Thermoelectric Energy Harvesting for Body Powered Medical Platforms

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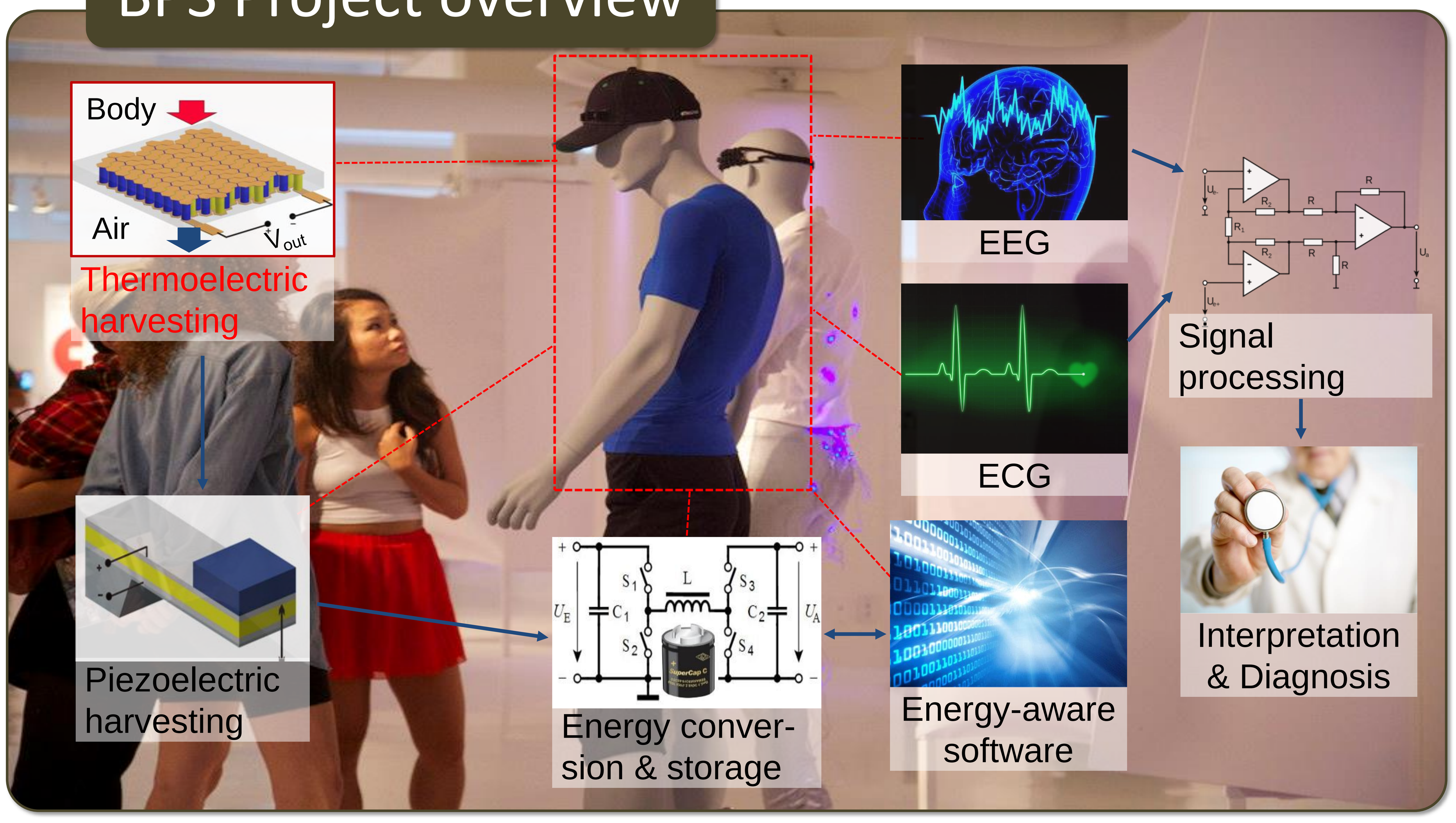
http://BodyPoweredSenSE.ch

BPS Project overview



Large-are harvester for the forehead

Motivation: Signal processing and the interpretation, storage and communication of data consumes power in the lower mW-regime

