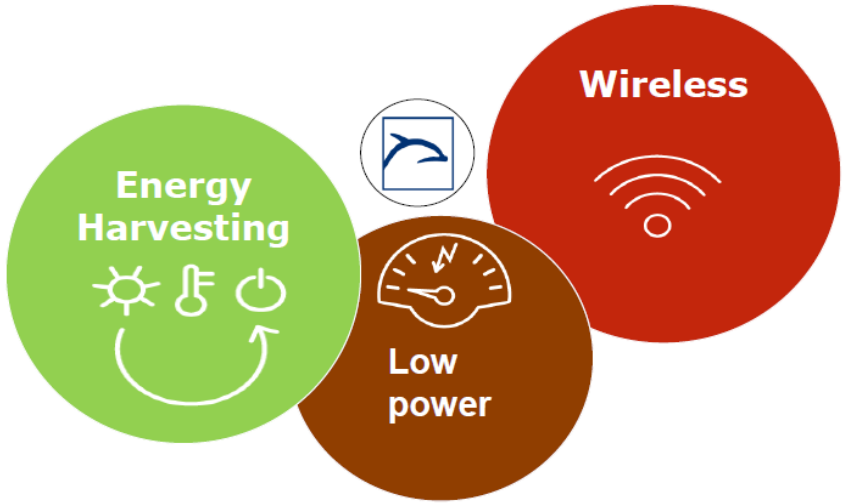
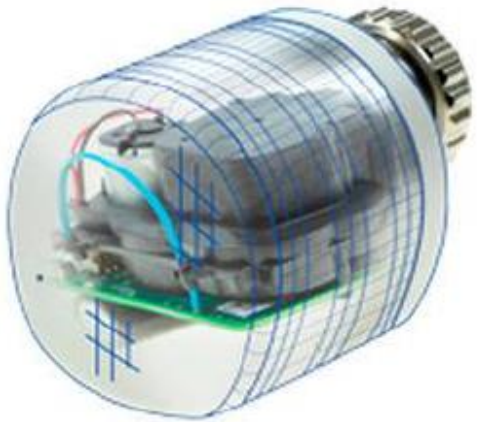
MEMBER





