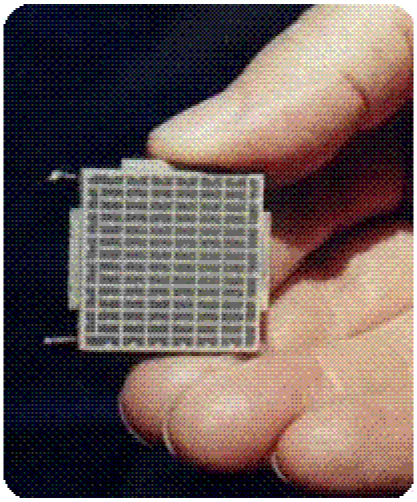
THERMOELECTRICS



Introduction

Thermoelectrics refers to the phenomena of a temperature difference in a conductive material creating an electric potential. Thermoelectrics encompasses three separate effects, the Seebeck effect, the Peltier effect and the Thomson effect. About 60% of the energy produced in the U.S. is lost in the form of heat and the field of thermoelectrics looks to utilize some of this lost energy.

The Seebeck Effect

The thermoelectric effect was actually discovered by Thomas Seebeck in 1821. He found that a compass needle deflected when placed near a closed loop formed by two dissimilar conductors when the junctions were at different temperatures. The magnitude of this deflection was proportional to the temperature difference and also depended on the conductive material. The Seebeck coefficient was then defined as the open circuit voltage between two points on a conductor where the difference in temperature between the two points is 1 K. Good thermoelectric materials should possess large Seebeck coefficients, high electrical conductivity and low thermal conductivity. High electrical conductivity is necessary to minimize Joule heating, and low thermal conductivity helps to retain heat at the junctions and maintain a large temperature gradient. These three properties were later combined in the so-called figure-of-merit, Z, defined as:

$$Z = \frac{\sigma S^2}{\lambda}$$

S = Seebeck coefficient of the material (microvolts/K)

σ = the electrical conductivity of the material

λ = the total thermal conductivity of the material.

This equation is more commonly expressed as a dimensionless factor ZT, which is simply Z multiplied by the average temperature $T_{avg} = (T_1+T_2)/2$. Materials with ZT≈1 are considered effective, but values between 3 and 4 are essential to compete with traditional mechanical power generation.

The Peltier Effect

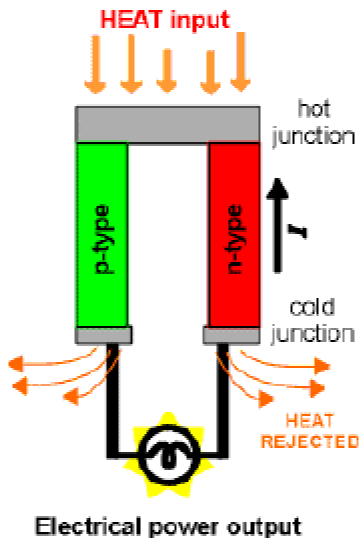
In 1834, Jean-Charles Peltier discovered the calorific effect of an electrical current at the junction of two different metals. He found that heat adsorption or generation at the junction of two different materials depends on the polarity of the current and that reversing this polarity will change the direction of transfer.

The Thompson Effect

In 1851, William Thomson observed the cooling and heating of a conductor resulting from the flow of an electrical current caused by a temperature gradient. The Thomson effect is defined as the rate of heat generated or absorbed in a single current carrying conductor in the presence of a temperature gradient.

Materials

There are two types of materials used in thermoelectric power generation, p-type and n-type. P-type materials cause a positive potential to form at the cold side, while n-type materials cause a negative potential to form at the cold side. When the hot side of the n-type and p-type materials are electrically connected, with a load connected across the cold ends, the voltage produced by the Seebeck effect will cause current to flow through the load, generating electrical power.



The main challenge in the search for efficient materials is to optimize the electrical transport while minimizing the thermal conductivity. Current research is focused on the development of advanced thermal electric materials with improved figure-of-merit, Z. One area of research focuses on the introduction of various phonon scattering mechanisms in an attempt to reduce the thermal conductivity without adverse reduction in electrical conductivity. Phonons play a major role in many of the physical properties of solids, including a material's thermal and electrical conductivities. Recent advances in thermoelectric devices show the opportunities offered by the development of complex materials for use in high-efficiency devices.

Source : http://me1065.wikidot.com/thermoelectrics