Inelastic Internal Friction, Adsorption Properties of Nanocomposites of Multiwalled Carbon Nanotubes and Polyvinyl Chloride, Polyethylene, Porous Polystyrene

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INTRODUCTION

The annealing of the structure defects in nanocomposite bends out of shape the type of internal friction (IF) temperature spectrum $Q^{-1}(T)$. The growth of IF maximum height Q_M^{-1} testifies the growth of the structural defects concentration, and the broadening of internal friction maximum ΔQ_M^{-1} here represents the relaxation process of structural defects new types in nanocomposite. Elastic deformation ε_E takes a place "instantly". Anelastic deformation ε_{AE} is conditioned motion of dislocations [1,2].

MATERIALS AND METHODS

Ultrasound (US) pulse-phase method for determining the velocities of elastic waves using USMV-LETI, modernized USMV-KNU and computerized "KERN-4" in fig. 1 with frequencies $f_\parallel \approx 1$ MHz and $f_\perp \approx 0{,}7$ MHz [3,4] .

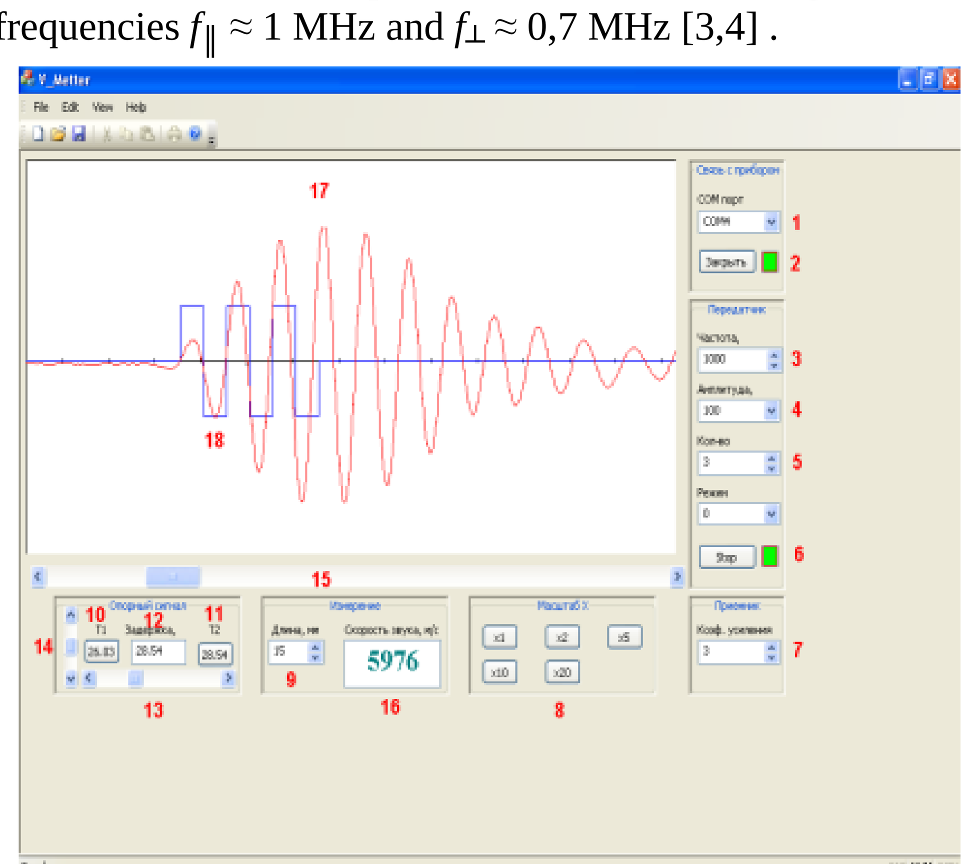


Fig. 1. Illustration of the window for processing data of elastic waves velocity $V_\parallel$ measurements in SiO_2/Si plate by echo-impulse method at frequency $f_\parallel \approx 1$ MHz and the presence of computer device KERN-4

RESULTS AND DISCUSSION

The quasitransversal US velocity $V_\perp = 756 \pm 30$ m/sec, shear modulus $G = \rho V_\perp^2 = 561$ Mpa, the quasilongitudinal US velocity $V_\parallel = 2365 \pm 30$ m/sec, dynamical elastic module $E = \rho V_\parallel^2 = 5{,}486$ GPa, Puasson coefficient $\mu = 0{,}44$ nanocomposite polyethylene with low density high pressure $(C_2H_4)_n$ + 0,2% multiwalled carbon nanotubes (MWCNT) were determined from the oscillogram [1] in fig. 2.

