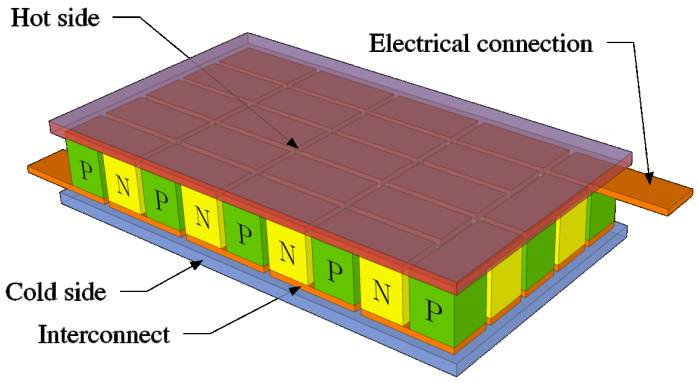
Thermoelectric cooling

Thermoelectric cooling uses the Peltier effect to create a heat flux between the junction of two different types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other side against the temperature gradient (from cold to hot), with consumption of electrical energy. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). The Peltier device is a heat pump: when direct current runs through it, heat is moved from one side to the other. Therefore it can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools.[1]

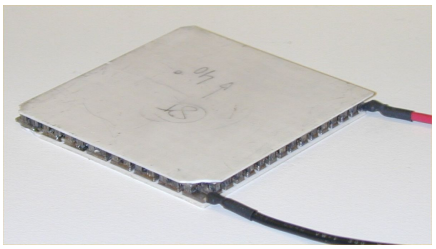
As a refrigeration technology, it is far less common than vapor-compression refrigeration. The main advantages of a Peltier cooler (compared to a vapor-compression refrigerator) are its lack of moving parts or circulating liquid, and its small size and flexible shape (form factor). Its main disadvantage is that it cannot simultaneously have low cost and high power efficiency. Many researchers and companies are trying to develop Peltier coolers that are both cheap and efficient. (See Thermoelectric materials.)

A Peltier cooler is the opposite of a thermoelectric generator. In a Peltier cooler, electric power is used to generate a temperature difference between the two sides of the device, while in a thermoelectric generator, a temperature difference between the two sides is used to generate electric power. The operation of both is closely related (both are manifestations of the thermoelectric effect), and therefore the devices are generally constructed from similar materials using similar designs.

Performance



Peltier element schematic. Thermoelectric legs are thermally in parallel and electrically in series.



Peltier element (16x16 mm)

Thermoelectric junctions are generally only around 5–10% as efficient as the ideal refrigerator (Carnot cycle), compared with 40–60% achieved by conventional compression cycle systems (reverse Rankine systems using compression/expansion). Due to the relatively low efficiency, thermoelectric cooling is generally only used in environments where the solid state nature (no moving parts, maintenance-free, compact size) outweighs pure efficiency.

Peltier (thermoelectric) cooler performance is a function of ambient temperature, hot and cold side heat exchanger (heat sink) performance, thermal load, Peltier module (thermopile) geometry, and Peltier electrical parameters.

Uses

Peltier devices are commonly used in camping and portable coolers and for cooling electronic components and small instruments. Some electronic equipment intended for military use in the field is thermoelectrically cooled. The cooling effect of Peltier heat pumps can also be used to extract water from the air in dehumidifiers.

Peltier elements are a common component in thermal cyclers, used for the synthesis of DNA by polymerase chain reaction (PCR), a common molecular biological technique which requires the rapid heating and cooling of the reaction mixture for denaturation, primer annealing and enzymatic synthesis cycles.

The effect is used in satellites and spacecraft to counter the effect of direct sunlight on one side of a craft by dissipating the heat over the cold shaded side, whereupon the heat is dissipated by thermal radiation into space.

Photon detectors such as CCDs in astronomical telescopes or very high-end digital cameras are often cooled down with Peltier elements. This reduces dark counts due to thermal noise. A dark count occurs when a pixel generates an electron because of a thermal fluctuation rather than because it has received a photon. On digital photos taken at low light these occur as speckles (or "pixel noise").

Thermoelectric coolers can be used to cool computer components to keep temperatures within design limits without the noise of a fan, or to maintain stable functioning when overclocking. In fiber optic applications, where the wavelength of a laser or a component is highly dependent on temperature, Peltier coolers are used along with a thermistor in a feedback loop to maintain a constant temperature and thereby stabilize the wavelength of the device. A Peltier cooler with a heat sink or waterblock can cool a chip to well below ambient temperature.

Peltier devices are used in recent products that chill beverages. Some products can also reverse the current to heat the beverage. Products such as the one pictured draw power from the USB port found on computers. However, these products' ability to heat and cool is limited, as the USB 2.0 standard guarantees only 500 mA of current (900 mA in the USB 3.0 standard).

A USB-powered beverage cooler

References

- http://sctbnord.com/article.php?id=152&rus=0 Applications of Thermoelectric Modules

[1] http://www.tec-microsystems.com/EN/Intro_Thermoelectric_Coolers.html - Introduction to Miniature Thermoelectric Coolers

External links

- Thermoelectrics (http://www.dmoz.org//Science/Technology/Energy/Devices/Thermoelectrics/) at the Open Directory Project

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