Co- and Ti-substituted M-type hexaferrites for high frequency applications

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The radio waves for 5G are expected to be in X- band (8-12 GHz) or in K-band (12-40 GHz) according to the latest 3GPP release. This necessitated the development of magnetic materials suitable at aforesaid frequency bands for passive devices as conventional soft-magnetic materials cannot be employed anymore owing to their extremely lossy characteristics at those frequency bands. M-type hexaferrites are blessed with reasonably high permeability and high magnetocrystalline anisotropy that restricts losses up to a few tens of GHz. However, appropriate cation substitution in their crystal lattice not only enables tuning of anisotropy but also transforms it magnetically soft. Co- and Ti-substituted Sr-based M-type hexaferrite can thus be of extreme importance owing to their suitable soft-magnetic properties in the desired frequency regime.

In this work, the candidature of $SrCo_xTi_xFe_{12-2x}O_{19}$, x=1.0, 1.2, and 1.4 polycrystalline powder as a suitable material for its use in microwave passives is assessed. H_C drops drastically from ~300 Oe to ~40 Oe as the level of substitution, x increases from 1.0 to 1.4. As a result, ferromagnetic resonance (FMR) frequency also decreases from ~20 GHz to 5.4 GHz, making it particularly suitable for the use of high frequency passives. ZFC/FC measurement reveals the absence of interparticular interactions in the samples. At the same time the magnetic layers, formed when the powder of all sample are mixed with epoxy resin, found to be magnetically isotropic in all direction. This lowers theirs real part of permeabilities to some extent. High frequency magnetic characteristics of ferrite-epoxy layers are investigated through two different measurement techniques [1], [2], such as microstrip probe, and shorted micro-strip line measurement. Both measurements are calibrated by high external DC bias field. The resulting frequency dispersion of permeability of one of the sample, obtained from both measurements agrees well with each other as demonstrated in Figure 1c, indicates the shift of FMR frequency from with level of substitution. Minute presence of impurity phases as revealed by XRD (Figure 1a) resulted in a small FMR peak around 1.3 GHz observed in all measurements as well.

These results outlined the suitability of CoTiM family of hexaferrites for their integration into high frequency passives. The work also highlights the strength and weaknesses of different broadband measurement techniques for the investigation of high frequency magnetic characteristics of relatively low permeable hexaferrites.

Reference
1) S. Takeda et al., J. J. Soc. Pow. Mat., 61, p303, (2014).
2) T. Kimura et al., J. Magn. Soc. Jpn, 38, 87, (2014).

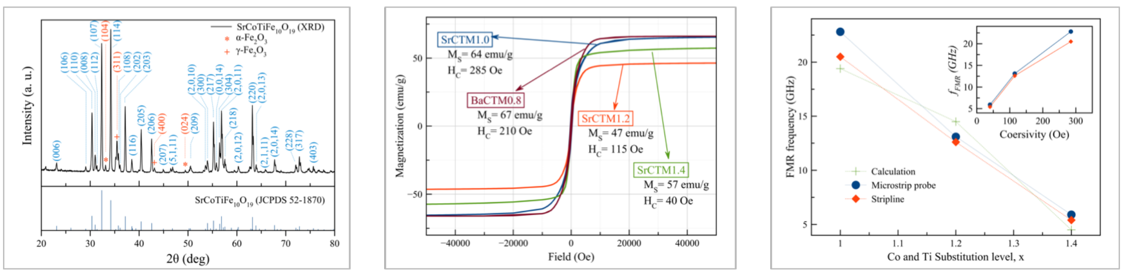

Figure 1: (a) Powder XRD pattern of the SrCoTiM; (b) M-H plot of four different CoTiM hexaferrite powder (c) Effect of Co and Ti substitution on FMR frequency and in inset, dependence of FMR frequency on coercivity.