UNIT-III

MAGNETIC AND DIELECTRIC MATERIALS

CONTENTS

3.4. Domain Theory of Ferro Magnetism

This theory was proposed by Weiss in 1907. It explains the hysteresis and the properties of ferromagnetic materials.

Postulates of domain theory:

1. A ferromagnetic material is divided into a large number of small region called domains (0.1 to 1 of area)
2. In each domain the magnetic moments are in same direction.
3. But the magnetic moment varies from domain to domain and the net magnetization is zero,
4. In the absence external magnetic field all the magnetic moments are in different direction.
5. When a magnetic field is applied there are two process takes place
   - ❖ By the motion of domain walls.
   - ❖ By the rotation of domains.

By the motion of Domain walls

When a small amount of magnetic field is applied, the dipoles in the domains are aligned parallel to the applied magnetic field. It increases domain area by the motion of domain walls.

By the rotation of Domains

If the applied magnetic field is further increased, the domains are rotated parallel to the field direction by the rotation of domains.

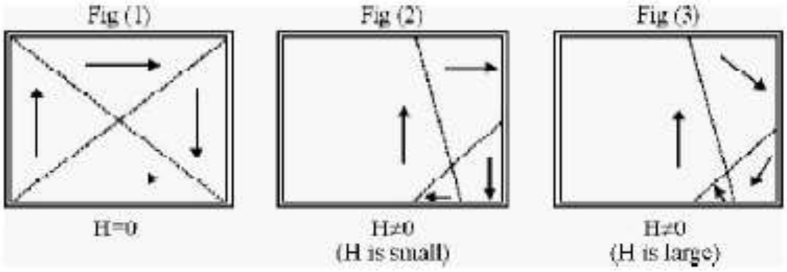


Fig 3.4.1.Effect of magnetic field

3.4.1 Energies involved in the domain growth (or) Origin of Domain theory of Ferromagnetism

The total internal energy of the domain structure in a ferromagnetic material is made up from the following

1. Exchange energy (or) Magnetic field energy.
2. Crystalline energy (or) Anisotropy energy.
3. Domain wall energy (or) Bloch wall energy.
4. Magnetostriction energy

1. Exchange energy (or) Magnetic Field energy

"The interaction energy which makes the adjacent dipoles align themselves" is the called **exchange energy (or) magnetic field energy.** It arises from an interaction of electron spins. It depends upon the inter atomic distance. This exchange energy also called magnetic field energy. Whose energy is required in assembling the atomic magnets into a single domain and this work done is stored as potential energy. The volume of the domain may very between 10^{-2} to 10^{-6} cm^3.

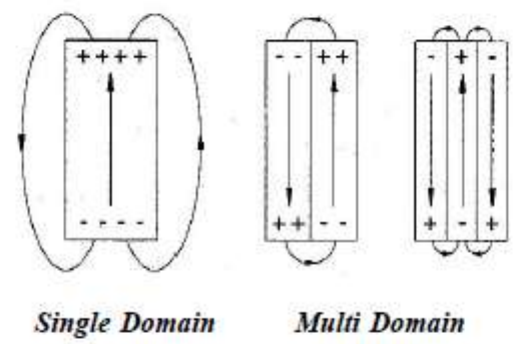


Fig 3.4.2 Exchange energy

2. Anisotropy energy

The excess of energy is required to magnetize a specimen along the hard direction is called the crystalline anisotropy energy. In ferromagnetic materials there are two types of directions of magnetization namely,

- ❖ **Easy direction and**
- ❖ **Hard directions.**

In easy direction of magnetization, weak field can be applied and in hard direction of magnetization, strong field should be applied.

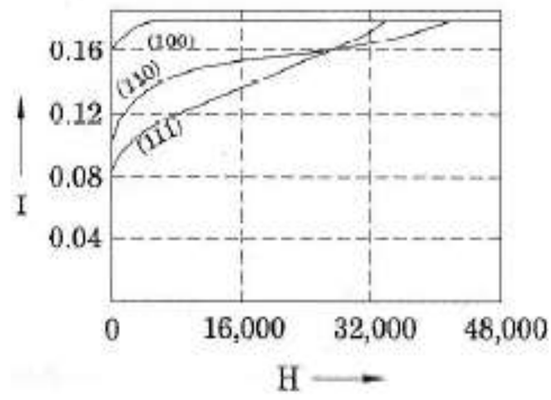


Fig 3.4.3.Direction of magnetization

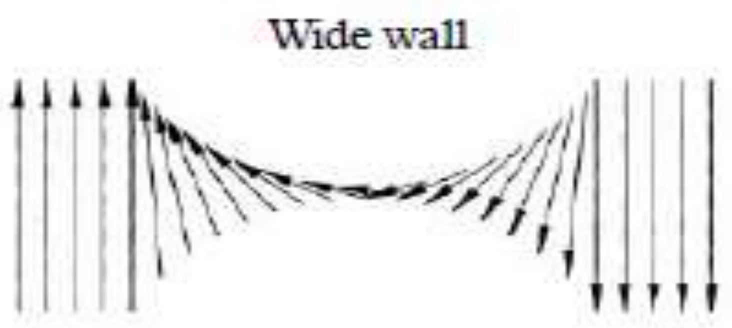
Crystalline anisotropy energy

The energy of magnetization which is the function of crystal orientation. As shown in figure magnetization curves for iron with the applied field along different crystallographic direction crystallographic directions have been drawn. For example, in BCC iron the easy direction is [100], the medium direction is [110], and the hard direction [111]. This energy is very important in determining the characteristic domain boundaries.

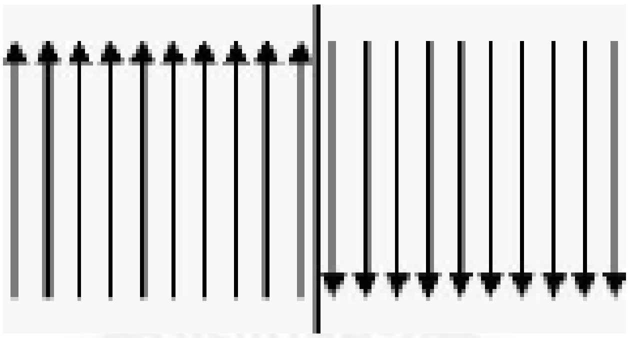
3. Domain wall energy or Bloch wall energy

A thin boundary or region that separates adjacent domains in different directions is called domain wall or Bloch wall**.** The size of the Bloch walls is about 200 to 300 lattice constant thickness. The energy of domain wall is due to both exchange energy and anisotropic energy. Based on the spin alignments, two types of Bloch walls may arise, namely

Thick wall: When the spins at the boundary are misaligned and if the direction of the **spin changes gradually** as shown in below figure, it leads to a thick Bloch wall. Here the misalignments of spins are associated with exchange energy.



Thin wall: When the spins at the boundaries **changes abruptly,** then the anisotropic energy becomes very less. Since the anisotropic energy is directly proportional to the thickness of the wall, this leads to a thin Bloch wall.



4. Magetostriction energy

When a material is magnetized, it is found that it suffers a change in dimensions. This phenomenon is known as **Magnetostriction.** This deformation is different along different crystal directions. So if the domains are magnetized in different directions, they will either expand or shrink. This means that work must be done against the elastic restoring forces. The work done by the magnetic field against these elastic restoring forces is called magneto-elastic energy or Magnetostrictive energy.