

# Theme: Functional Material

## Subject x: Hexaferrite Particle of Single Magnetic Domain Size

### Introduction

Hexaferrite (Hexagonal ferrite) have become important material commercially and technologically, accounting for the bulk of the total magnetic materials manufactured globally, and there are multitude of uses and applications as components in electrical devices operating at microwave/GHz frequencies.

In particular, the miniaturization and the bandwidth increase of antenna can be realized by increasing permeability. However, the ferrite ferromagnetic resonance frequency needs to be higher than the antenna operation frequency, and also high permeability is desired. This is because the magnetic loss tangent ( $\mu''/\mu'$ ) of ferrite significantly increases near the ferromagnetic resonance frequency and bandwidth and miniaturization factor increase with permeability. On the contrary, permeability decreases with increasing ferromagnetic resonance frequency according to the Snoek's limit. One way to achieve high resonance frequency is to use a high magneto-crystalline anisotropy hexaferrite such as M, Y or Z type hexaferrites. It is, however, difficult to use the hexaferrites in antenna applications because they have permeability still smaller than 2.5 and magnetic loss tangent larger than 0.05 at 2.1GHz frequency. Thus, one promising possibility of overcoming this drawback is to make hexaferrite particle having no magnetic domain wall which is the main cause of residual loss in ferrites.

### Scope

The objective is to make Y and Z type hexaferrite ( $\text{Co}_2\text{Y}$  and  $\text{Co}_2\text{Z}$ ) particle of single magnetic domain size.

Main target specifications of the hexaferrite particles are:

- $\text{Ba}_2\text{Co}_2\text{Fe}_{12}\text{O}_{22}$  &  $\text{Ba}_3\text{Co}_2\text{Fe}_{24}\text{O}_{41}$  particles of single magnetic domain size ( $D_{50}$ : ~0.5 to 1.0  $\mu\text{m}$ )
- Permeability 2.5 and magnetic loss tangent 0.05 @ 2.1 GHz

### Research questions

Additional research questions are open for discussion with research partners.

- What is the main cause of the magnetic loss tangent in hexaferrite?
- Are there any other types of materials or concepts for high permeability and low magnetic tangent loss in high frequency antenna and EMC applications?

### Expected Deliverables

- Delivery of the developed material sample & if possible, demo sample of fabricated powders or cores
- Presentation, discussions, and documentation on the result of the research study
- Upon agreement, sharing or co-owning of the intellectual property stemming from the research study