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Experimental Studies of the Reverse Load-Unloading Effect on the Mechanical, Linear and Nonlinear Elastic Properties of n-AMg6/C60 Nanocomposite

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Abstract : The paper presents the results of an experimental study of the effect of reverse mechanical load-unloading on the mechanical, linear, and nonlinear elastic properties of n-AMg6/C60 nanocomposite. Samples for experimental studies of n-AMg6/C60 nanocomposite were obtained by grinding AMg6 polycrystalline alloy in a planetary mill with 0.3 wt % of C60 fullerite in an argon atmosphere. The resulting product consisted of 200-500-micron agglomerates of nanoparticles. X-ray coherent scattering (CSL) method has shown that the average nanoparticle size is 40-60 nm. The resulting preform was extruded at high temperature. Modifications of C60 fullerite interferes the process of recrystallization at grain boundaries. In the samples of n-AMg6/C60 nanocomposite, the load curve is measured: the dependence of the mechanical stress σ on the strain of the sample ε under its multi-cycle load-unloading process till its destruction. The hysteresis dependence $\sigma = \sigma(\varepsilon)$ was observed, and insignificant residual strain $\varepsilon < 0.005$ were recorded. At $\sigma \approx 500$ MPa and $\varepsilon \approx 0.025$, the sample was destroyed. The destruction of the sample was fragile. Microhardness was measured before and after destruction of the sample. It was found that the loading-unloading process led to an increase in its microhardness. The effect of the reversible mechanical stress on the linear and nonlinear elastic properties of the n-AMg6/C60 nanocomposite was studied experimentally by ultrasonic method on the automated complex Ritec RAM-5000 SNAP SYSTEM. In the n-AMg6/C60 nanocomposite, the velocities of the longitudinal and shear bulk waves were measured with the pulse method, and all the second-order elasticity coefficients and their dependence on the magnitude of the reversible mechanical stress applied to the sample were calculated. Studies of nonlinear elastic properties of the n-AMg6/C60 nanocomposite at reversible load-unloading of the sample were carried out with the spectral method. At arbitrary values of the strain of the sample (up to its breakage), the dependence of the amplitude of the second longitudinal acoustic harmonic at a frequency of $2f = 10$MHz on the amplitude of the first harmonic at a frequency $f = 5$MHz of the acoustic wave is measured. Based on the results of these measurements, the values of the nonlinear acoustic parameter in the n-AMg6/C60 nanocomposite sample at different mechanical stress were determined. The obtained results can be used in solid-state physics, materials science, for development of new techniques for nondestructive testing of structural materials using methods of nonlinear acoustic diagnostics. This study was supported by the Russian Science Foundation (project №14-22-00042).

Keywords : nanocomposite, generation of acoustic harmonics, nonlinear acoustic parameter, hysteresis
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