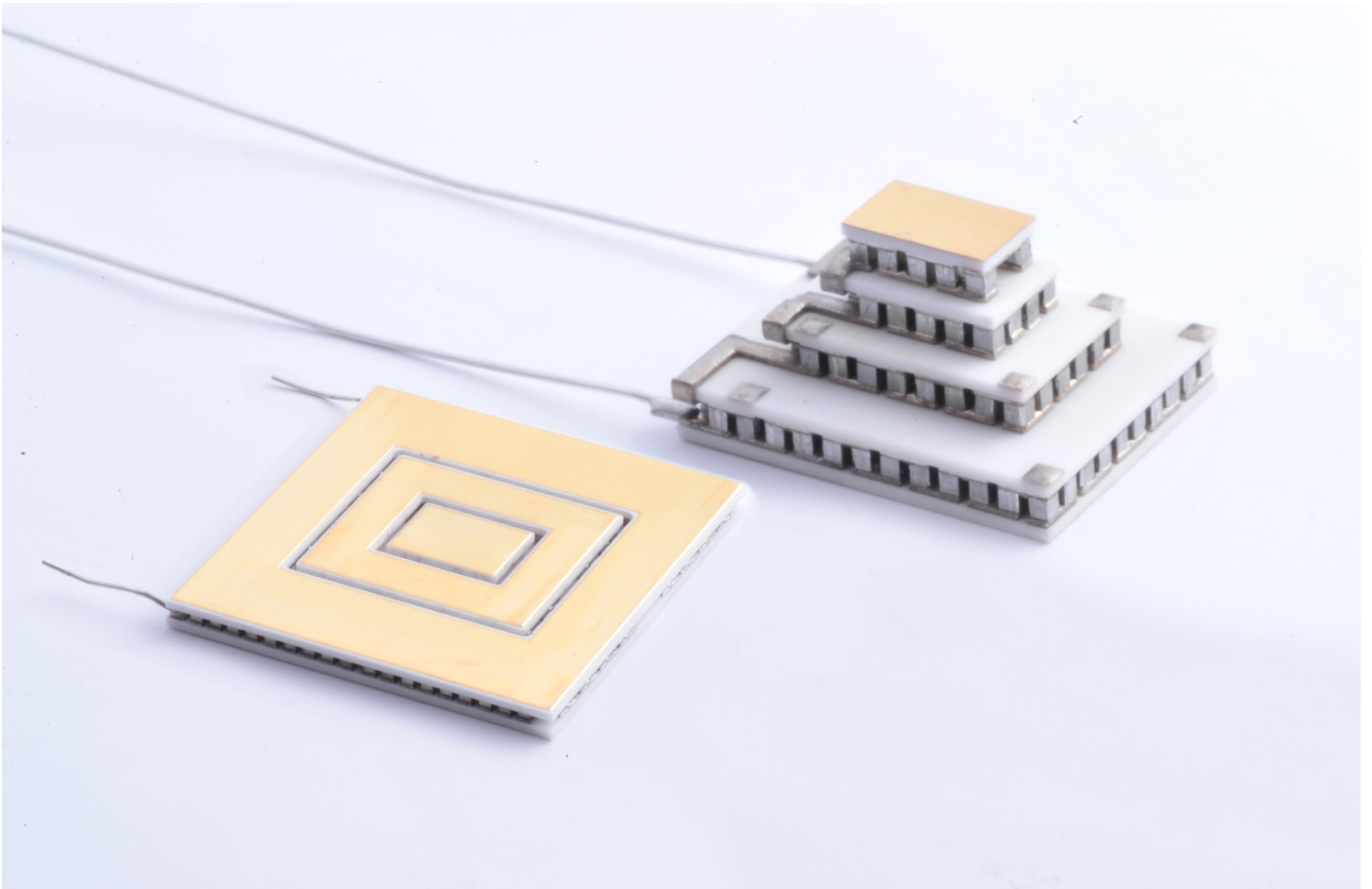


Thermoelectrics

THERMOELECTRIC SOLUTIONS GUIDE

High quality thermoelectric solutions

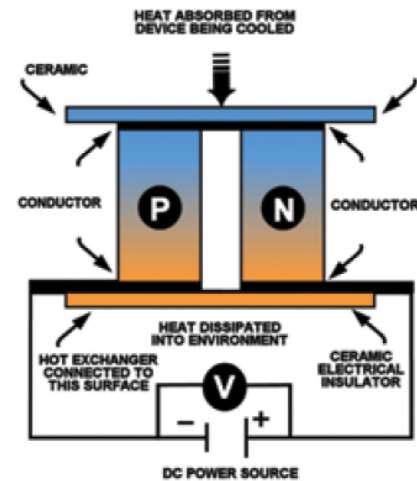


What are Thermoelectrics?

