Proceedings of the 8th World Congress on New Technologies (NewTech'22)
Prague, Czech Republic– August 03-05, 2022
Paper No. ICNFA 125
DOI: 10.11159/icnfa22.125

Influence of Magnetite Synthesis Method on the Structure, Morphology and Dielectric Properties

Adrian Radon[1, 2], Rafal Babilas[1]
[1]Silesian University of Technology
Konarskiego 18A St., 44-100, Gliwice, Poland
adrian.radon@polsl.pl; rafal.babilas@polsl.pl
[2]Łukasiewicz Research Network - Institute of Non-Ferrous Metals
Sowinskiego 5 St., 44-100, Gliwice, Poland

Extended Abstract

Due to their structure, ferrite nanoparticles are characterised by unusual properties that are still the subject of many scientific studies [1], [2]. Although magnetite itself has been the basis of research for many years, its properties still intrigue a large group of scientists in recent years. Above that, magnetite nanoparticles (NPs) are widely tested in various applications, including drug delivery systems and catalysis. This broad spectrum of applicability is related to their unique properties, such as biocompatibility and reactive surface [3]. In addition, ferrite nanoparticles are widely studied and tested as nanostructured magneto-dielectric antenna substrates and as electromagnetic interference (EMI) shielding materials. Understanding the electron's behaviour in inorganic materials in a wide range of frequencies and temperatures is one of the leading research issues, especially in electronic, optoelectronic and energy storage applications. Moreover, these properties can be changed by the structure, size, shape and chemical composition modifications. For example, the influence of Fe_3O_4 nanoparticles' shape on their dielectric and electromagnetic EMI shielding properties has been described in the literature for spherical and rod-shaped nanoparticles (nanorods) [4].

Accordingly, dielectric and electrical conduction mechanisms were studied and analysed in the context of the magnetite nanoparticle synthesis methods. It is well-known that the synthesis method can allow us to synthesise nanoparticles with various shapes, controlled agglomeration degrees, and surfaces modified by organic compounds, polymers, or even through other inorganic materials (core-shell structures). Herein, the changes in the electrons' behaviours were studied in the context of the structure modification through the heat treatment, surface functionalisation and magnetite oxidation under co-precipitation. While for the commonly used polycrystalline ferrites, magnetodielectric properties can be easily modified through the grains and grain boundaries modification, in the case of the nanoparticles, the changes in their surface play a crucial role in the electron transport. Interestingly, a properly chosen magnetite synthesis method can allow obtaining samples characterised by ultralow (about 10^{-5} S/cm) or ultrahigh (about 10^{-1} S/cm) electrical conductivity and modulated dielectric losses (low for the applicability in the supercapacitors and high for the EMI shielding materials).

Acknowledgements: We acknowledge the Polish Ministry of Science and Higher Education for supporting this research by Diamond Grant VII [grant number 0220/DIA/2018/470].

References

[1] L. Y. Novoselova, "Nanoscale magnetite: New synthesis approach, structure and properties," *Appl. Surf. Sci.*, 2021, 148275.
[2] X. Batlle, C. Moya, M. Escoda-Torroella, Ò. Iglesias, A. Fraile Rodríguez, and A. Labarta, “Magnetic nanoparticles: From the nanostructure to the physical properties,” *J. Magn. Magn. Mater.*, 2022, 168594.
[3] A. Ali, T. Shah, R. Ullah, P. Zhou, M. Guo, M. Ovais, Z. Tan and Y. Rui, "Review on Recent Progress in Magnetic Nanoparticles: Synthesis, Characterisation, and Diverse Applications," *Frontiers in Chemistry*. 2021, 629054
[4] M. Jazirehpour and S. A. Seyyed Ebrahimi, "Effect of aspect ratio on dielectric, magnetic, percolative and microwave absorption properties of magnetite nanoparticles," *J. Alloys Compd.*, 2015, pp. 188–196.