10 Years on the Thermoelectric Market

TEC Microsystems 2017
ADVANCED THERMOELECTRIC TECHNOLOGIES AND PRODUCTS

Founded in 2007, the Hi-Tech company TEC Microsystems GmbH is based in the prominent Technology Park Berlin Adlershof, Germany. Thermoelectric technologies are our core competence based on almost a decade of analysis, innovative development, product design and numerous successful projects in this field. Specialized in miniature thermoelectric modules (Peltier elements), TEC Microsystems GmbH is a driver of innovation and technological progress including state-of-the-art analysis techniques. Our worldwide customers operate in key industries like opto-electronics, telecom, micro-electronics, space, medical equipment/health care, security systems, small scale energy harvesting and fundamental research. All thermoelectric modules and related products are designed and developed in our ISO 9001:2008 certified facility in Berlin, Germany.
Miniature Thermoelectric Coolers

ADVANCED THERMOELECTRIC COOLING SOLUTIONS

- LD and Superluminescent Diodes
- X-Ray and IR-Sensing Applications
- Photodetectors
- Avalanche Photodiodes (APD)
- Focal Plane Arrays (FPA)
- Charge Couple Devices (CCD)
- More than 5000 TEC types
- Advanced HD Assembly Technology
- High-quality Materials
- Sn-Sb assembly Solder ($T_{\text{melt}}=230^\circ\text{C}$)
- 100% Quality Control
- RoHS compliant by default

We work directly with engineering teams of our customers and provide advanced thermoelectric solutions optimized for exact application requirements. Our key advantages are in ultra-fast application analysis, world widest range of thermoelectric coolers and great flexibility with TECs manufacturing options. All thermoelectric modules and related products are designed and developed in our ISO 9001:2008 certified facility in Berlin, Germany.
Miniature Thermoelectric Coolers

TEC MICROSYSTEMS TE COOLERS KEY FEATURES AND BENEFITS

- More than 5000 developed TEC types
- Pellets per cm²: x4
- Cooling Capacity: +120%
- TEC C.O.P.: +50%

On average x2.5 faster TEC Development

On average x2 faster TEC Manufacturing

- Development
- Manufacturing

TEC Microsystems vs Other sources
ADVANCED PELLETS PLACEMENT TECHNOLOGIES FOR TE MODULES

- Regular
- HD Technology
- Advanced HD
- Super HD

144 Elements per cm²
256 Elements per cm²
400 Elements per cm²
1100 Elements per cm²

5mm
# Miniature Thermoelectric Coolers

**MINIATURE THERMOELECTRIC COOLERS DIMENSIONS RANGE**

<table>
<thead>
<tr>
<th>Dimensions, mm</th>
<th>Width</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min possible</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Most Common</td>
<td>&lt; 16</td>
<td>&lt; 16</td>
</tr>
<tr>
<td>Available</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Max possible</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

[Image of a graph showing the dimensions range of miniature thermoelectric coolers.]
Miniature Thermoelectric Coolers

**SINGLE-STAGE TECs**
- **Cold side:** up to 18 x 18mm²
- **Height:** from 0.8mm
- **dTmax:** 68 - 75K (@300K T_{amb})
- **Qmax:** up to 50W
- **Technology:** regular, HD
- **Solutions:** >3000

**TECs WITH HOLES**
- TE Coolers with central holes or multiple holes. Optimal for external cooling of un-cooled laser diodes on TO-46, TO-56 and TO-9 headers.

**CUSTOM SHAPES**
- Modification of standard TEC shape in accordance to Customer requirements. Customized thermoelectric cooler developments.
Miniature Thermoelectric Coolers

2-STAGE TECs

- Cold side: up to 18 x 18mm²
- Height: from 1.6mm
- dTmax, K: 80 - 100 (@300K T_{amb})
- Qmax, W: up to 27W
- Technology: regular, HD
- Solutions: >250

3-STAGE TECs

- Cold side: up to 17 x 17mm²
- Height: from 2.2mm
- dTmax, K: 100 - 110 (@300K T_{amb})
- Qmax, W: up to 12W
- Technology: regular, HD
- Solutions: >300