A thermoelectric cooler (TEC), sometimes called a thermoelectric module or Peltier module, is a semiconductor-based electronic component that functions as a small heat pump. By applying a low voltage DC power source to a TEC, heat flows via the semiconductor elements from one face to the other. The electric current cools one face and simultaneously heats the opposite face. Consequently, a given face of the device can be used for heating or cooling by reversing the polarity of the applied current. The characteristics of TECs make them highly suitable for precise temperature control applications and where space limitations and reliability are paramount or refrigerants are not desired.

A typical single stage cooler consists of two ceramic plates with “elements” of p type and n-type semiconductor materials (bismuth telluride alloys) between the plates. Figure 1 illustrates a single-couple; an array of these comprises a single stage cooler. The elements of semiconductor materials are connected electrically in series and thermally in parallel. When a positive DC voltage is applied as shown, electrons pass from the p-type to the n-type element, and the cold-side temperature decreases as the electron current absorbs heat, until equilibrium is reached. The heat absorption (cooling) is proportional to the current and the number of thermoelectric couples. This heat is transferred to the hot side of the cooler, where it is dissipated into the heat sink and surrounding environment.

The theories behind the operation of thermoelectric cooling first appeared in the early 1800s. Jean Peltier discovered a heating/cooling effect when passing electric current through the junction of two conductors. Alessandro Volta and Thomas Seebeck found that holding the junctions of two dissimilar conductors at different temperatures creates an electromotive force or voltage. William Thomson (Lord Kelvin) showed that over a temperature gradient, a single conductor with current flowing in it has reversible heating and cooling. With these principles developed and the introduction of semiconductor materials in the late 1950s, thermoelectric cooling became a viable technology for small cooling applications.



Advantages of Thermoelectrics

- Inherent high reliability from solid state construction (no moving parts)
- Heating or cooling options depending on DC polarity
- Precise temperature control
- Vibration free operation
- Chloro-fluorocarbon free, for applications where gases are not permitted
- Scalability, enabling devices to be optimized for specific application requirements
- No acoustical or electrical noise
- Performs in any physical or gravitational orientation, including upside down or sideways
- Operates in zero-gravity
- Withstands the high g-forces of space and military applications

Advanced Materials & Design Innovation

Optimum performance requires a combination of the highest quality materials and design innovation. At our state-of-the-art research facility, Coherent's team of scientists and design engineers are leading the industry in new material development and thermoelectric design. With over 40 issued patents and 15 published authors on staff, Coherent Industries offers a strategic advantage to the customer in selecting the appropriate thermal solution to match their application's requirements.

• Materials

Production thermoelectric materials made at Coherent Industries are alloys of bismuth telluride. These alloys are made by two different processes, the melt-grown and the MAM+ growth processes, which impart different characteristics to the materials making them suitable for different applications. The melt-grown process is used to make materials for our industrial, medical, automotive and defense/space/photonics markets. The advantages of melt-grown materials are lower cost and compatibility with our TAN diffusion barrier. Our TAN (Thermally Applied Nickel) barrier is used to make the most

mechanically robust modules that are designed to survive mechanical shock or extensive thermal cycling. We use a proprietary process to make our MAM+ materials, which are used in our telecom and defense/space/photonics markets. The advantages of MAM+ are better thermal performance, temperature tuning and compatibility with very small element dimensions.

- Design Innovation

When market trends or business objectives require product specifications that are not within our current manufacturing limits, Coherent's research and product development teams work to extend those limits. These groups develop new manufacturing and assembly processes that enable new products, as well as prototype and pilot production products. With the highest demand for custom solutions, Coherent Industries product line continuously changes—leading to marketsensitive and cutting edge thermoelectric design.

Manufacturing Capabilities

With the foundation of Coherent Industries as a thermoelectric supplier to the aerospace and defense markets, quality and reliability were structured into all products and processes as the defining elements of success for the company. This foundation allowed Coherent to comply with the most stringent requirements, including: automotive, Telcordia certification, RoHS compliance, temperature cycling and defense/space qualification.

