

# **STUDY OF PEROVSKITE STRUCTURE AND THEIR SUPERCONDUCTIVITY**

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## **ABSTRACT**

*Superconductivity, a phenomenon characterized by the disappearance of electrical resistance in various metals, alloys, and compounds when they are cooled to very low temperatures, was first observed in 1911 by Heike Kamerlingh Onnes. In Onnes' early studies, he noted that the resistance of a frozen mercury rod abruptly dropped to zero when cooled to the boiling point of helium, 4.2 Kelvin. He also discovered that a material in a superconducting state can be returned to its standard, nonsuperconducting condition through exposure to a strong magnetic field of a certain critical value or by passing a large current through it.*

**Keywords: Electrical Resistance, Low Temperatures, Strong Magnetic Field.**

## **I INTRODUCTION**

Heike Kamerlingh Onnes was even awarded the Nobel Prize for Physics in 1913, the extremely cold temperatures required to instigate superconductivity necessitated the use of liquid helium, which made it cost prohibitive to utilize traditional superconductors for many applications. The discovery of perovskite superconductors revolutionized this field, however, and by 1987, superconductivity in these materials could be induced above 77K, the boiling point of liquid nitrogen. This significant advance made superconductors cheaper to cool to their critical temperature, since liquid nitrogen is considerably less costly than liquid helium.

The first superconducting perovskite was discovered by IBM researchers Bednorz and Mueller, who were examining the electrical properties of a family of materials in the Ba-La-Cu-O system. One of the materials they were studying was reported to have a critical temperature of approximately 35 Kelvin, which was a benchmark in field of superconductivity at the time. For their discovery, which opened up an entirely new area of study since their high-temperature superconductors did not conform to the **BCS theory** widely believed to govern the activity of all superconductors known up to that time, Bednorz and Mueller were awarded the Nobel Prize for Physics in 1987. Meanwhile, between 1986 and 1988 the critical temperature for superconductivity in perovskite ceramics was raised by more than 100 Kelvin, but in recent years only several degrees have been added to this remarkable elevation. Many of these minor increases in the critical temperatures of ceramic superconductors have stemmed from the utilization of increasingly exotic elements in the base perovskite.

## II REVIEW OF LITERATURE

Other industrial applications of perovskites are ion conduction (LaGaO<sub>3</sub>) linear and nonlinear optical switching (LiNbO<sub>3</sub>) .catalysis (LaFeO<sub>3</sub>) and colossal magneto resistance, super conduction (YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub>). Photo luminescent properties as anionic conductivity over a wide temperature range. Fluorides as well as their doped analogues have found wide applicability as components of high-density optical devices, lenses, biological labels, sensors and insulators. The ternary metal fluorides, possessing cubic perovskite structures with the chemical formula AMnF<sub>3</sub> (A = K, NH<sub>4</sub>, Rb, Tl, Cs), are antiferromagnetic, so these materials have generated considerable interest owing to their exceptional magnetic, piezoelectric and photo luminescent properties.

Future applications of perovskites are indicated by current research. Certain more complex perovskites and application as microwave resonators, on account of their high relative permittivity, low dielectric loss, and near-zero temperature coefficient of resonant frequency. Thin films of Cr-doped SrTiO<sub>3</sub> and SrZrO<sub>3</sub>, for example, are being studied for their potential in non-volatile computer memories. The majority of materials exhibiting a giant magneto resistive response are perovskites, and the now famous high temperature oxide superconductors still under intensive investigation are also generally considered as members of the extended perovskite family. Finally, we remark on the importance of perovskites in the earth sciences. Magnesium silicate in particular, MgSiO<sub>3</sub>, is considered to adopt the perovskite structure in the earth's lower mantle, making silicate perovskites the most abundant minerals on earth .The influence of phase transitions on the elastic constants of lower mantle perovskites may be of particular significance in seismology. There are reasons aplenty for investigations of perovskites to be continued.

## III MATERIAL AND METHOD

In addition to capacitors, some perovskites have begun to find wide use in **piezoelectric** devices, which generate electricity when they are subjected to mechanical pressure and, conversely, undergo a change in dimension when exposed to an applied voltage. Piezoelectric perovskites obtain their distinctive properties through processes that cause their typically cubic structures to shift so that they lack a true center of symmetry, as discussed above in regard to barium titanate. The ceramics synthesized to be piezoelectric may be used in a wide variety of products, including communications equipment, crystal-controlled timing devices, transducers, pressure gauges, buzzers, and accelerometers. Interestingly, perovskites have also been found to show significant potential for use as materials that may safely encapsulate radioactive waste and are being heavily investigated by scientists in the environmental discipline for such purposes.

Some perovskites manifest a *ferroelectric* property the property seen in materials which are polarizable and can reverse the polarity in an electrical field.

## IV RESULT AND CONCLUSIONS

One such well-known ferroelectric perovskite is barium titanate (BaTiO<sub>3</sub>), also the best-known electro-ceramic in commercial use. Under an applied electrical field, the cations are energized and displaced and the crystal

becomes more polarized. On release of the applied field, the cations return slowly to their normal positions and release the stored energy. BaTiO<sub>3</sub> is thus used in capacitors, which store charge from pulses of current and then release the stored charge between pulses, thereby producing a steady direct current. It is employed as a voltage surge protector (which is often used in computers). When a surge of electricity (say, from a lightning strike) reaches the BaTiO<sub>3</sub> crystal, it absorbs the pulse and slowly dissipates it.

