American Superconductor™

REVOLUTIONIZING THE WAY THE WORLD USES ELECTRICITY™

FactSheet

Superconductivity

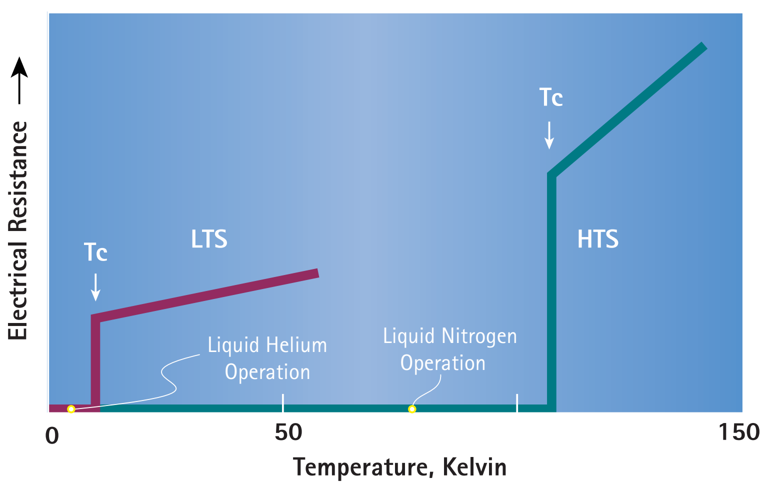
What is it?

■ **Zero Resistance**
Superconductors lose all resistance to the flow of direct electrical current and nearly all resistance to the flow of alternating current when cooled below a critical temperature, which is different for each superconducting material.

■ **Perfect Conductor of Electricity**
A superconductor is a perfect conductor of electricity; it carries direct current with 100% efficiency because no energy is dissipated by resistive heating. Once induced in a superconducting loop, direct current can flow undimished forever. Superconductors can also conduct alternating current, but with some slight dissipation of energy.

■ **Critical Temperature**
Superconducting materials known today, including both high temperature superconductor ("HTS") and low temperature superconductor ("LTS") materials, need to be cooled to cryogenic temperatures in order to exhibit the property of superconductivity.

HTS vs LTS

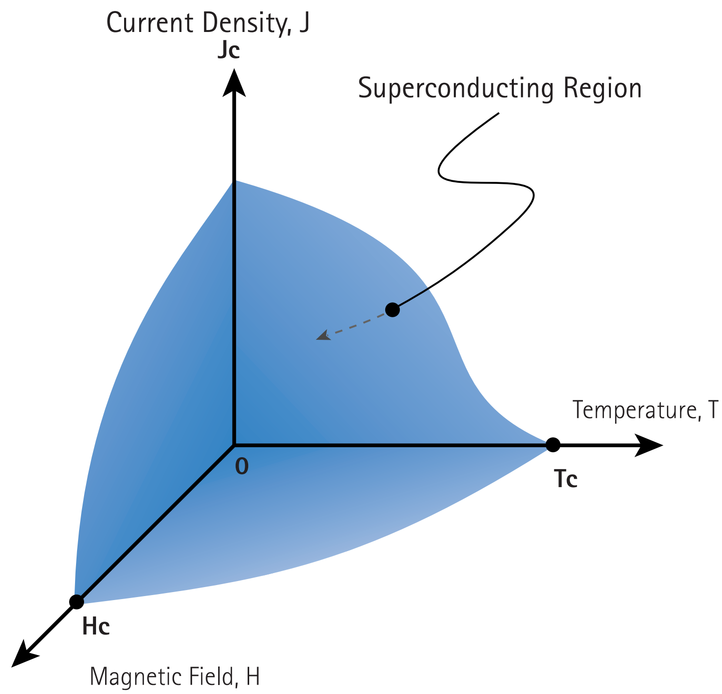


This graph illustrates the complete loss of resistance to the flow of electricity through wires of an LTS material (niobium-titanium alloy) and an HTS material (bismuth-based, copper oxide ceramic) at the critical temperature Tc which is different for each superconducting material. The specific HTS material in this chart has no electrical resistance below 108K (-265° F) as opposed to the specific LTS material in this chart, which has no electrical resistance below 10K (-441° F).

A combination of three conditions must be met for a material to exhibit superconducting behavior:

- The material must be cooled below a characteristic temperature, known as its superconducting transition or critical temperature (Tc)
- The current passing through a given cross-section of the material must be below a characteristic level known as the critical current density (Jc)
- The magnetic field to which the material is exposed must be below a characteristic value known as the critical magnetic field (Hc).

These conditions are interdependent, and define the environmental operating conditions for the superconductor.



Not only must a superconducting material be cooled below its critical temperature, Tc to lose all resistance to the flow of electricity, but also the amount of current flowing through a given cross sectional area of superconducting wire must not exceed a critical amount, the critical current density Jc, and the magnetic field to which the superconductor is exposed must not be above a critical level, Hc.

Advantages of Superconducting Wire

Superconducting wires provide significant advantages over conventional copper wires because

- They conduct electricity with little or no resistance and associated energy loss
- They can transmit much larger amounts of electricity than conventional wires of the same size

More about Superconductivity

The initial discovery of superconductive materials was made in 1911. Before 1986, the critical temperatures for all known superconductors did not exceed 23 Kelvin (23K or -418 degrees Farenheit; 0K is absolute zero or -459 degrees Farenheit). Before the discovery and developmentof HTS materials, the use of superconductivity had not been practical for widespread commercial applications, except for magnetic resonance imaging ("MRI") and superconducting magnetic energy storage ("SMES") applications, principally because commercially available superconductors (i.e. LTS materials) are made superconductive only when these materials are cooled to near 0K. Although it is technologically possible to cool LTS materials to a temperature at which they become superconductive, broad commercialization of LTS materials has been inhibited by the hish cost associated with the cooling process. For example, liquid helium, which can be used to cool materials to about 4K (-452 degrees Farenheit), and which has been commonly used to cool LTS materials, is expensive and relatively costly to maintain.

In 1986, a breakthrough in superconductivity occurred when two scientists, Dr. K. Alex Muller, who is currently under contract as a consultant to ASC, and Dr. J. Georg Bednorz, at an IBM laboratory in Zurich, Switzerland, identified a ceramic oxide compound which was shown to be superconductive at 36K (-395 degrees Farenheit). This discovery earned them a Nobel Prize for Physics in 1987, which is one of four Nobel Prizes that have been awarded for work on superconductivity. A series of related ceramic oxide compounds which have higher critical temperatures were subsequently discovered, including those being used by American Superconductor.