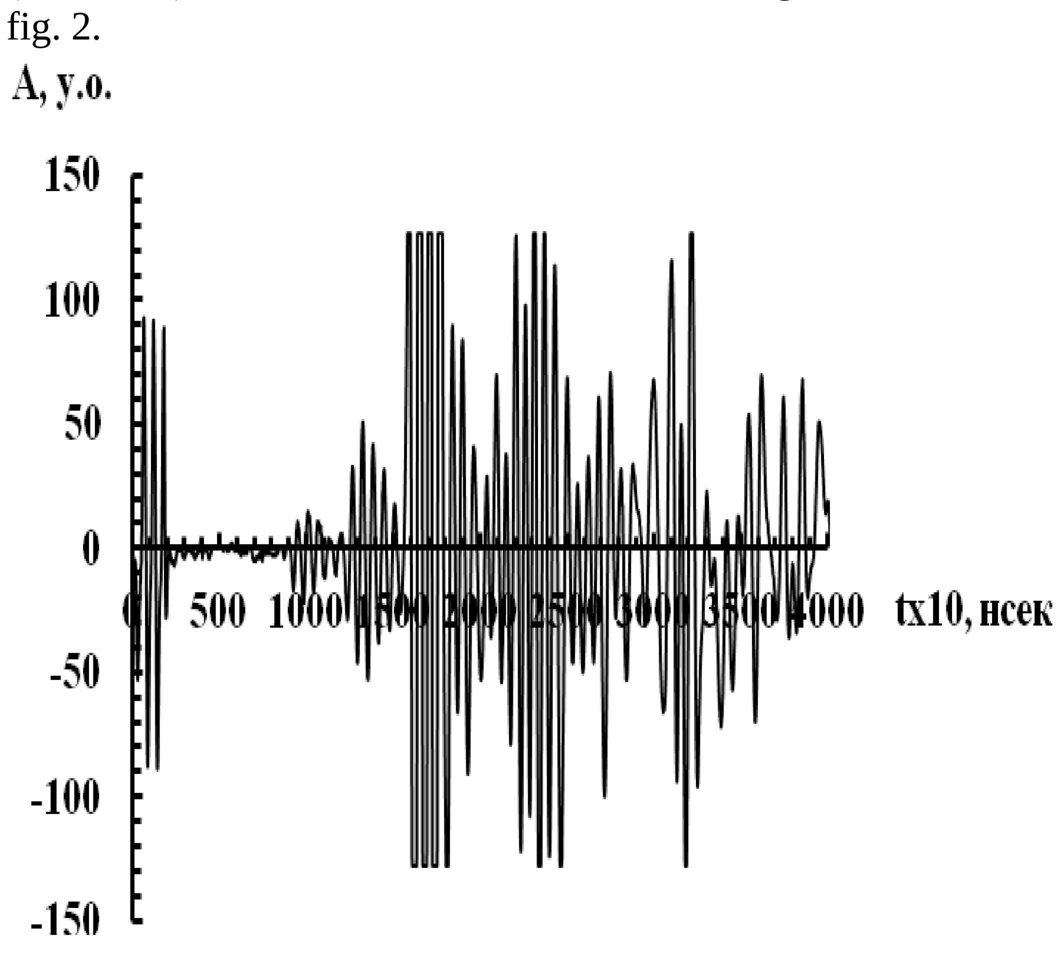


Fig. 2. The data plot illustration of the quasitransverse elastic waves velocity $V_\perp = 756$ m/s in nanocomposite of low-density high pressure polyethylene $(C_2H_4)n$ + 0,2% MWCNT by impulse-phase ultrasonic method at frequency $f_\perp = 0{,}7$ MHz. The logarithmic decrement ultrasound attenuation

$$\delta = \ln\left(\frac{A_{n+1}}{A_n}\right) = \ln\left(\frac{111}{64}\right) \approx (5{,}51 \pm 0{,}1) \times 10^{-1}$$

The modified polymer real network has the large number of the different defects, those do not participate in the transfer of the strains σ in the network, and, therefore, do not contribute to its elastic modulus G, E. It's showed, that anelastic Q^{-1} and elastic E characteristics are essentially depended from morphology of surface layer. The determination method of the distributing function of microcracks orientation is developed from data of the azimuthal measurings of elastic waves velocities.