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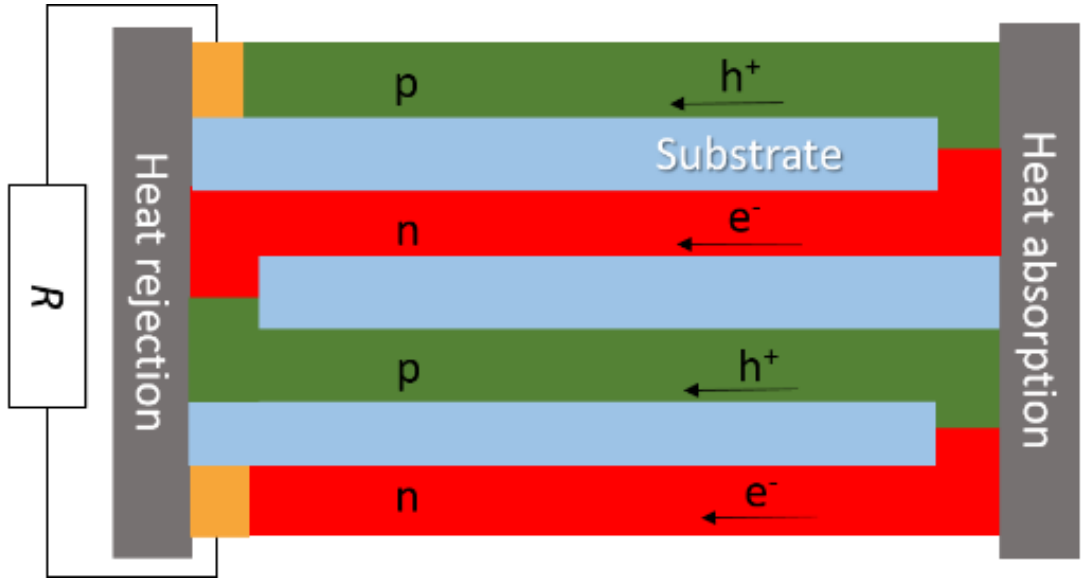
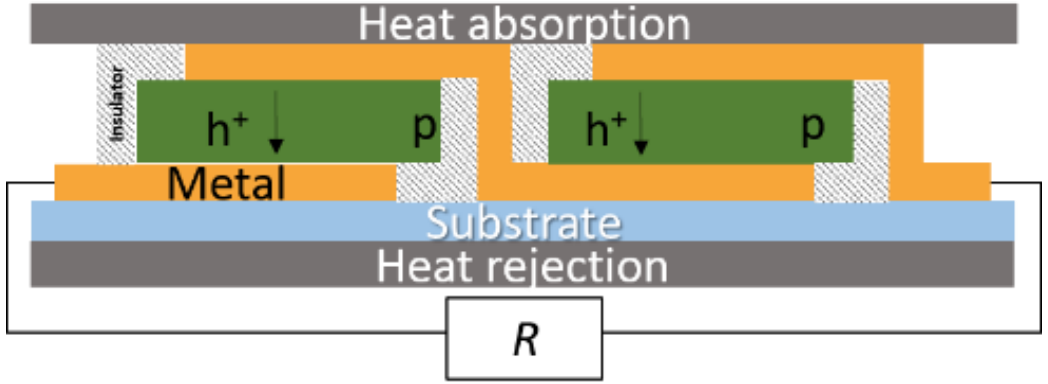