The other interesting property shown by BaTiO<sub>3</sub> perovskite is *piezoelectricity*. This property arises because, when an external electric field displaces the Ti atoms from their normal positions, the shape of the crystal changes. Conversely, mechanical pressure deforming the crystal releases electrical energy. Hence, BaTiO<sub>3</sub> perovskite also finds a use in transducers, such as are employed in loudspeaker buzzers and microphones. Similar properties are manifested by PZT perovskites. Perovskite oxides Perovskite compounds comprise a very large and immensely important family of ferroelectric materials. Their chemical formula is a simple ABO<sub>3</sub> oxide, with the A and B cations typically being metals of either mono-/divalent and tetra-pentavalent atoms respectively. The physical properties of the entire family are as wide as they are many. They can be metallic or insulating depending upon the composition and cationic ordering, and can exhibit many different types of structural and magnetic order.

The perovskite structure is one of the most frequently encountered structure types in solid-state inorganic chemistry. It accommodates cations of most of the metallic elements in the periodic table and a significant number of anions. Although most of the compounds that adopt the perovskite structure are oxides and fluorides, some hydrides, oxyfluorides and oxynitrides are also found to crystallize in this structure. Structurally, the ideal perovskite oxide has a stoichiometry formula of ABO<sub>3</sub> and belongs to the cubic space group Pm3m, with the A cation in a 12-fold coordination site and the B cation in a sixfold coordination site. As shown in Fig. 1, the A cation is located at the body center of the cube, the B cation is at each of the eight corners and the O anion is at each of the centers of the 12 edges. The most common description of a perovskite structure is a three dimensional framework of corner-sharing BO<sub>6</sub> octahedra, with the A cation filling the 12-coordinate cavities.

Owing to the non-stoichiometry of the cation or anion, the distortion of the cation configuration and the electronic structure arising from mixed-valence, perovskite and perovskite-related materials exhibit versatile physical and chemical properties, which have attracted considerable research interest in materials chemistry. For instance, perovskite ceramics with ferroelectric and piezoelectric properties, such as BaTiO<sub>3</sub>, PbTiO<sub>3</sub>, Bi<sub>2</sub>ZnTiO<sub>6</sub> and Bi(Mg<sub>1/2</sub>Ti<sub>1/2</sub>)O<sub>3</sub> [43] play a dominant role in the electro ceramics industry. Other industrial applications of perovskites are: catalysis, ion conduction, linear and nonlinear optical switching (LiNbO<sub>3</sub>), superconduction (YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub>), colossal magnetoresistance etc. Therefore, it is desirable to search for the regularities governing whether perovskite compounds can be formed and the factors governing their structural stability, with the aim of providing useful clues for the discovery of novel materials.

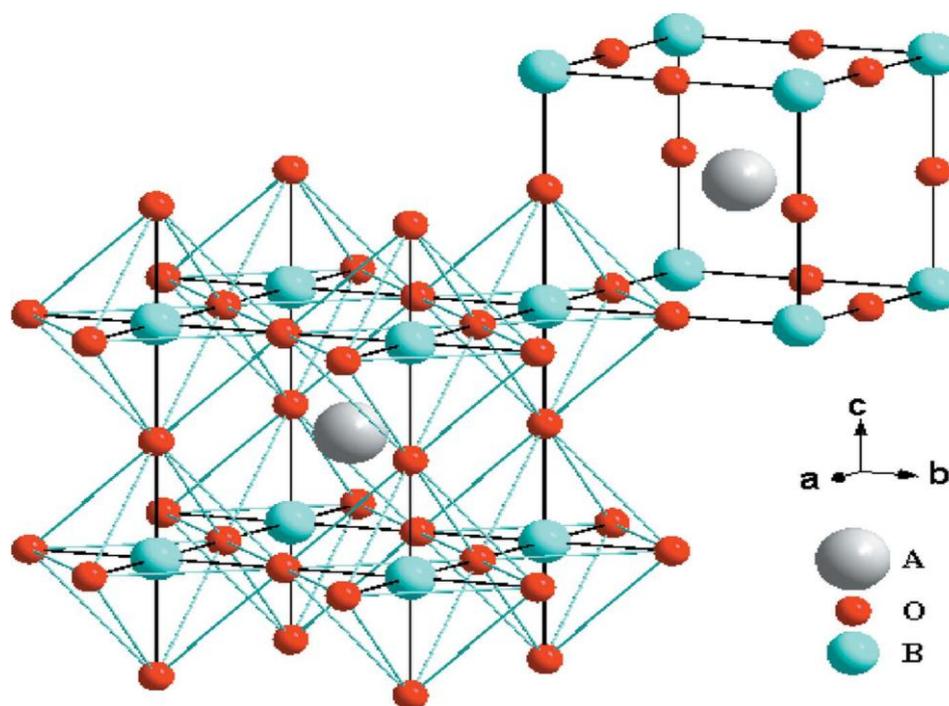


Figure 1 - Fragment of the crystal structure of an ideal cubic perovskite. Note the corner-sharing  $\text{BO}_6$  octahedra, extending in three dimensions to form the network.

## REFERENCE

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