- Thermoelectric Modules

Coherent has extensive experience building thermoelectric modules. Depending on the market and customer requirements, these modules and assemblies may be built in our Dallas, Texas (USA) or our Ho Chi Minh City (Vietnam) manufacturing facilities. Our products range from small MicroTEC modules (2 mm x 3 mm) to large single-stage modules (40 mm x 80 mm).

- Value-Added Systems

Coherent Industries is also an experienced, high volume manufacturer of value-added systems with a well established, low-cost supply chain. These solutions combine all the aspects of thermoelectric systems to provide a balanced design to meet performance at the desired tradeoffs. Efficiency, acoustical noise, power budget, desired life and cost are all balanced for specific applications to tune a system to the customer's needs.

Quality Manufacturing Principles

Coherent defines quality according to the customer's application requirements. We strive to meet or exceed the customer's quality and reliability standards at prices that enable them to effectively compete in their markets.

We continually improve our manufacturing processes by measuring production and throughput in real-time against established standards for continuous improvement. From start-to-finish, we manage by statistical process control—following product development procedures, lean manufacturing techniques and the principles of six sigma. This translates into maximum performance, precision, efficiency and innovation.

“The highest quality thermoelectric solutions at competitive prices.”

As a vertically integrated manufacturer, Coherent builds custom thermoelectric components, subsystems and end-use products to maximize performance and minimize cost.

When Coherent designs the comprehensive thermal system, customers benefit from:

- Coherent's expertise in thermoelectric module & assembly design
- Coherent's diversified market experience to support multiple applications
- A seamless integration with the customer's application—ensuring optimum design and longer lifetime
- Low cost manufacturing through Coherent's manufacturing facility in Vietnam
- A reduction in customer's engineering and development expenses
- Parts designed for manufacturability, minimizing overall application costs
- Coherent's advanced assembly and test capabilities

Global Customer Support Network

As a global company, Coherent can offer closer interaction and real-time technical support for customers manufacturing worldwide.

- **Manufacturing Locations**

The corporate headquarters of Coherent is in Dallas, Texas. The ISO 9001 qualified facility in Dallas, Texas exists as a center for technical excellence—hosting advanced material and product development, administration and global sales as well as manufacturing for U.S.-based defense and space products. Coherent's primary manufacturing operation, located in Ho Chi Minh City, Vietnam, is also an ISO 9001 qualified facility.

- **Sales & Technical Support**

Coherent provides engineering, sales and customer service through our design centers in North America, Europe and Asia. Coherent also offers sales and technical support through a global network of channel partners and regional offices located in the U.S., Germany, China, Japan and Singapore.

Selecting the Optimum Thermoelectric Solution

Custom or Standard Product?

- Will a standard product fit your size and performance qualifications?

Recommended Solution: Standard Catalog Product

- Could we modify a standard product to meet your requirements?

Recommended Solution: Request a Standard Product with Modifications

- Does your application require Telcordia, Space or other advanced qualifications?

Recommended Solution: Custom Design

- My application requires unique dimensions and/or performance.

Recommended Solution: Custom Design

Standard Catalog Products

Coherent sells standard catalog products through our online store at coherent.com. For customers currently using a competitor's thermoelectric products, the website's Part Finder will help you determine a competitive match in the Coherent product line. The online store provides a cost-effective way for Coherent customers to buy and ship standard products worldwide.

Custom Thermoelectric Solutions

For more information on custom thermoelectric solutions, Coherent offers a variety of tools to support our customers. The Thermoelectric Design Guide, offered in PDF format online, provides a step-by-step process to help customers define their application's thermoelectric requirements. These requirements can be used within the Thermoelectric Modeling Tool online (select optimum solution) to contact Coherent for a quote or technical support.

Snapshot of the custom design process

- Through Coherent's worldwide sales offices and partners, sales engineers gather a customer's requirements and
- work directly with regional design centers to develop an optimized solution.
- Market-specific engineering teams optimize the product and processes to meet customer requirements. An optimized product offers the best value in volume production by balancing the combination of performance, cost and size.
- Prototypes are tooled, built and tested.
- Manufacturing of the product is transitioned to our Dallas, TX (USA) or Ho Chi Minh City (Vietnam) facility for production.
- Our sales engineers and customer service representatives ensure the process meets customer requirements.
- Coherent's product line includes a one-year warranty and on-going customer support.