Brief Work Report

Ph.D. Topic: Topic: Investigations on Synergy of Magnetic and Conducting Nanoparticles Reinforced Silicone Rubber Composites for Electromagnetic Interference Shielding Applications

PART 1 – EMI SHIELDING APPLICATIONS

Simulation Oriented Approach to Design Multilayered Heterogeneous Arrangements for EMI Shielding Applications

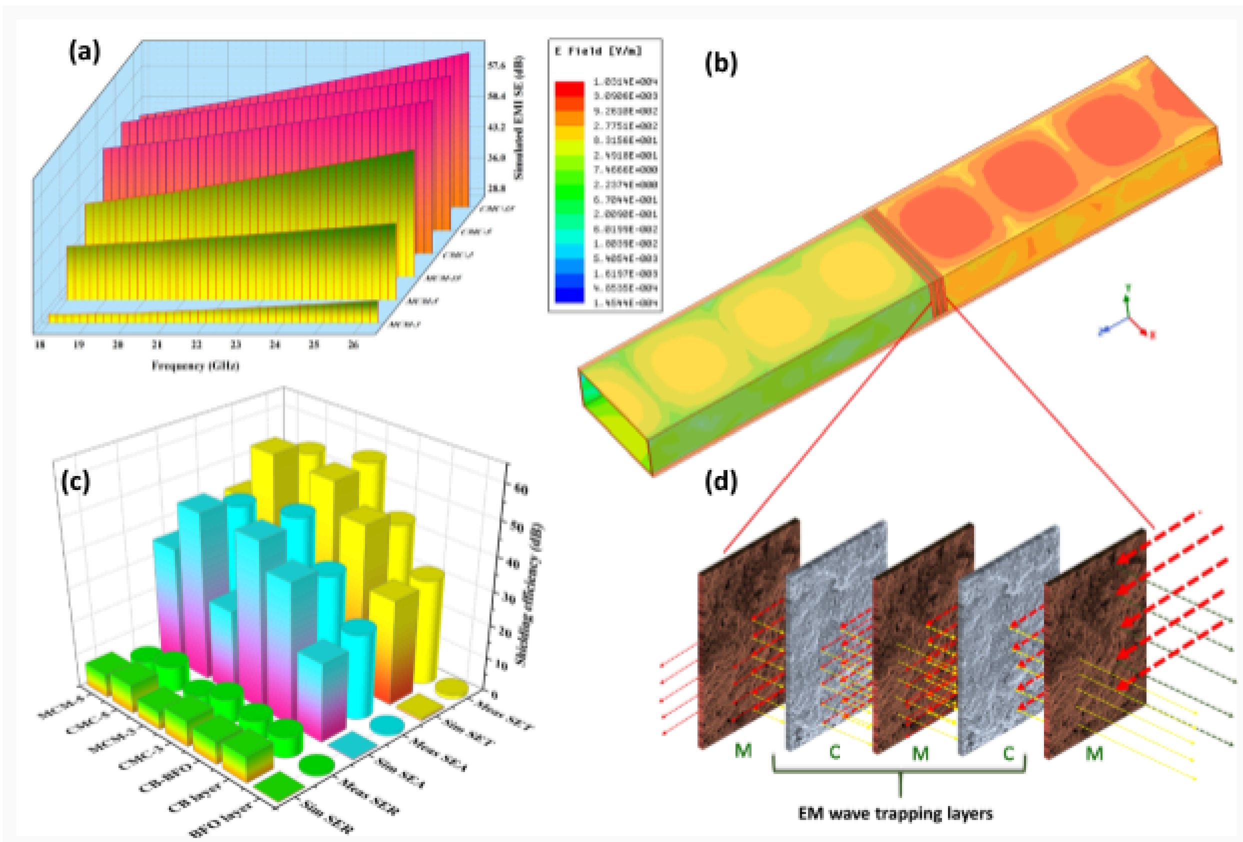

Figure shows (a) the simulated EMI shielding effectiveness (SE) of various multilayered heterogeneous arrangements (MHAs), (b) a five layered MHA in a virtual waveguide measurement environment, (c) reflection and absorption based shielding efficiency of simulated and fabricated MHAs, and (d) EMI shielding mechanism in an MHA.

The electromagnetic interference (EMI) shielding market is one of the fast-growing sectors owing to the increasingly complicated electromagnetic environment. Recently, there has been a pressing priority to improvise the techniques to fine-tune and predict the shielding properties of structures without exhausting raw materials and reduce the expense as well as the time required for optimization. In this article, we demonstrate an effective and precise method to predict the EMI shielding effectiveness (SE) of materials via simulating the performance of composites having alternate layers of conducting and magnetic materials in a virtual waveguide measurement environment based on the finite element method (FEM). The EMI SE of multilayered heterogeneous arrangements (MHAs) is simulated in the K-band region using ANSYS High Frequency Structure Simulator (HFSS) software, which can be extended to all other bands as well. Various simulations carried out by changing the order of the conducting and magnetic layers and the number of layers revealed that the strategical arrangement of EM energy trapping layers inside impedance matching layers in the MHAs significantly contributes toward the enhancement of absorption-dominated EMI shielding. The simulation results resonated with the testing results that all the conducting-magnetic-conducting (CMC) systems exhibited shielding effectiveness above 50 dB. The MHAs are realized for testing using polyvinylidene fluoride-based composites of low-cost carbon black and barium hexaferrite, an easily accessible ferrite. Through this study, we propose the idea that materials with costly production expenses and cumbersome fabrication procedures are not necessary to realize highly efficient shielding materials.