4-STAGE TECs

- Cold side: up to 4.0 x 4.0mm²
- Height: from 2.9mm
- dTmax, K: 110 - 130 (@300K T_{amb})
- Qmax, W: up to 2W
- Technology: regular, HD
- Solutions: >150
Miniature Thermoelectric Coolers

THERMOELECTRIC COOLER TERMINAL CONNECTIONS

- Blank Wires
- Insulated Wires
- Insulated Color-Coded Wires
- Varnished Wires
- Front WB Pads
- Side WB Pads
- WB Posts
- Flip-Chip
Miniature Thermoelectric Coolers

THERMOELECTRIC COOLERS CERAMICS SURFACE

Standard Surface Solutions
(available by default)

- Blank (bare)
- Au plated
- Pre-tinned

Advanced Surface Solutions
(provided by request)

- Custom gap
- Au patterns
- Selective pre-tinning
Thermoelectric Sub-Assemblies

TE COOLER + HEADER = THERMOELECTRIC SUB-ASSEMBLY

• Minimized Risks and Expenses
• Significant Time Saving for Projects
• Single Source for TECs and Headers
• Perfect Solution for R&D
• Optimization for Application

• More than 5000 TEC types
• High-Quality Glass-To-Metal Headers
• High-Temperature TEC Soldering
• 100% Quality Control
• RoHS compliant by default

The term “thermoelectric sub-assembly” means a thermoelectric cooler mounted into standard or customized package. Thermoelectric sub-assembly is a perfect solution for fast and easy integrating into final application. There is a range of industry standard headers and packages, that are usually used with thermoelectric coolers.
Thermoelectric Sub-Assemblies

**TO-46 ASSEMBLIES**
- Header type: TO-style
- Number of pins: 4 - 6
- Material: Kovar
- Space for TEC: 1.2 x 1.9mm²
- TEC types: single-stage only
- Solutions: 15

**TO-39 ASSEMBLIES**
- Header type: TO-style
- Number of pins: 3 - 10
- Material: Kovar
- Space for TEC: 3.2 x 3.2mm²
- TEC types: single- and multistage
- Solutions: 160

**TO-8 ASSEMBLIES**
- Header type: TO-style
- Number of pins: 6 - 20
- Material: Kovar or CRS
- Space for TEC: 8.2 x 8.2mm²
- TEC types: single- and multistage
- Solutions: 990
TO-66 ASSEMBLIES

- **Header type:** TO-style
- **Number of pins:** 6 - 10
- **Material:** Kovar or CRS
- **Space for TEC:** 4.2 x 4.2mm²
- **TEC types:** single- and multistage
- **Solutions:** 321

TO-3 ASSEMBLIES

- **Header type:** TO-style
- **Number of pins:** 6 - 9
- **Material:** Kovar or CRS
- **Space for TEC:** 8.2 x 8.2mm²
- **TEC types:** single- and multistage
- **Solutions:** 990

TO-822 ASSEMBLIES

- **Header type:** TO-style
- **Number of pins:** 12 - 14
- **Material:** Kovar or CRS
- **Space for TEC:** 12.0 x 12.0mm²
- **TEC types:** single- and multistage
- **Solutions:** 1480
Thermoelectric Sub-Assemblies

**FLATPACK TYPES**
- Header type: Flatpack
- Number of pins: 10 - 72
- Material: Kovar or CRS
- Space for TEC: up to 25 x 45 mm²
- TEC types: single- and multistage
- Solutions: depends on size

**DUAL-IN-LINE (DIL)**
- Header type: DIL (Dual-in-Line)
- Number of pins: up to 72
- Material: Kovar or CRS
- Space for TEC: up to 45.0 x 45.0 mm²
- TEC types: single- and multistage
- Solutions: up to 5000 types

**HIGH HEAT LOAD (HHL)**
- Header type: High heat load
- Number of pins: 9
- Material: Kovar / CuW
- Space for TEC: 28.0 x 28.0 mm²
- TEC types: single- and multistage
- Solutions: up to 5000 types
Thermoelectric Sub-Assemblies

“BUTTERFLY” 14PIN

- Header type: DWDM “Butterfly”
- Number of pins: 14
- Material: Kovar/ CuW
- Space for TEC: 14.0 x 9.0mm²
- TEC types: single- and multistage
- Solutions: 1330

CUSTOMIZED TYPES

- Modification of standard headers and packages in accordance to Customer requirements. Customized thermoelectric coolers, headers and packages development.