System overview

(1) Heat sink (R_{th} = 25 K/W) to dissipate heat into the environment

(2) Stacked TEGs (QC32, R_{el}=5.54Ω, R_{th}=85K/W) for power generation

(3) Hot interface (Al, A=2.5cm²) to increase effective harvesting area

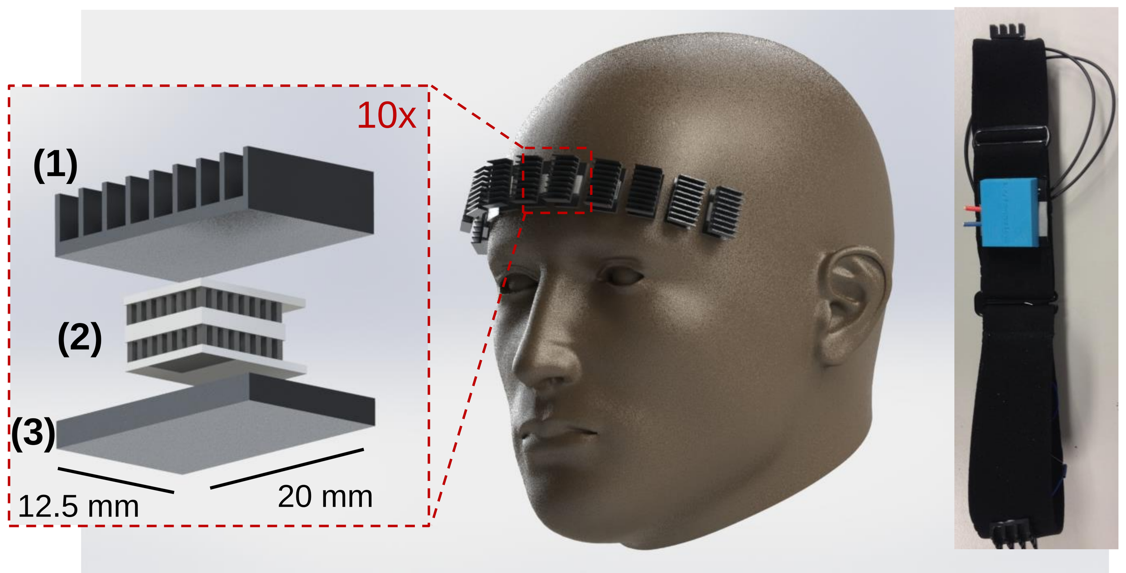
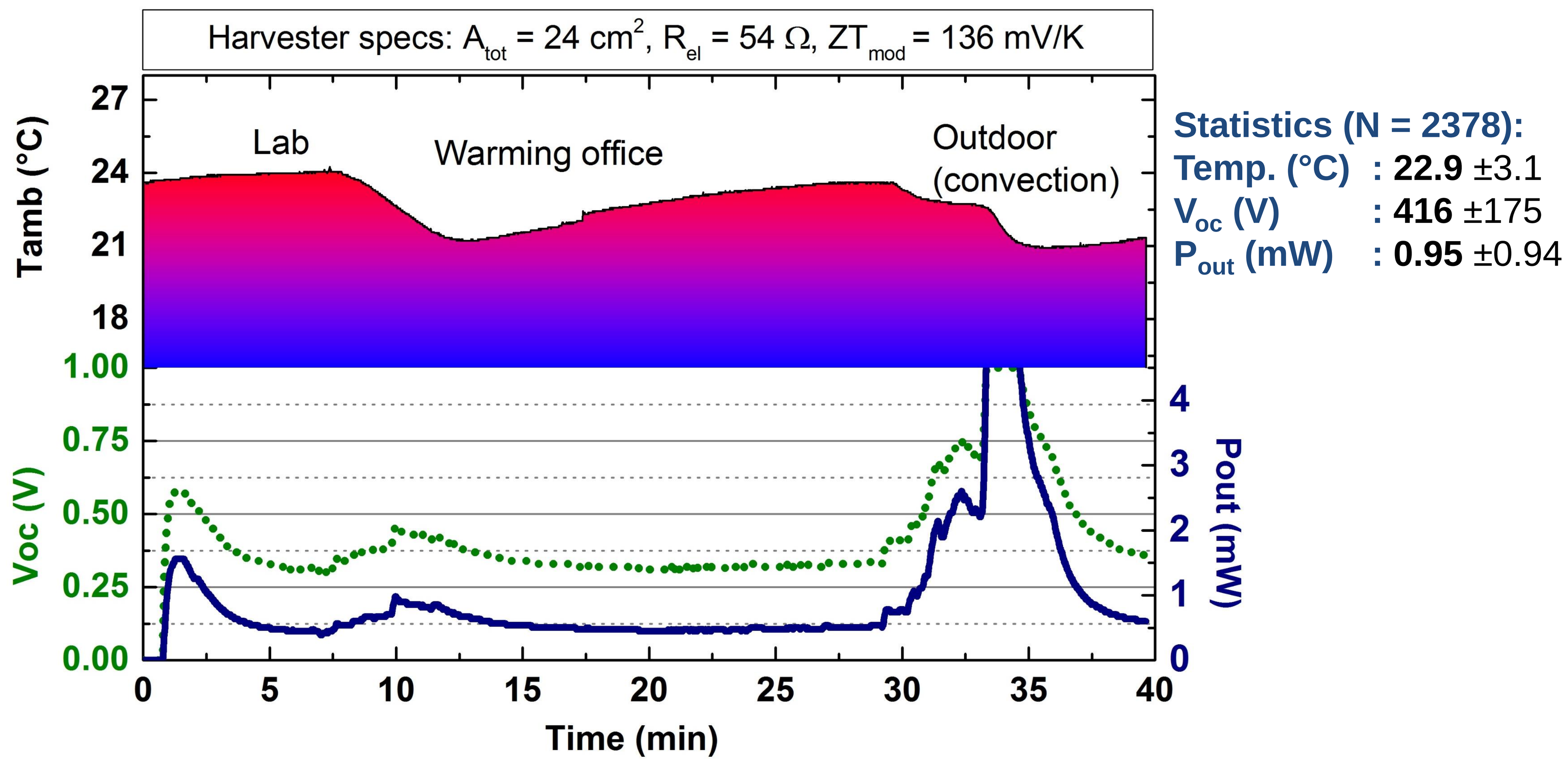