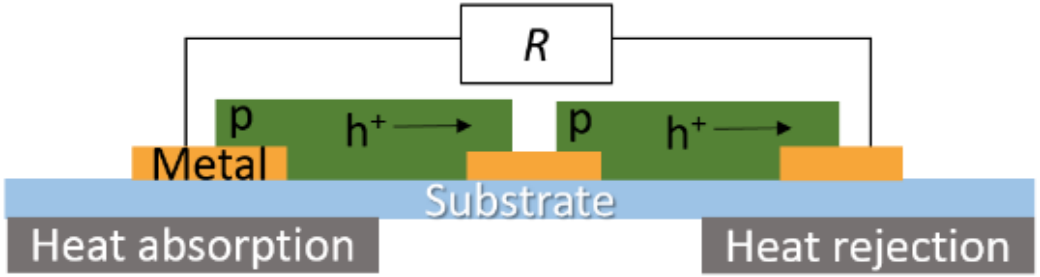
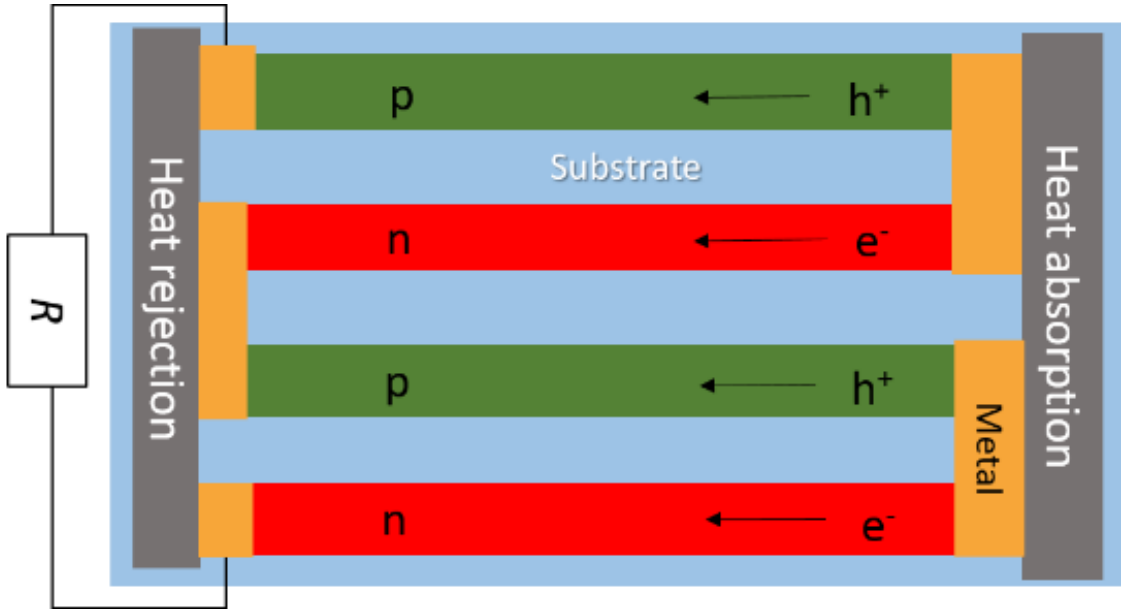
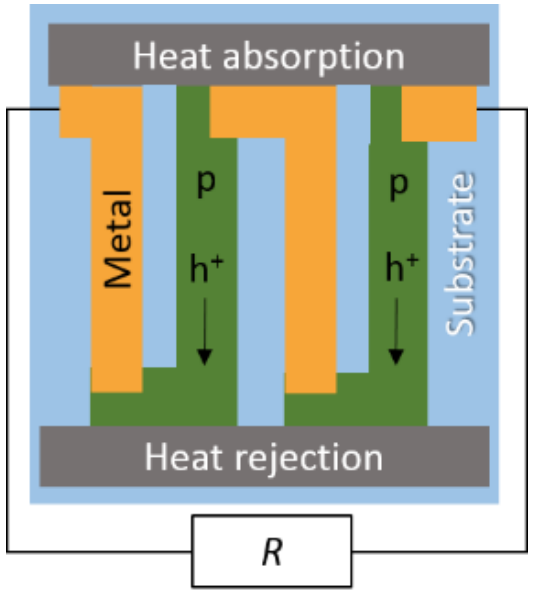
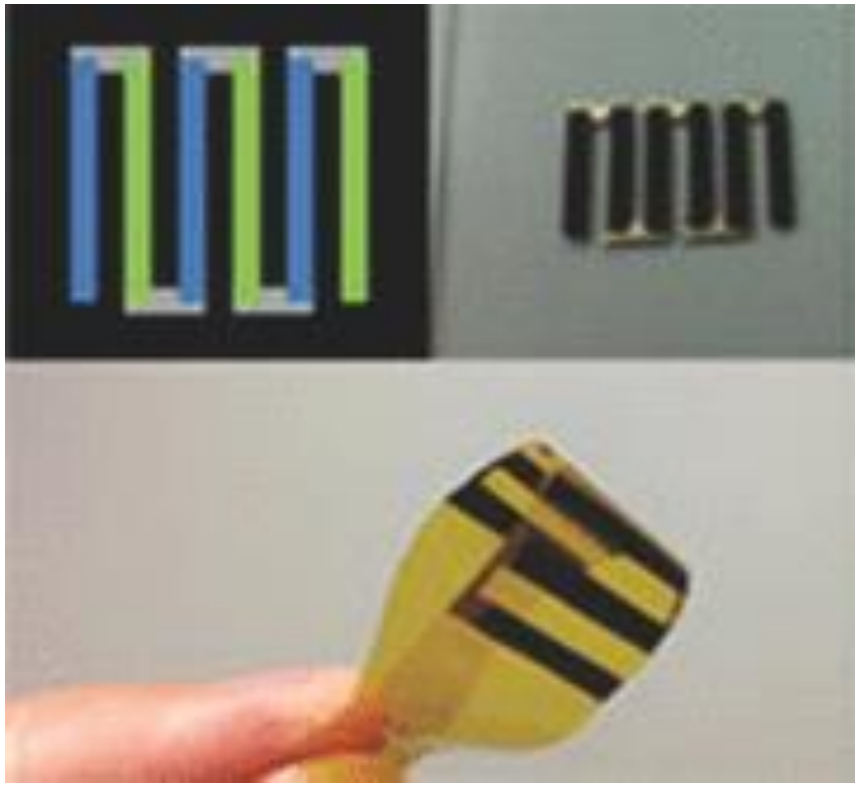

