Abstract

Microwaves (MW) are primarily used in communications through satellite, cellular phones, radar communication etc. In spite of these important applications, there are numerous unkind effects such as detection of our strategic airborne objects through enemy radars, communicational interference among electronic devices, adverse effect of cellular mobile radiation on human health, etc. Therefore, materials that absorb/scatter microwave radiation are gaining interest among the scientific community to mitigate these challenges. Microwave absorbing materials (MAM's) are not only important for strategic applications such as Radar Cross Section (RCS) reduction of airborne objects but also for applications in the civil sectors such as control of communication interference among electronic devices, reduction in antenna background etc. With the advent of advanced antenna technology and availability of wide range of radars used in different frequency bands, there is a need to develop materials for 2-18 GHz wide-band MW frequency range to counter these challenges.

In this thesis work, development of functional materials having different ferroic ordering viz. ferromagnetic, ferroelectric, multiferroic etc. have been focused by optimizing their process parameters to obtain desired microwave absorption properties in the extended frequency range. Further, rubber based composite sheets are developed by using the different loading weight fraction of functional materials and their electromagnetic (EM) performance has been investigated. Spinel ferrites with different Zn compositions, $Ni_{1-x}Zn_xFe_2O_4$ (x=0, 0.25, 0.5, 0.75), have been synthesized using gel to carbonate precipitation and x=0.5 i.e. $Ni_{0.5}Zn_{0.5}Fe_2O_4$ material has shown enhanced microwave absorption properties in the frequency range 2-12.4 GHz (S, C & X-bands). Graphite coated Ni nanoparticles in core/shell geometries are prepared using the wet chemical process, followed by pyrolytic decomposition of Ni nanocomposite. The optimized Ni nanoparticles with graphitic core materials exhibited the desired MW absorption over 12.4-18 GHz (Ku-Band). Ferroelectric $BaTiO_3$, multiferroic $BiFeO_3$ and Co substituted Z-type Strontium hexaferrite ($Sr_3Co_2Fe_{24}O_{41}$) functional materials are synthesized using solid-state milling, sol-gel and wet chemical routes, respectively, to understand the microwave absorption properties in 8-18 GHz (X & Ku-bands). The structural, magnetic and morphological properties are investigated to comprehend their impact on microwave absorption properties. These findings may assist in selecting the material's structure and morphology with composition to tailor the microwave absorption properties in the desired frequency band. Further, the developed rubber based MW absorbing composites using optimized functional filler materials have been investigated for their matching thickness to achieve maximum MW Return Loss (R.L.) > 10 dB (90% MW signal attenuation). The microscopic origin for the onset of MW absorption has been identified in these rubber- MAM's composite system.

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