Fig 1: System overview (center), closeup of the harvester module (left) and prototype(right).

Long-term measurement results



Statistics (N = 2378):
Temp. (°C) : 22.9 ±3.1
V_{oc} (V) : 416 ±175
P_{out} (mW) : 0.95 ±0.94

Fig 2: Long-term measurement with harvester prototype in varying environmental conditions

Comparison with State of the Art

Attribute	IMEC (1)	BPS	Change
Area	64 cm²	25 cm²	- 61 %
Volume	~ 250 cm³	40 cm³	- 84 %
Weight	~ 300 g	80 g	- 73 %
Rel	?	54 Ohm	
Pout (uW/cm2)	30 at RT	26 at RT	-13 %
Temp. range	21-26°	15-30°	x 3

Testing under real-world conditions

Fig3: Young test subject with prototype

Outlook: Power-per-area similiar to the SoA with strongly reduced form factor → True wearability

(1) Leonov, V., et al., *THERMINIC 2009. 15th International Workshop on*. IEEE, 2009

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Zero-power active EEG electrode

Motivation: Active amplification and filtering of signals in the biopotential electrode consumes power in the uW-regime

System overview

(1) Heat sink (R_{th} = 29 K/W) to dissipate heat into the environment

(2) ASIC for power management and signal processing → EPFL ESPLAB

(3) Generator (MPG651)