PART 2 – ANTENNA APPLICATIONS

Development of $SrFe_{12}O_{19}$ – Li_2MoO_4 Cold-Sintered Composite Based Wide-Bandwidth Ferrite Resonator Antenna for Ku-Band Applications

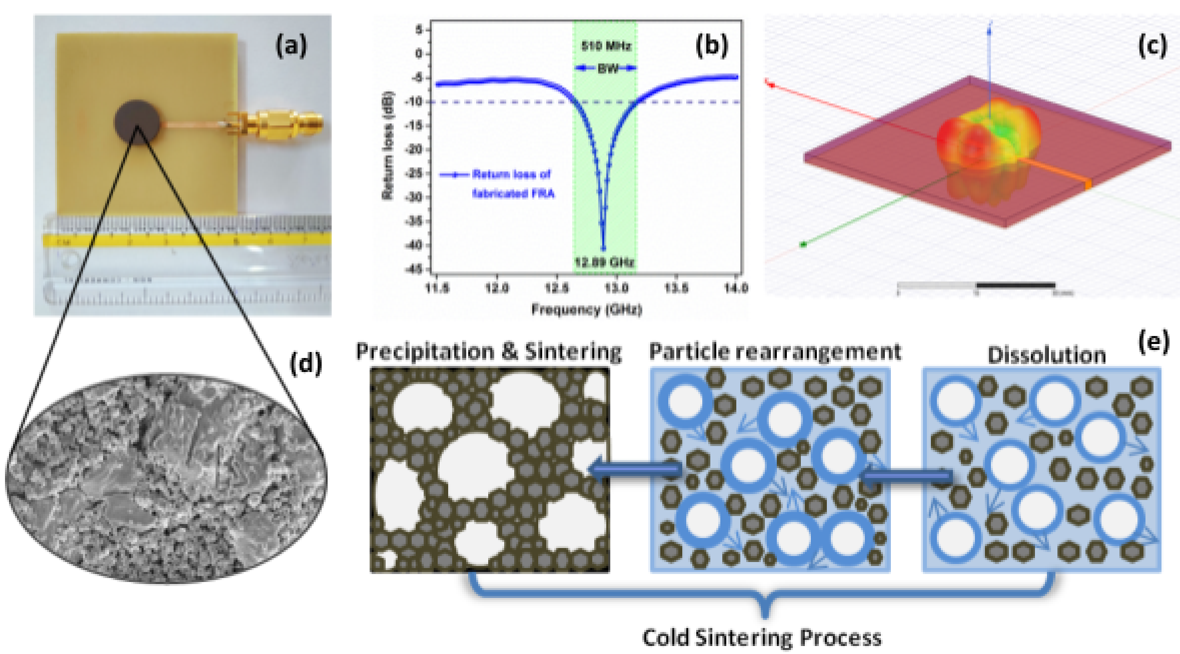

Figure shows (a) fabricated ferrite resonator antenna based on $0.3SrFe_{12}O_{19}$-$0.7Li_2MoO_4$ (0.3SFO-0.7LMO) cold-sintered composite, (b) measured return loss of FRA, (c) simulated FRA with 3D gain pattern, (d) microstructure of 0.3SFO-0.7LMO composite and (d) cold sintering mechanism in SFO-LMO composites.

A sustainable cold-sintering process was adopted to fabricate composites of (1-x) $SrFe_{12}O_{19}$-xLi_2MoO_4, x = 0.4, 0.5, 0.6 and 0.7 with density up to 91% and their broadband electromagnetic properties were deciphered. XRD analysis revealed the coexistence of $SrFe_{12}O_{19}$ (SFO) and Li_2MoO_4 (LMO) phases in the composites, unaccompanied by any additional phases. The evolution of microstructure facilitating enhanced densification was observed with an increase in LMO volume fraction. The real permittivity (ε') increased with increase in LMO volume fraction while the dielectric loss ($\tan \delta_\varepsilon$) is decreased. Further, the real permeability (μ') of all the composites is found to be greater than unity and the magnetic loss ($\tan \delta_\mu$) is found to be in the order of 10^{-2}. The 0.3SFO-0.7LMO composite having the highest densification possess an ε' of 6.7, $\tan \delta_\varepsilon$ of $2x10^{-3}$, μ' of 1.14 and $\tan \delta\mu$ of $2x10^{-2}$ at 900 MHz along with an appreciable room-temperature saturation magnetization (M_s) of 32.2 emu/g. In order to demonstrate the application potential of this magnetodielectric composite towards microwave antenna applications, a ferrite resonator antenna (FRA) integrated using SFO-LMO composite was designed, simulated and fabricated. The fabricated FRA resonating at 12.89 GHz exhibited an exceptionally high return loss of -40 dB and wide impedance bandwidth of 510 MHz. The remarkable properties of the fabricated ferrite resonator antenna suggest that it is a potential candidate for Ku-band applications.

Work in progress:

(i) Development of cold sintered composites based on $Ba_3Co_2Fe_{24}O_{41}$ (BCFO) for NavIC antenna applications – Synthesis of BCFO has been carried out successfully. Optimization of cold sintering parameters going on.

(ii) Simulation and development of coaxial multilayered heterogeneous microwave absorbers – Simulation optimization going on.