R
Heat rejection
p
h+
Substrate
n
e-
p
h+
n
e-
Heat absorption


Heat absorption
insulator
h+
p
h+
p
Metal
Substrate
Heat rejection
R

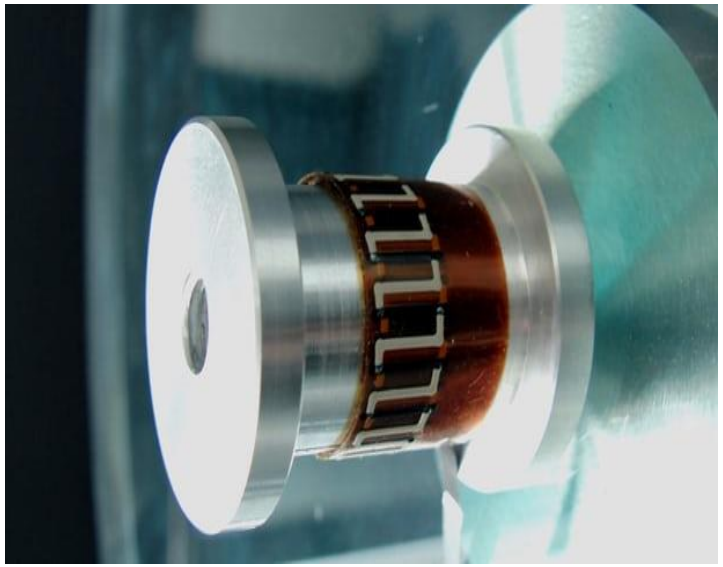

R
p
h+
p
h+
Metal
Substrate
Heat absorption
Heat rejection


R
Heat rejection
p
h+
Substrate
n
e-
p
h+
Metal
n
e-
Heat absorption


Heat absorption
Metal
p
h+
p
h+
Substrate
Heat rejection
R



Lu *et al*, Small 2014



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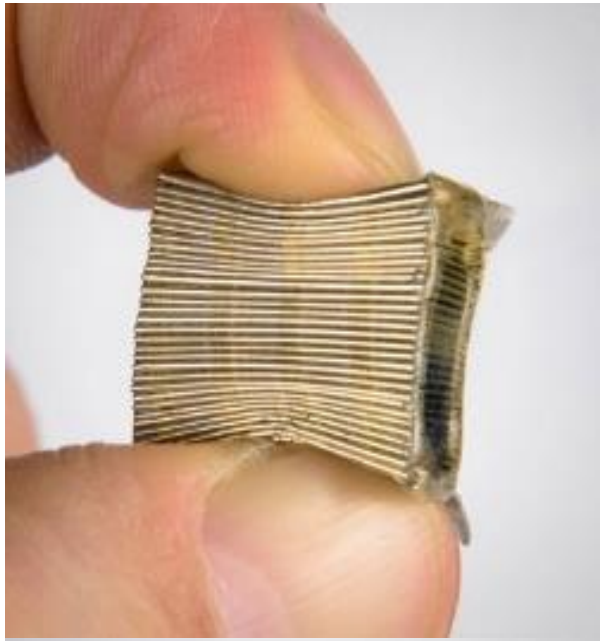

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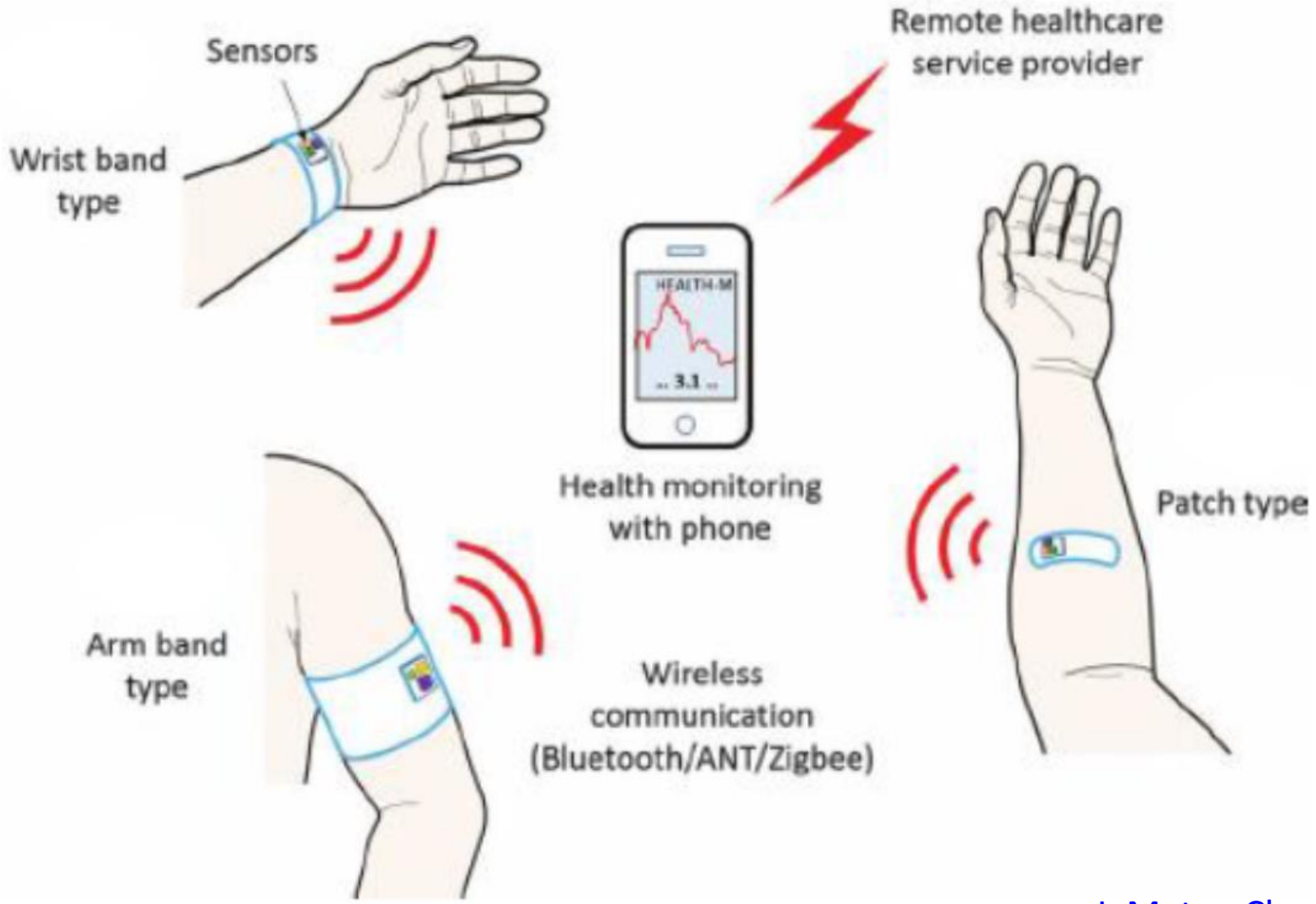

