Materials Letters 253 (2019) 222–225

Contents lists available at ScienceDirect

Materials Letters

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

Swift heavy-ions irradiated nano-magnetite/exfoliated-nanographite/polymethylmethacrylate nanocomposites with excellent microwave-absorption performance

Prachi Yadav [a], Sunita Rattan [a,*], Ambuj Tripathi [b], Sandeep Kumar [c,d]

[a] Amity Institute of Applied Sciences, Amity University, Noida, Uttar Pradesh 201303, India
[b] Inter-University Accelerator Centre (IUAC), Aruna Asaf Ali Marg, New Delhi 110067, India
[c] Magnetics and Advanced Ceramics Lab, Department of Physics, Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110016, India
[d] Department of Physics, Bhaskaracharya College of Applied Sciences, University of Delhi, Delhi 110075, India

ARTICLE INFO

Article history:
Received 28 May 2019
Received in revised form 12 June 2019
Accepted 15 June 2019
Available online 17 June 2019

Keywords:
Polymer nanocomposites
Swift heavy-ion irradiation
Complex permeability
Complex permittivity
Reflection loss

ABSTRACT

In this work, a new method (swift heavy-ion (SHI) irradiation) has been adopted to develop the light-weight nano-magnetite/exfoliated-nanographite/polymethylmethacrylate (Fe_3O_4/NG/PMMA) nanocomposites with strong and broadband MW absorbing characteristics. The effects of SHI [C^{6+}(80 MeV) and O^{7+}(100 MeV)] irradiation on MW-absorbing properties of Fe_3O_4/NG/PMMA nanocomposites were investigated in 2–18 GHz frequency range. Irradiated nanocomposites demonstrated better homogenization of nanofillers, lower saturation magnetization, higher coercivity, stronger MW-absorption and higher effective bandwidth of absorption. Nanocomposites irradiated with O^{7+}(100 MeV) ions at fluence of 1×10^{12} ions/cm^2 exhibited a minimum reflection loss (R_{Lmin}) of -32.4 dB (99.94% MW-absorption) and broad bandwidth (for $R_L \leq -10$ dB) of ~6.8 GHz.

1. Introduction

The extensive use of microwaves (MWs), both in civilian and military applications, has generated the serious problems of MW pollution and electromagnetic interference (EMI) [1,2]. MW-absorbing materials have received tremendous attention because of their ability in curbing unwanted MW radiation and shielding against EMI. Moreover, MW-absorbers are critical for military applications in reducing radar signatures [3–7]. The low-cost light-weight polymer nanocomposites (NCs) with strong and broadband absorptions are in great demand for high-performance MW-absorbing applications. Nanoscale magnetite (Fe_3O_4) is an excellent filler in polymer matrices owing to its strong magnetic properties [1–5]. The low-cost, low-density, easy-processing, large dielectric loss, and high mechanical strength of exfoliated nanographite (NG) makes it a promising dielectric MW-absorber [1,8]. The concurrent dielectric and magnetic losses through compositing of Fe_3O_4 nanoparticles and NGs in polymethylmethacrylate (PMMA) matrix can produce excellent MW-absorption results [1,8]. It is hard to achieve strong and wideband MW-absorption performances simultaneously due to impoverished solubility of nanofillers in polymer matrices and poor impedance matching of NCs.

In literature, swift heavy-ion (SHI) irradiation technique has been successfully implemented in modification of material properties (i.e., dielectric, magnetic, sensing etc.) by inducing controlled defects, stress and structural disorders [9,10]. In this work, we report influences of SHI irradiation on MW-absorbing properties of melt-blended Fe_3O_4/NG/PMMA NCs for the first time. This unique and effective technique (SHI irradiation) attains strong (-32.4 dB) and broadband (~6.8 GHz) MW-absorption in irradiated NCs.

2. Material and methods

Exfoliated NGs were prepared through a three-step process as described in literature [8]. Fe_3O_4 nanoparticles were processed through a solution combustion method using $Fe(NO_3)_3{\cdot}9H_2O$ as starting raw material [11]. After dissolving $Fe(NO_3)_3$ in de-ionized water, citric acid was added to solution for preventing precipitation of metal-cations. Glycine was added to precursor solution, after pH neutralization, to fuel the reaction. Solution was then heated at ~180 °C under magnetic stirring to produce a brownish and fluffy product. As-obtained product was calcined at ~600 °C for 2 h to acquire Fe_3O_4 phase. To prepare Fe_3O_4/NG/

* Corresponding author.
E-mail address: srattan@amity.edu (S. Rattan).

https://doi.org/10.1016/j.matlet.2019.06.053
0167-577X/© 2019 Published by Elsevier B.V.

Prachi yadav