MOUNTING SERVICES

- TEC Microsystems GmbH provides mounting services - TEC integrating into Customer packages and headers. Flux-free soldering technique with 100% quality control and TEC testing.
THERMOELECTRIC THERMAL REFERENCE SOURCES (TTRS)

Thermoelectric Thermal Reference Source (TTRS) sub-assemblies provide a temperature-controllable, uniform-temperature, high-emissivity surface used in calibrating infrared (IR) detector arrays and FLIR systems. Most TTRS sub-assemblies are provided as open devices consisting of a thermoelectric cooler, emitting surface and temperature sensor. The header cap with IR window and hermetic sealing can be provided for customized solutions. TTRS controllers are available as well.
THERMOELECTRIC SOLUTIONS FOR SMALL SCALE ENERGY HARVESTING

- Smart Home
- Aviation and Train Monitoring
- Industrial Process Control
- Automotive Industry
- Security Systems
- Wearable Devices

- More than 500 standard TEG types
- Bulk TE Technology with 400uV/K
- Ultra-miniature TEG sizes
- Maintenance-free
- Long Lifetime
- Best Price-Performance Ratio

Thermoelectric harvesting is considered as a key component for many future technological applications, like wireless sensor networks, multi-purpose self-organising autonomous (micro-)systems and many others. The key advantages of thermoelectric micro-generators: small sizes, simple scalability; no moving parts, very long operational lifetime – tens of years without maintenance. And the most unique property – the possibility to convert heat into electricity starting from very low temperature differences of just a few degrees.
Miniature Thermoelectric Generators

BULK THERMOELECTRIC MATERIAL TECHNOLOGY FOR TE GENERATORS

Every couple gives around 400μV/K. This value is specified for TEGs provided by TEC Microsystems. As a reference - thin-film technology TEGs have 250μV/K.

α = 400μV/K
The advantage of thermoelectric module (TEM) over differential thermocouple is in much higher Seebeck effect (electromotive force), exactly because of semiconductor usage. For example, in usual Copper-Constantan thermocouple the electromotive (EMF) is 38uV/K, while one BiTe P-N pellet pair inside a thermoelectric module provides EMF 400uV/K - ten times higher. This key advantage makes thermoelectric modules very promising to use as heat flux sensors.
Thermoelectric heat flux sensors with integrated temperature sensor Pt1000. Round shape. Self-calibrating patented method. 180cm FET cable with or without connector.

Standard solutions, quad shape, ultra-thin heat flux sensors w/o temperature sensors integrated. Self-calibrating patented method. 180cm FET cable with or without connector.

SMD style miniature heat flux sensors for radiation heat flux measurements. Self-calibrating patented method. Suitable for flip-chip mounting, up to 260ºC processing temperature.
DX5100 PRECISE PROGRAMMABLE TEC CONTROLLERS WITH PID AUTO-TUNE

- Bi-Directional Regulation
- Supports NTC and PTC Thermistors
- Two Channels 32W (4Ax8V) each
- PID Temperature Regulation Mode
- PID Auto-Tune Function
- Constant Voltage Operation Mode
- Programmable Controllers
- PC Controlled and Stand-alone
- Network connectivity (up to 128 channels at once in array)
- USB and RS-485 interfaces
- Complete LabView Integration

Thermoelectric Controllers of the DX5100 family represent a range of precision-programmed devices (standard and OEM versions) for management of thermoelectric coolers (TECs, Peltier modules). DX5100 Controllers have a bi-directional (heating and cooling) PID regulation with PID Auto-Tune function. Besides the PID regulation additional modes of operation are realized in the Controller: DC voltage mode, T-regulation and programming of an object temperature behaviour with time.
Programmable TEC Controllers

**DX5100 OEM**

3A x 8V; 4A x 8V; 12A x 8V

Compact modular DX5100 OEM TEC Controllers for integrating with PID temperature regulation and PID Auto-Tune for thermoelectric coolers management and efficient operating. Several configurations are available.

