Mikrobangų ekranavimo priklausomybė nuo temperatūros fosfatais surištose $CoFe_2O_4$-$xBaTiO_3$ keramikose

Microwave shielding efficiency as a function of temperature for phosphate-bonded $CoFe_2O_4$-$xBaTiO_3$ multiferroic composite ceramics

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Development of the materials with high electromagnetic (EM) shielding ability is extremely necessary due to the existence of EM interference problems that could seriously affect the normal operation of electronic components.

For planar geometry, two microwave EM shielding cases are noted. The first mode is the non-reflective planar surface with a mirror behind, the so-called Salisbury screen geometry. While the second one is free-standing layers of the radar absorbing material, which would desirably provide as low transmission as possible in combination with high absorption. Both distinguished cases have already found a huge number of potential applications including antennas, radars, anechoic chambers, cloaking, imaging, etc. [1].

However, despite the significant efforts and valuable results in this direction, most of the work is devoted to room temperature region. While the temperature effect on EM shielding has been studied extremely rarely [2], although slight temperature changes might dramatically affect the electromagnetic response of the composite.

Primarily, carbon materials and their structures [3] are known as remarkable candidates for EM shielding applications, however, additionally, this list has been expanded by phosphate bonded inorganic materials [4], which also turned out to be prospective options for this purpose. Moreover, on the one hand, the hexaferrites or spinels ($CoFe_2O_4$, or $NiFe_2O_4$) addition is interesting due to possible synergism between different phases. On the other hand, ferroelectrics (like $BaTiO_3$) have high dielectric permittivity and therefore are prospective for EM shielding in microwaves.

Current research is devoted to numerical and experimental studying of the effect of the temperature and composition on EM shielding efficiency for the case of $CoFe_2O_4$-$BaTiO_3$-based phosphate-bonded unsintered ceramics. A series of $CoFe_2O_4$–$xBaTiO_3$ (x=0.4–0.9) composite ceramics will be prepared and studied both in 'Salisbury screen' geometry and as a free-standing layer in the frequency range of 25–54 GHz and temperature interval of 120-500 K. For instance, the average shielding efficiency of the free-standing layer (4 mm-thick) at room temperature in free space is presented in Fig. 1. The SE was evaluated using formulas $SE_R = -10log_{10}(1-R)$, $SE_A = -10log_{10}(1-A_{eff})$, and $SE_T = SE_A + SE_R$, where $A_{eff} = (1-R-T)/(1-R)$, R is reflection, T is transmission and A is absorption. The dominant mechanism of SE is absorption. The total shielding efficiency reaches 30 dB for the CFO-0.9BTO sample layer. Therefore the composite system is promising for many applications.

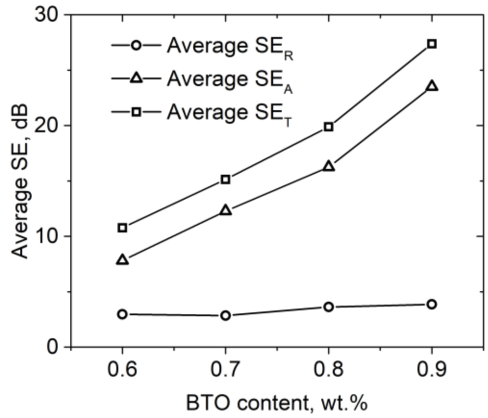

Fig. 1. Average reflection and absorption losses and total shielding efficiency over the 25-54 GHz frequencies (Ka and V bands) at room temperature

Besides, the sensitivity of the electromagnetic response of multiferroic composite ceramics in microwaves to small temperature variations (about 5–10 K) will be demonstrated and discussed.

Keywords: phosphate-bonded ceramics, barium titanate, cobalt ferrite, EMI shielding efficiency, microwaves.

Literature

[1] R. Panwar, J.R. Lee, Functional composites and structures **1(3)**, 032001 (2019).
[2] Z. Barani, et al, Advanced Electronic Materials, **6(11)**, 2000520 (2020).
[3] L. Vovchenko, et al, Applied Nanoscience, **12(4)**, 1037-1049 (2022).
[4] A. Plyushch, et al, Applied Physics Letters, **12(4)**, 1037-1049 (2022).