NEW MATERIALS

The value of impurities

Brazilians discover a new family of materials that conduct electricity without losing energy

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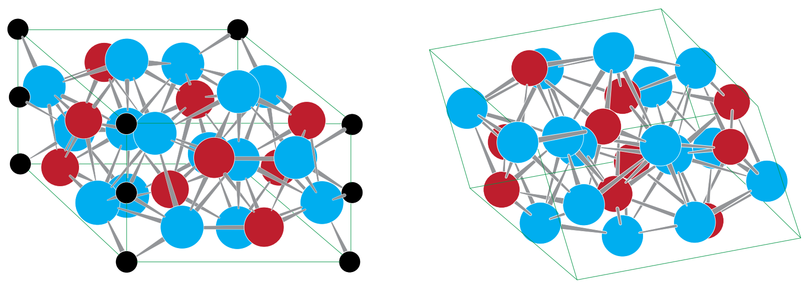
Materials engineers Antonio Jefferson Machado and Carlos Alberto Moreira dos Santos of the Lorena School of Engineering of the University of São Paulo (USP) radically transformed the electrical properties of a metallic compound. They did so by inserting atoms of lighter chemical elements such as boron, carbon, and nitrogen between the atoms that form the crystalline network of the compound. Using this technique, which is referred to as interstitial doping, they have created approximately 30 new superconductive electrical materials since 2003.

The most promising discovery involving these superconductors was announced in June of this year in an article published in the *Journal of Applied Physics*. Here, the researchers from Lorena, in partnership with materials engineer Ausdinir Bortolozo of the Federal University of Itajubá and physicists Renato Jardim of USP and Flávio Gandra of the State University of Campinas, describe what happens when carbon atoms are added during the manufacturing process of a well-known metal compound, Nb_5Ge_3, which is a combination of niobium and germanium. This compound, which emerged in 1977, has not been of significant interest to materials science because it becomes a superconductor at a temperature that is considered to be too low for practical applications—less than -272 degrees Celsius (°C). "The electrical behavior of the doped material changed completely," says Machado, who has already successfully doped Nb_5Ge_3 with six other chemical elements.

TRANSFORMED MOLECULES

Brazilian superconductor: This compound based on germanium (*red*) and niobium (*blue*) conducts electricity without resistance when doped with carbon atoms (*black*)



The carbon-doped material is a superconductor at a temperature of -258°C, the highest temperature ever achieved by the Brazilian engineers. This temperature is of industrial interest. Although it is extremely low, it is 11 degrees above the boiling point of liquid helium (-269.15°C), which is normally used to cool superconductor metals in their technological applications, for instance, in equipment used for magnetic resonance imaging.

NO RESISTANCE

In a superconductor material, the electrical resistance disappears below a certain temperature, meaning an electric current can travel through the material without losing energy in the form of heat. In 1911, superconductivity was observed for the first time by Dutch physicist Heike Onnes. A number of superconducting materials—most of them metallic—have been discovered since then. These materials become superconducting at extremely low temperatures, a few degrees above absolute zero (-273°C).

Although relatively high, the temperature achieved by the Brazilians is far from the world record, which is held by another class of materials based on copper oxides. This class of materials, with superconducting temperatures above -196°C, was first synthesized in 1987. However, the fact that these materials are ceramic makes them heterogeneous and brittle, which hinders large-scale production. Therefore, researchers are engaged in an ongoing search for a superconducting material that can function at higher temperatures and is malleable and homogeneous like metals.

According to physicist Zachary Fisk of the University of California at Irvine, the discovery made by the Brazilian engineers has opened up the possibility of using interstitial doping to create highly desired high-temperature superconducting metal alloys. "This is an exciting development," he says. ■

Scientific article

BORTOLOZO, A. D. et al. Interstitial doping induced superconductivity at 15.3K in Nb5Ge3 compound. **Journal of Applied Physics**. 2012.