Ceramics International 50 (2024) 11697–11706

Contents lists available at ScienceDirect

Ceramics International

journal homepage: www.elsevier.com/locate/ceramint

Synthesis of core-shell NiO/BFO nanocomposites for microwave absorbing applications

Neha [a], Priyanka Sharma [b], Prachi Yadav [c], Devendra Kumar Rana [d], Partha S. Pal [a], Herendra Kumar [a], Sandeep Kumar [a,*]

[a] Department of Physics, Bhaskaracharya College of Applied Sciences, University of Delhi, Delhi, 110075, India
[b] Magnetics and Advanced Ceramics Lab, Department of Physics, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, 110016, India
[c] Department of Physics, Kirori Mal College, University of Delhi, Delhi, 110007, India
[d] Department of Physics, Atma Ram Sanatan Dharma College, University of Delhi, Delhi, 110021, India

ARTICLE INFO

Handling Editor: Dr P. Vincenzini

Keywords:
Core-shell nanoparticles
Light-weight nanocomposites
Impedance matching
Microwave absorption
Dielectric relaxation
Magnetic resonance
Wide absorption bandwidth

ABSTRACT

Magnetic core-shell nanostructures are often employed in high-performance microwave-absorbing applications due to their strong concurrent magnetic-dielectric losses. However, microwave absorbers designed using a single core-shell nanostructure may not attain the desired bandwidth of absorption. Herein, we introduce core-shell nanocomposites of (100-x)NiO/(x)$BiFeO_3$ (x = 0, 25, 50, 75, & 100), prepared by a facile two-step sol-gel wet-chemical method for high-efficiency absorbing applications. Measurements of microwave absorption performance show that the core-shell 50NiO/50$BiFeO_3$ (x = 50) nanocomposite exhibits a remarkable reflection loss of up to −27.3 dB at a matching thickness of 1.9 mm, and the corresponding −10 dB reflection loss bandwidth extends to 6.8 GHz (in X- and Ku-bands). The study suggests that the fabricated core-shell nanocomposite has the potential to be a promising candidate for lightweight microwave absorbing applications. This is evidenced by its showcased improved efficiency, attributed to the synergistic effects of magnetic-dielectric losses, multiple internal reflections, superior impedance matching, and enhanced interfacial polarization at NiO/$BiFeO_3$ interfaces.

1. Introduction

The swift development of wireless communication technology, in the range of microwave (MW) frequencies, has induced adverse environmental effects along with harmful effects on human health [1–3]. The unwanted MW radiation may cause the problems of electromagnetic interference (EMI) and electromagnetic compatibility (EMC) in electronic circuits, which can negatively impact the performance of electronic devices [4,5]. Thus, the development of efficient microwave absorbing materials (MAMs) to absorb harmful electromagnetic (EM) radiation is a critical step to serve humanity [6,7]. Furthermore, MAM can be utilized as radar-absorbing material (RAM) in advanced military weapon systems to achieve stealth capabilities. The MAMs are designed to dissipate the absorbed MW energy in the form of heat, thereby reducing the reflected energy. In the pursuit of a light-weight, cost-effective, strong and broadband MAMs, the researchers have explored a wide variety of materials ranging from nanoscale ferrites to carbon-based allotropes [8–10]. MWs store energy in both electric and magnetic fields; thus, the MAMs with concurrent and synergistic magnetic and dielectric losses can meet the requirements of modern technology.

With advancements in nanomaterials fabrication technology, recent studies successfully explored the unique nanostructures such as yolk-shell CoNi@Air@C/SiO_2@Polypyrrole (PPy) [11], CoNi@void@C/CoNi@void@C@MoS_2 [12], and CoNi@void@C/FeNi@void@C [13] magnetic multicomponent nanocomposites (MCNCs) and mixed-dimensional carbon foam (CF)/carbon nanotubes (CNTs)@Fe_3C@Fe_3O_4 framework structures [14] in potential MW absorbing applications. In addition, the core–shell $CoFe_2O_4$@mesoporous carbon hollow spheres (MCHS) [15], multicomponent hollow carbon spheres@MoS_xSe_{2-x} (x = 0.2, 0.6, and 1.0) [16], Co@nitrogen-doped carbon/Ni (Co@NC/Ni) [17], hollow

* Corresponding author.
E-mail address: sandeep.kumar@bcas.du.ac.in (S. Kumar).

https://doi.org/10.1016/j.ceramint.2024.01.074
Received 23 September 2023; Received in revised form 4 January 2024; Accepted 5 January 2024
Available online 6 January 2024