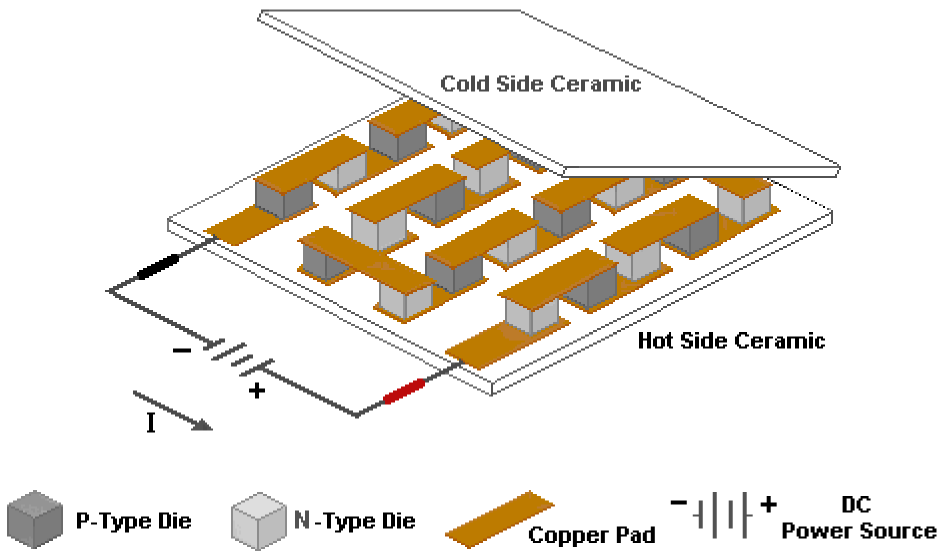
How A TE Cooler Works



A typical thermoelectric module is composed of two ceramic substrates that serve as a foundation and electrical insulation for P-type and N-type Bismuth Telluride dice that are connected electrically in series and thermally in parallel between the ceramics. The ceramics also serve as insulation between the modules internal electrical elements and a heat sink that must be in contact with the hot side as well as an object against the cold side surface. Electrically conductive materials, usually copper pads attached to the ceramics, maintain the electrical connections inside the module. Solder is most commonly used at the connection joints to enhance the electrical connections and hold the module together.

Most modules have and even number of P-type and N-type dice and one of each sharing an electrical interconnection is known as, "a couple." The above module would be described as an 11-couple module.

While both P-type and N-type materials are alloys of Bismuth and Tellurium, both have different free electron densities at the same temperature. P-type dice are composed of material having a deficiency of electrons while N-type has an excess of electrons. As current (Amperage) flows up and down through the module it attempts to establish a new equilibrium within the materials. The current treats the P-type material as a hot junction needing to be cooled and the N-type as a cold junction needing to be heated. Since the material is actually at the same temperature, the result is that the hot side becomes hotter while the cold side becomes colder. The direction of the current will determine if a particular die will cool down or heat up. In short, reversing the polarity will switch the hot and cold sides.

Leads to the modules are attached to pads on the hot side ceramic. If the module is sealed you can determine the hot side without applying power. With the module on a flat surface, point the leads toward you with the positive lead, usually in red wire insulation, on the right. The bottom surface will be the hot side.

Material researchers are investigating the use of other materials to improve the efficiency of thermoelectric modules but Bismuth Telluride remains the most economical material for cooling modules used in ambient temperature applications. However, at low temperature (around minus 110 degrees Celsius) this material stops becoming a semiconductor and performance is severely diminished. Typically, the highest temperature that modules can operate is the melting point of the solder inside, usually + 150 or 200 °C (302 or 392° F).

Some Bismuth Telluride based modules for power generation applications are fabricated with high melting temperature solder or without solder entirely that can be used at temperatures up to + 400 °C. Hi-Z Technology, Inc. has some interesting and helpful information on this subject and manufactures modules of this type.

If you would like to learn more, we highly recommend:

- CRC Handbook of Thermoelectrics (1995)
- Principles of Thermoelectrics: Basics and New Materials Development (2001)
- Thermoelectric Materials 2000 - The Next Generation Materials for Small-Scale Refrigeration and Power Generation (2001)
- Semiconductors and Semimetals, Volume 69: Recent Trends in Thermoelectric Materials Research, Part One (2000)
- Semiconductors and Semimetals, Volume 70: Recent Trends in Thermoelectric Materials Research, Part Two (2000)
- Semiconductors and Semimetals, Volume 71: Recent Trends in Thermoelectric Materials Research: Part Three (2000)
- Thermoelectric Materials - New Directions & Approaches (1997)

Additional information that may be important to you may include:

- Module Specifications
- Module Prices
- Module Overview