DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB101J-Electromagnetic Theory, Quantum Mechanics, Waves and Optics

Module 2 Lecture-2

Ferromagnetism: Basic Ideas and Concepts of ferromagnetic domains: Discussion how domain change with magnetization

Ferromagnetism: Basic Ideas

- Certain metals like iron, cobat, nickel and certain alloys exhibit high degree of magnetisation.
- These materials show the spontaneous magnetization i.e., they have a small amount of magnetization (atomic magnetic moments are aligned) even in the absence of an external magnetic field.
- This indicates that there is a strong internal field within the material which makes the atomic magnetic moments align with each other. This phenomenon is known as **Ferromagnetism.**

Ferromagnetic materials

The materials which exhibit the ferromagnetism are called Ferromagnetic materials.

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Ferromagnetism: Basic Ideas

Properties

- All the dipoles are aligned parallel to each other due to the magnetic interaction between the dipoles.
- They have permanent dipole moment. They are strongly attracted by the magnetic field.
- They exhibit magnetisation even in the absence of magnetic field. This property of Ferromagnetic materials is called as spontaneous magnetisation.
- They exhibit hysteresis (lagging of magnetisation with applied magnetic field).
- On heating, they lose their magnetisation slowly.
- The dipole alignment is shown in Fig.
- The magnetic susceptibility is very high and it depends on temperature.

Ferromagnetism: Basic Ideas

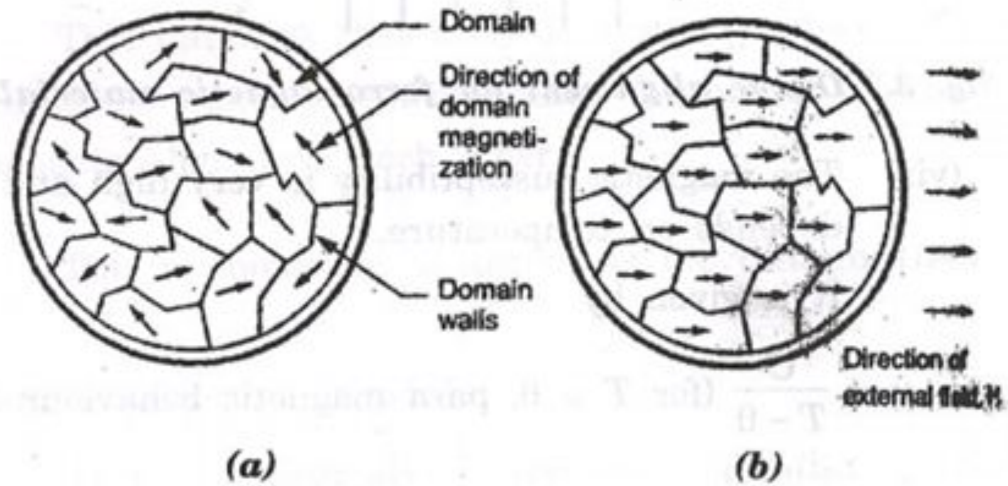

Fig. ***(a) Schematic illustration of magnetic domains in a demagnetised ferromagnetic material. In each domain the magnetic dipoles are aligned but the domains are aligned at random so that the net magnetization is zero.***

(b) Domain configuration in a magnetized body. The magnetic moments of domains are aligned resulting in strong net magnetization.

Ferromagnetism: Basic Ideas

Domain Theory of Ferromagnetism

Weiss proposed the concept of domains in order to explain the properties of ferromagnetic materials.

Principle

The group of atomic dipoles (atoms with permanent magnetic moment) organised in tiny bounded regions in the ferromagnetic materials are called magnetic domains.

Explanation

- Ferromagnetic material contains a large number of domains. In each domain, the magnetic moments of the atoms are aligned in same direction.
- Thus, the domain is a region of the Ferromagnetic material in which all the magnetic moments are aligned to produce a net magnetic moment in one direction only. Thus it behaves like a magnet with its own magnetic moment and axis.

Ferromagnetism: Basic Ideas

- In a demagnetized ferromagnetic material, the domains are randomly oriented as shown in Fig. a. so that the magnetization of the material as a whole is zero.

- The boundaries separating the domains are called domain walls. These domain walls are analogous to the grain boundaries in a poly crystalline material.

- However, the domain walls are thicker than the grain boundaries. Like grain growth, the domain size can also grow due to the movement of domain walls.

- When a magnetic field is applied externally to a ferromagnetic material, the domains align themselves with field as shown in Fig. b. This results in a large net magnetization of the material.

Ferromagnetism: Basic Ideas

Process of Domain Magnetisation

- We know that in an unmagnetised specimen, the domains are randomly oriented and the net magnetization is zero.
- When the external magnetic field is applied, domains align with the direction of filed resulting in large net magnetization of a material.
- There are two possible ways in which the domains are aligned in the external field direction.

(a) By the motion of domain walls

- Fig. a. shows an unmagntised specimen in which domains are randomly aligned.
- When a small magnetic field is applied, the domains with magnetisation direction parallel or nearly parallel to the field, grow at the expenses of others shown in fig. b.

Ferromagnetism: Basic Ideas

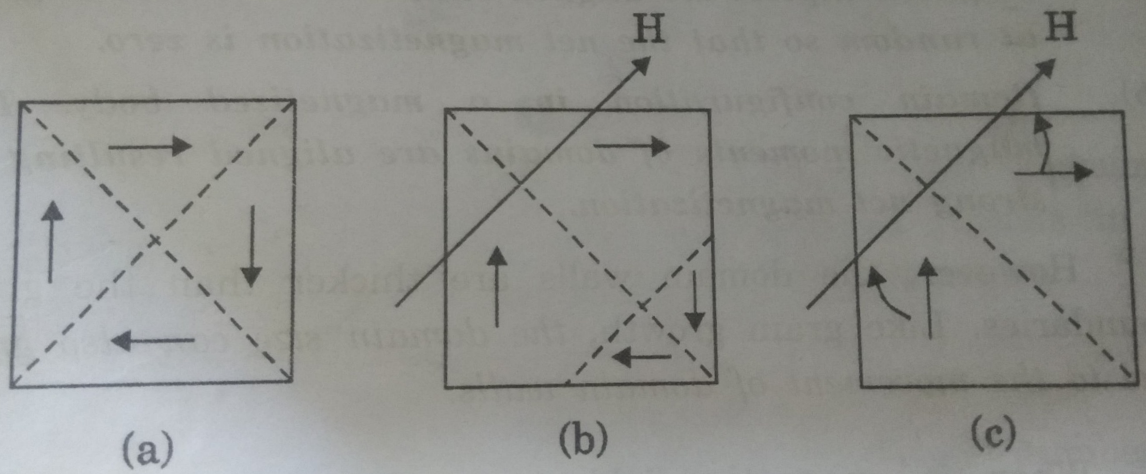

Fig. 3.9

(a) Random domain alignment (b) Domain wall movement (c) Domain rotation.

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Ferromagnetism: Basic Ideas

- This domain growth occurs due to the movement of domain walls away from the minimum energy state.

(b) By rotation of domains

- As the magnetic field is increased to a large value (i.e., near saturation) further domain growth becomes impossible through domain wall movement.

- Therefore, most favourably oriented and fully grown domains tend to rotate so as to be in complete alignment with the field direction, as shown in fig. c.

Thank you