Answer on Question #51554, Physics, Solid State Physics

What are ferroelectric materials? Explain with the example of BaTiO3. How are they different from piezoelectric materials?

Answer:

Ferroelectricity is a property of certain materials that have a spontaneous electric polarization that can be reversed by the application of an external electric field (see Fig.1). They are useful as piezoelectric crystals and capacitors. Piezoelectricity is the phenomenon whereby polarization is induced in a material by the imposition of external forces.

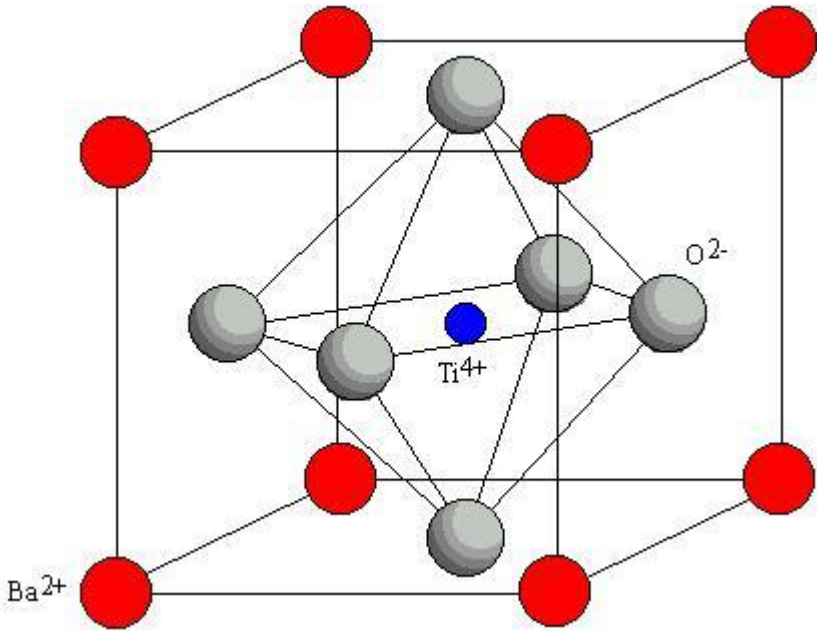

Fig.1

A typical representative of ferroelectric materials is barium titanate. At a temperature above 120^0C (Curie point), barium titanate has a crystal perovskite-type crystal structure shown in Fig.2,a. The composition the unit cell having the shape of a cube includes one formula type unit ABO_3. Constitute the basic structure of the oxygen octahedra in central titanium ions are located. In turn the oxygen ions centered verge cubes composed of barium ions. The dimensions of the unit cell is greater than twice the amount of the ionic radii of titanium and oxygen. Therefore, titanium ion has some freedom of movement within the oxygen octahedron.

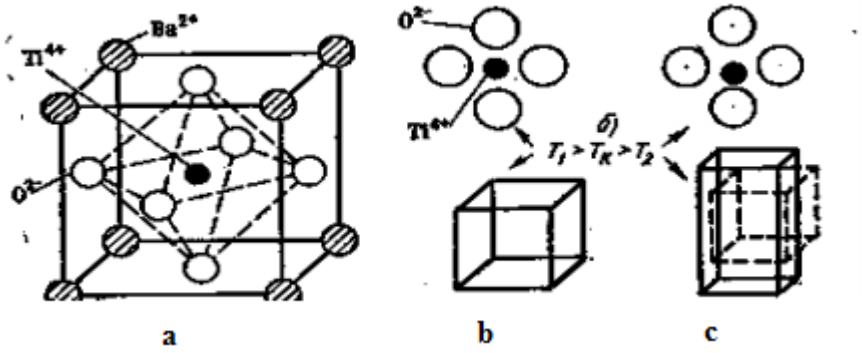

Fig.2

At high temperatures, due to intensive thermal motion titanium ion continuously being transferred from one ion to another oxygen, so that its average position coincides in time with the center of the unit cell. Due to the central symmetry of such a cell does not have an electric moment (Fig. 2,b).

At temperatures below 120^0C energy of thermal motion is not sufficient for the transfer of the titanium ion from one equilibrium position to another, and it is localized near one of the surrounding oxygen ions.

Simultaneously, the distorted shape of the cell, it acquires a tetragonal symmetry (Fig. 2,c).