(4) Silicone ring for thermal isolation and structural stability

(5) Heat transfer structure to funnel heat to the TEG and prevent parasitic flux

(6) Stainless steel **disc electrode**

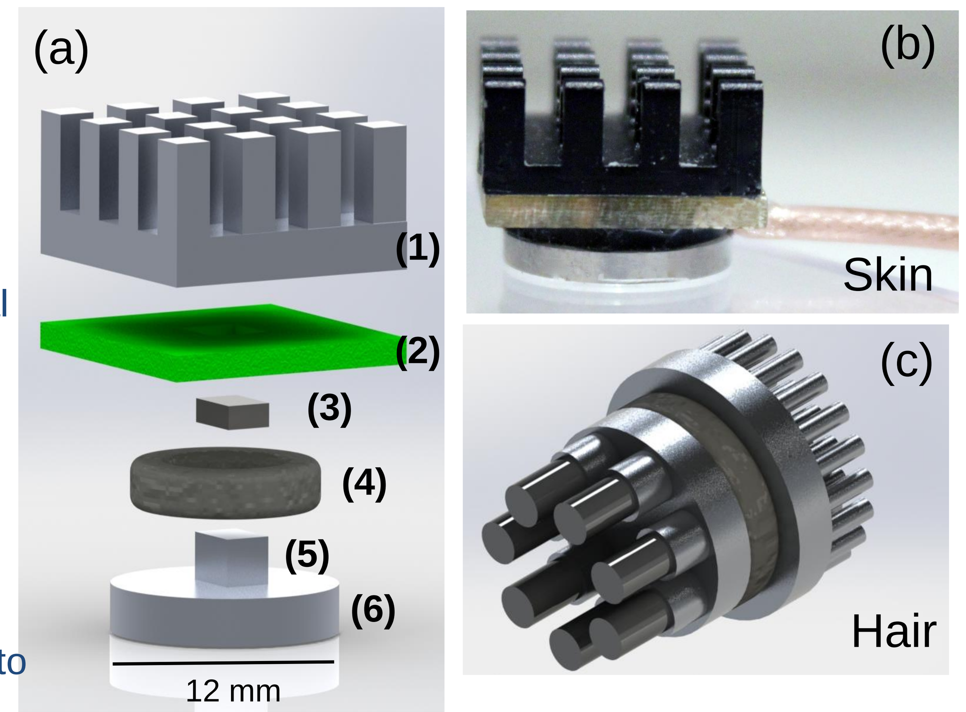
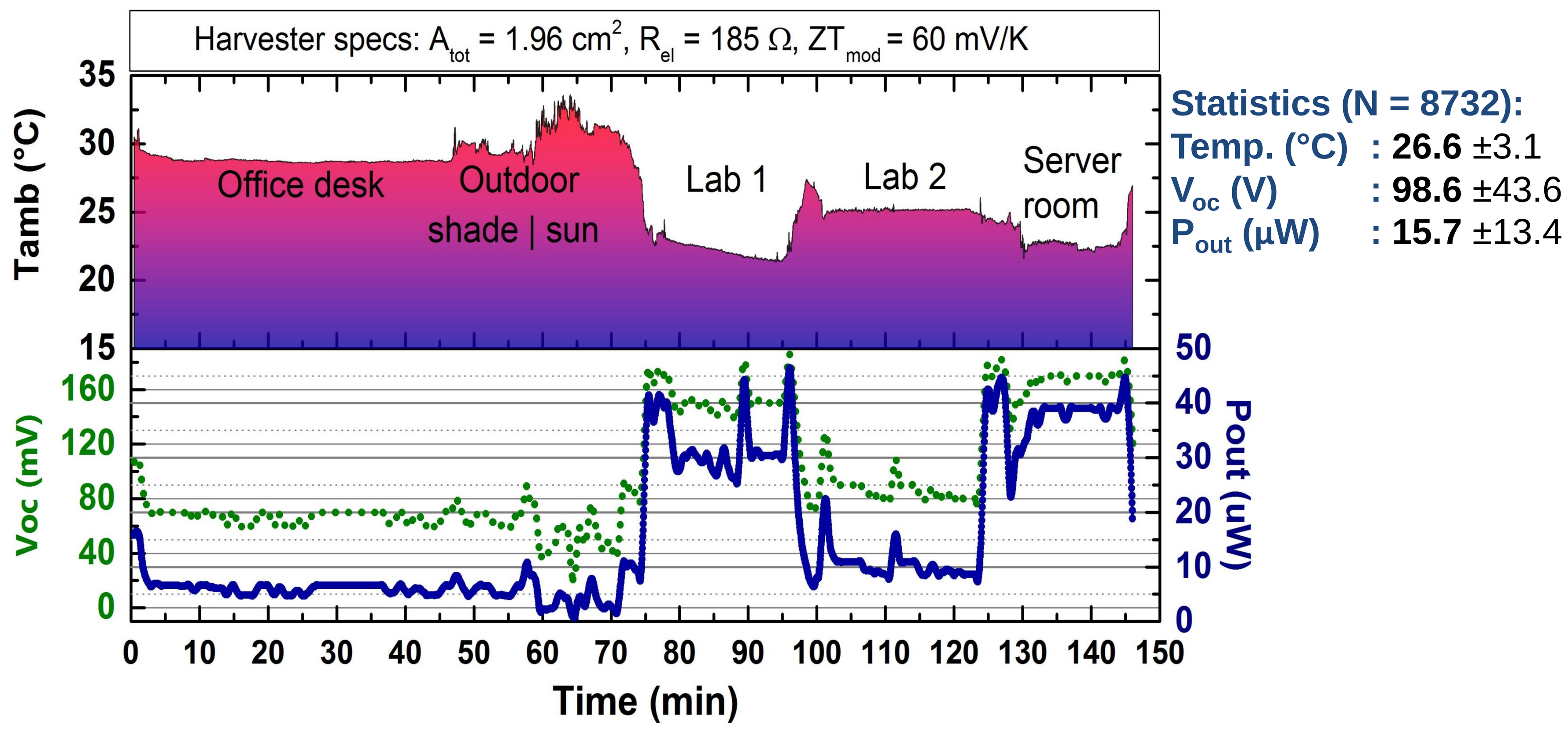


Fig 4: (a) System overview, (b) prototype for measurements on skin, (c) design for the application in hair.

