Mikrobangų spinduliuotės plačiajuosčio absorberio tobulinimas

The development of carbon nanotubes based broadband absorber of microwave radiation

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In present work, the carbon nanotube-based composites are considered for their potential use as the broadband radar absorbers in Ka-band (26-37GHz). The considered composites have a filler concentration above the percolation threshold, thus they possess a macroscopic conductivity, as well as the pronounced dispersion of the dielectric permittivity [1].

When considering a normally incident electromagnetic wave on a plane parallel layer of composite located on the metallic substrate, one may write the reflection amplitude as follows[2-3]:

$$S_{11}(\lambda,\tau,\varepsilon) = \frac{-k_z(\exp[2i\tau k_{2z}]-1)+k_{2z}(1+\exp[2i\tau k_{2z}])}{k_z(1-\exp[2i\tau k_{2z}])+k_{2z}(1+\exp[2i\tau k_{2z}])}, \quad (1)$$

with

$$k_z = \frac{\pi}{\lambda a}\sqrt{4a^2-\lambda^2}, k_{2z} = \frac{\pi}{\lambda a}\sqrt{4\varepsilon a^2-\lambda^2}, \quad (2)$$

where τ is the thickness of the composite, a the width of the waveguide (set to 7.2 mm), $\lambda=c/v$ the wavelength, c the vacuum light velocity, v the frequency, and $\varepsilon=\varepsilon'+\varepsilon''$ the complex (relative) permittivity. From Eq. (1), it is easy to calculate the absorption coefficient as $A=1-S_{11}^2$.

Analysis of Eq. (1) shows that the absorption coefficient, and thus the absorption maxima are strongly dependent on the frequency, thus it is impossible to develop a broadband absorber unless one uses dispersive materials. The easiest way of obtaining the dispersive materials is the use of the conductive inclusions in the composite [3]. Dispersion of the dielectric permittivity allows for the significant broadening of the absorption peak. For a composite on a metallic substrate, the absorption in free space was theoretically predicted to be 97-100% in the entire Ka-band region [4].

The commercially available epoxy resin (ED-22) and multiwall carbon nanotubes were used in the manufacturing process as a matrix and filler respectively.

The microwave measurements were conducted with the use of the scalar network analyzer ELMIKAR2-208R [2]. All the measurements took place in the 7.2×3.4mm waveguide system, and the only considered mode was H_{10}.

Fig. 1 shows the experimental data of absorption coefficient A of the 1.12mm thick composite material with 1.5%wt. filler concentration placed on the metallic substrate inside the waveguide. The predicted absorption in free space are also presented in Fig. 1.

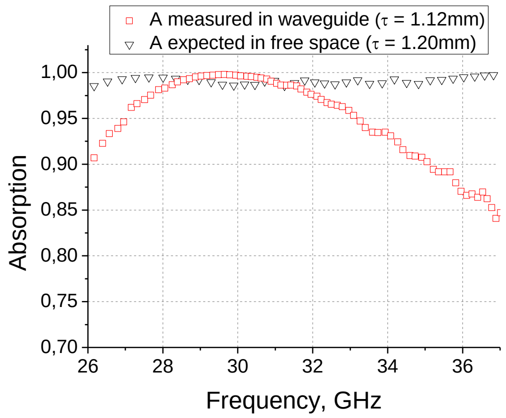

Fig. 1. Measured A absorption coefficient for 1.12 mm-thick composite with 1.5%wt. MWCNTs inside the waveguide and expected A absorption for 1.20 mm-thick composite in free space

As it can be seen from Fig. 1, the above-mentioned composites when studied in the waveguide, have their absorption coefficient in the range 84-100% for the entire Ka-band region.

These results show, that the carbon-nanotube-based composites with 1.5%wt filler concentration may be potentially used as the effective microwave absorbers in the 26-37GHz frequency range.

Keywords: Multiwall carbon nanotubes, dispersive materials, electromagnetic response of composites in microwave.

References

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