**DX5100 FRAME**

3A x 8V; 4A x 8V; 12A x 8V

DX5100 Frame TEC Controllers with metal housing for installation into industry standard racks. PID temperature regulation and PID Auto-Tune for thermoelectric coolers management and efficient operating.

**DX5100 TABLETOP**

2X 4A x 8V

All-in-one table-top TEC driver with 2x independent 4A x 8V output channels. Ideal solution for laboratory experiments and R&D. Precise programmable TEC driver with PID Auto-Tune.
Hi-end professional R&D systems for comprehensive analysis of TE Modules and TE Materials. It allows to measure all TEC key performance parameters and power consumption under specified conditions. Expert laboratory R&D systems that provide automatic measuring and full specifications of TE modules and materials in one measuring cycle. Perfect for acceptance, qualification and research testing of single- and multistage TE modules.
DX8020 TEC EXPERT

DX8020 provides automatic capability to measure full specifications of a TE module at one measuring cycle in given ambient conditions. DX8020 is intended for acceptance, qualification and research testing of TE modules.

DX8080 TEM EXPERT

DX8080 provides detailed analysis of thermoelectric (TE) properties of BiTe material, P/N-type in pellets: Seebeck coefficient, electrical conductivity, Figure-of-Merit Z and thermal conductivity in a given temperature interval.

DX8070 INGOTS TESTER

DX8070 provides incoming control of BiTe material in ingots and disks. It measures the Seebeck coefficient and electrical conductivity of BiTe material ingots taking into account the polarity. Must-have instrument for TEM and BiTe material manufacturers.
Z-METERs FOR THERMOELECTRIC MODULES EXPRESS QC

- Simple and quick TE Module Testing
- Suitable for mounted TEMs
- Perfect For “Before-After” Testing
- Express Testing of TE Modules with Terminal Wires and WB Contacts
- ACR Resistance Measurement
- Figure-of-Merit Measurement
- Time Constant Measurement
- Results Normalization for Required Ambient Temperature

Thermoelectric Modules (TEMs) are solid state devices with very long maintenance-free lifetime. Modern thermoelectric modules provide more than 25 years of continuous operating at normal conditions. However mounting procedures and/or improper handling may increase the risks of TEM damages. Z-Meters are the best solution for thermoelectric modules express quality control and performance testing.
ACR (AC Resistance) shows TEC current conditions and performance on a "before-after" basis. A change by more than 5% after impact is accepted as criteria of failure by Telcordia GR-468.

Z (Figure-of-Merit) shows TEC material quality and performance level. Used for analysis of degradation, performance drops and similar issues.

τ (Time Constant) shows the time required by TEM from turning on to a stabilized operating mode. Used as a criteria for assembly and proper mounting tests.
DX4085 Z-METER TESTER

Autonomous device, no connection to PC required. Combines three devices in one: portable Z-Meter for TEC parameters measurement, voltmeter and digital thermometer for ambient and operating temperature tests.

DX4090 Z-METER

Universal device for thermoelectric coolers quality control and R&D. It has two measuring interfaces - inner clips and external clips. The device is ideal for express control of small and medium size batches, R&D projects, income, in-process and outcome TEC control.

DX4095 Z-METER MINI

Pocket size device as small as typical USB flash drive. It has the same measuring functionality as a standard Peltier Z-Meter and is designed mainly for single thermoelectric coolers testing, R&D, trial batch check and laboratory usage. Ideal for occasional testing.
The Z-Meter DX4190 is the must-have device for TE Modules manufacturers or consumers with large volumes. The DX4190 allows to implement 100% quality control in all stages of mass production with no compromises. The device measures directly three TE Module key parameters (ACR, Figure-of-Merit and Time Constant) for up to 10 thermoelectric modules simultaneously. The DX4190 Z-Meter can be used with separate (not mounted) TEMs by manufacturers or consumers at income/outcome control, or for TE modules quality control and performance testing in the end-product with integrated TEM.