

## Thermal Energy Harvesting through Waste Heat Recovery

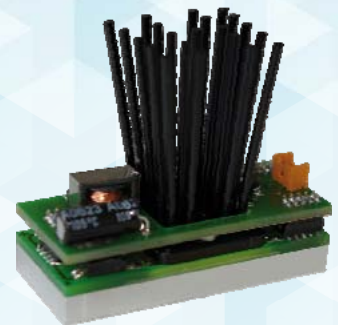
Micropelt is the leader in thin-film thermoelectric (TE) products. The company has revolutionized the way of fabricating thermoelectric elements by using silicon wafer technology. Combined with corresponding system engineering expertise Micropelt offers **single chip products** as well as **energy harvesting modules** as **embedded power supply for self-sustaining systems**:

- Ideal for difficult-to-access or no-access areas
- Deploy-and-forget systems with maintenance free 'eternal' operation
- Integrated modules including step-up converter and energy storage
- Easy to integrate products with micro-scale dimensions, very low weight, no moving parts and low cost at high volume production

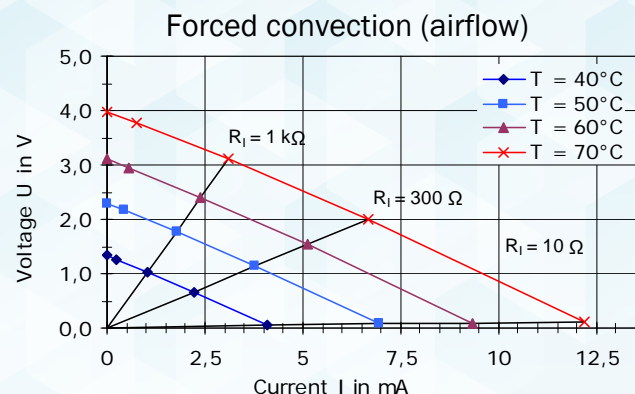
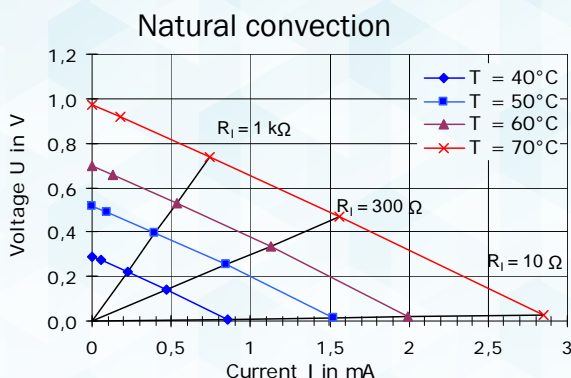
Machine health as well as process monitoring are currently the most common areas for the use of wireless sensor nodes (WSN) and networks. Market research company ON-WORLD predicts 128 Mio WSN deployed worldwide by 2010. Gapless WSN condition monitoring based on periodic or continuous measurements of vibrations, temperature, pressure, humidity, speed, acceleration etc. enable operators and maintenance teams to control production machines, vehicles, automation systems and processes completely. Such smart systems will help to **prevent from unpredicted production downtime**, to **reduce total cost of ownership** and to **increase process performance**.

Micropelt's first generation of 'battery-level' integrated harvesting modules **TE-Power-Plus** uses only one single thermoelectric generator (MPG-D751, chip size 11.4 mm<sup>2</sup>) with optimized thermal path. With a seamlessly adapted power conditioning electronics it provides an adjustable *stabilized output voltage* between 1.5 V and 5 V. The current is determined by thermal conditions.

The diagrams below show measured output current and voltage of the harvester alone at heat source temperatures of 50 °C, 60 °C and 70 °C versus a heat sink temperature of 25 °C (ambient). The temperature influences only the current supplied by TE-Power-Plus. A forced airflow increases the available power (right).



TE-Power-Plus



**Case study:** Micropelt fabrication equipment utilizes vacuum pumps with recommended maintenance every 2nd year. Bearing elements as a main source of failures are replaced, mainly because no actual condition information is available. Related cost is nearly 10 % of the initial purchase price of €50.000. Integrated vibration analysis could largely extend replacement intervals while reducing the risk of unexpected breakdowns.

Maintenance expenses saved at Micropelt would immediately pay for Energy Harvester driven monitoring equipment.



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Samples and Eval.-Kits available from stock.

## Company Overview

Micropelt focuses its resources primarily on core technology and IP development while generating application related know-how and IP wherever necessary to enable target applications. As a product company, Micropelt will start with a small wafer production up to 30 wafers per week in its own fabrication site, which will drive down cost and protect non-patented IP and know-how.

Beside the market of power generation Micropelt addresses **three additional target markets:**

### Life Science (PCR)



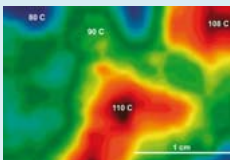
Due to its high cooling and heating speed capabilities of > 15 K per second (versus 3 K per second available today), a new generation of high speed PCR Cycler systems will enable medical diagnostic companies and research labs to significantly reduce throughput time combined with increased probe quality.

### Laser cooling



Laser thermal management systems are used to either increase laser efficiency or to stabilize wavelength in Telecom and industrial laser applications. Conventional TE modules are widely used but limited in miniaturization to reduce packaging cost as well as cost of ownership. Micropelt coolers allow the usage of TO-can packages (picture) instead of expensive butterfly packages.

### Chip cooling



Integrated circuits, in particular high performance microprocessors, are limited in clock speed performance by so called Hot-Spots. Hot-Spots are very small areas with highest current input, leading to temperatures up to 50 % above surrounding chip temperatures of typically 80 °C. A package with an integrated spot cooling device can solve such heat problems which also limits the circuit life time.

## Micropelt in Brief

The company has developed a unique technology with no other comparable thin-film process technology existing world-wide. The experienced management team and key technical staff are on board since many years with in-depth know-how in thermoelectric and related applications. Products are fabricated on a pilot production line with up to 15 wafer starts per week in Freiburg. Full production capacity of up to 30 wafer starts per week is expected in 2009.

### Benchmark

compared to conventional thermoelectrics:

10 x higher cooling power density

50 x more leg pairs per sqmm

100 x faster response times

1000 x smaller size

**Product** sizes range from sub-mm<sup>2</sup> Laser cooling products (left) to 25 mm<sup>2</sup> high performance heating/cooling elements (right). Power generation (MPG-Series) and cooling devices (MPC-Series) have identical dimensions but differ in the number of leg pairs and leg geometries.



MPC-D303 on conventional element



MPC-D303

MPC-D901

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