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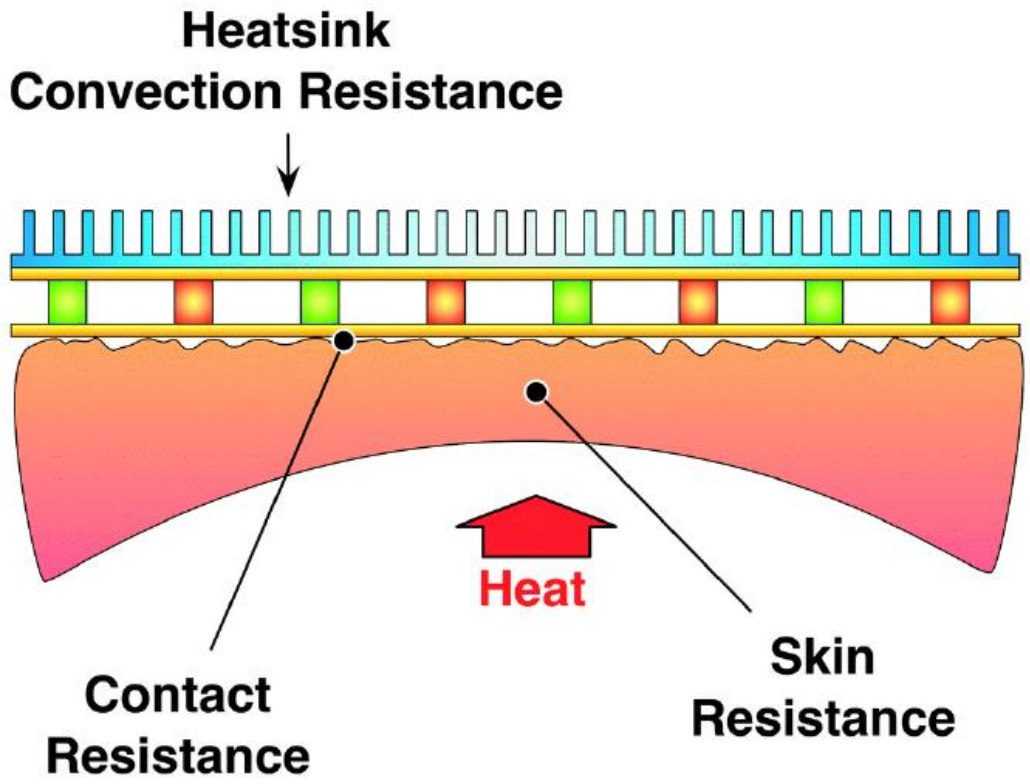

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