Long-term measurement results



Statistics (N = 8732):
Temp. (°C) : 26.6 ±3.1
V_{oc} (V) : 98.6 ±43.6
P_{out} (µW) : 15.7 ±13.4

Fig 5: Long-term measurement with harvester prototype in varying environmental conditions

Outlook: Active energy autonomous biopotential electrode

Chest harvester for ECG

Motivation: ECG with ~0.5 mW power consumption

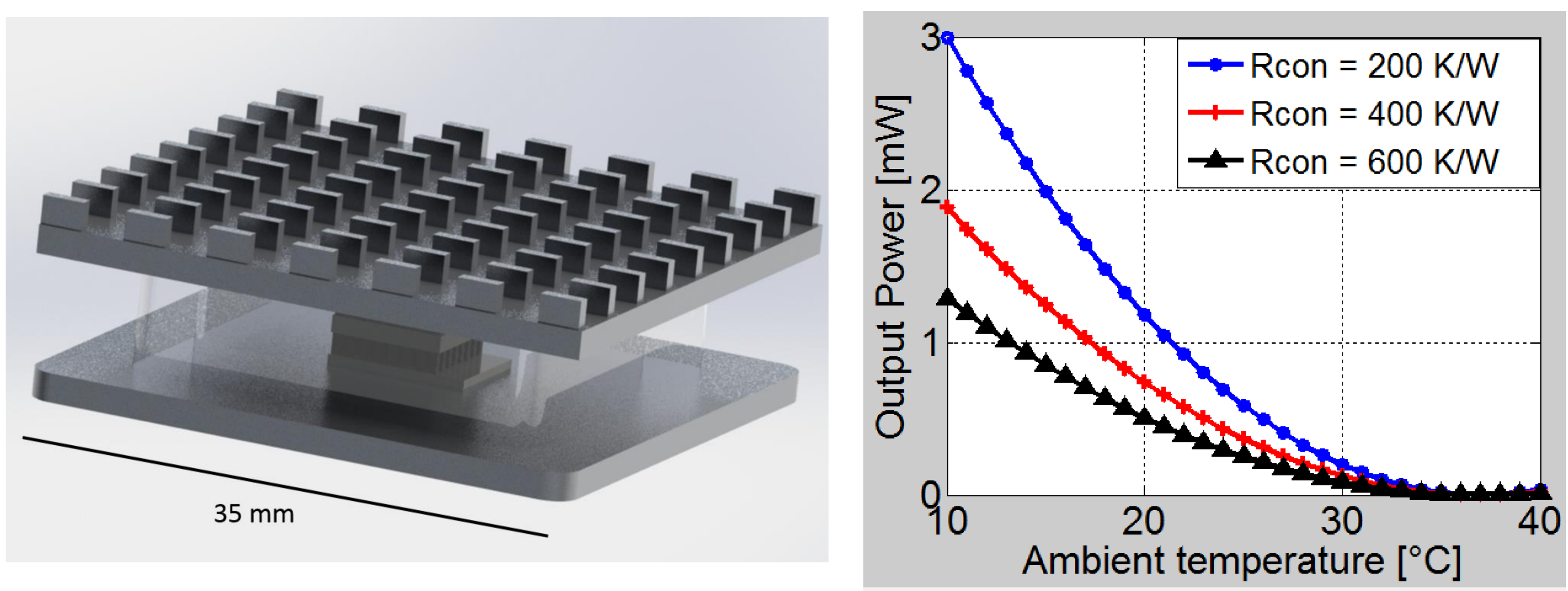


Fig 6: CAD of proposed prototype (left), simulation of max. output power for different skin contact resistances

Outlook: Prototype fabrication and testing

Findings and outlook

Highlights

- Power generation in the mW regime from human body heat
- Compact systems that can be comfortably worn for several hours

Outlook

- Decreased size and weight with power comparable to SoA
- Integration into complete BPS system