

B.Sc. Part II

Physics Honors

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Current Electricity



## Thermodynamical treatment of Seebeck effect ←

The Seebeck effect is a phenomenon in which a temp. difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances.

When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler one. If the pair is connected through an electrical circuit, direct current (DC) flows through that circuit.

The voltages produced by Seebeck effect are small. Usually only a few microvolts (millionths of a volt) per kelvin of temp. difference at the junction. If the temp. difference is large enough, some Seebeck effect devices can produce a few millivolts. Numerous such devices can be connected in series to increase the output voltage or in parallel to increase the maximum deliverable current. Large arrays of Seebeck effect devices can provide useful, small scale electrical power if a large temp. difference is maintained across the junction.

### Semiconductor Thermocouple Seebeck effect ←

The Seebeck effect is responsible for the behaviour of thermocouples, which are used



to approximately measure temp. differences or to actuate electronic switches that can turn large systems on and off. This capability is employed in thermoelectric cooling technology. Commonly used thermocouple metal combinations include constantan / copper, constantan / iron, constantan / chromel and constantan / alumel.

Thomas Johann Seebeck discovered the phenomenon in the 1800s. More recently, in 2008, physicists discovered what they are calling the spin Seebeck effect. The spin Seebeck effect is seen when heat is applied to a magnetized metal. As a result, electrons rearrange themselves according to their spin. Unlike ordinary electron movement, this rearrangement does not create heat as a waste product. The spin Seebeck effect could lead to the development of smaller, faster and more energy efficient microchips as well as spintronics devices.

### Cause of Seebeck effect —

When two different metals are brought into contact, the free electrons tend to diffuse from the metal with greater density to the other with lower electron density. Due to diffusion, a potential difference is set up at the junction of



two metals, called contact potential, when both junctions are at the same temp. The contact potential of the junctions will be equal and opposite, hence no current flows through the thermocouple. But if one junction is kept at a higher temp. the rate of diffusion of free electrons at the junction will increase. Therefore, the contact potential at the two junctions will become different and hence there will be an effective emf in the circuit called the thermo emf.