With the purpose of determination of temperature position of relaxation of the elastic modulus $\Delta G/G_o$ simultaneously with the internal friction $Q^{-1} = \delta/\pi$, where δ - the logarithmic decrement ultrasound attenuation, measuring temperature dependence of $G = \rho V_\perp^2$ was measured. The large absolute value of the shear modulus G(C), the elastic modulus E(C) of nanocomposite polyvinyl chloride $(C_2H_3Cl)_n$ + and methylene dark blue colouring agent (CH_2) indicate about the significant interaction with maximum at $C_0 \approx 5\%$.

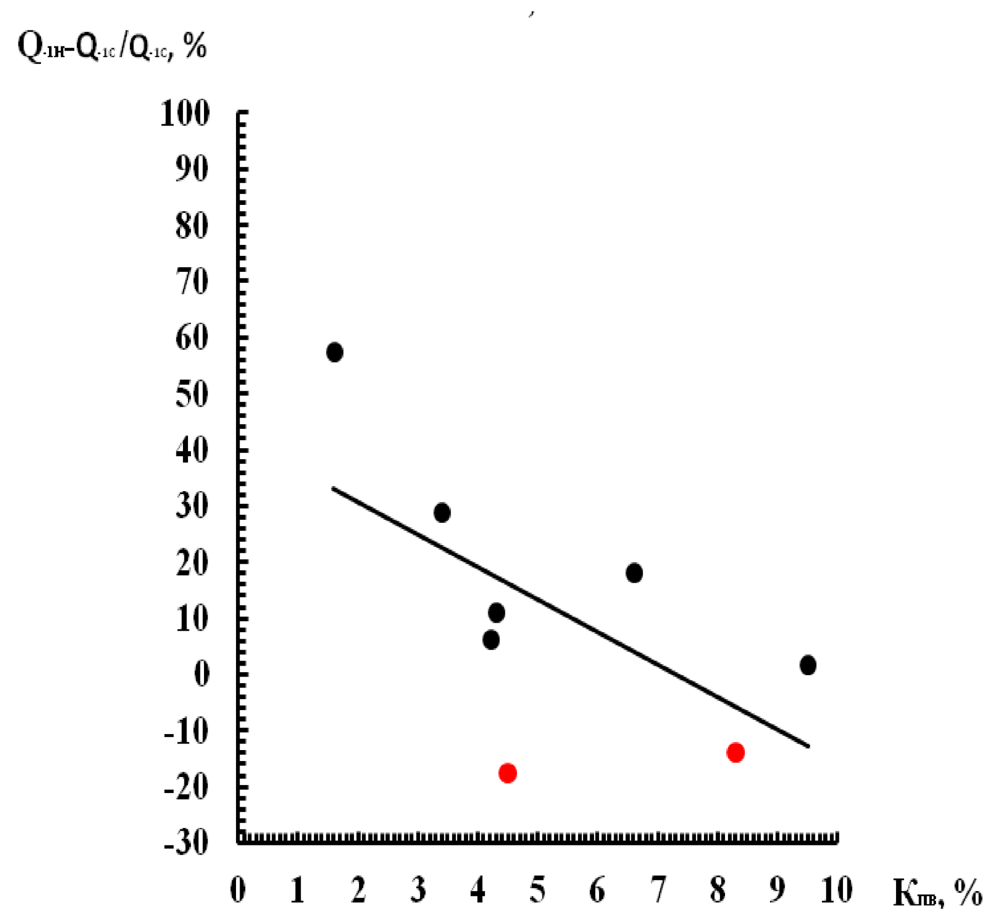


Fig. 3. Correlation dependence of the internal friction defect $\Delta Q^{-1}/Q^{-1}$ in SiO_2 from the open porosity coefficient $K_{PO} = V_{PO}/V$

$$E^*/E = \delta = \pi Q^{-1} = \alpha\lambda = \alpha V/f, \quad (1)$$

where α is US attenuation coefficient, λ is the US wavelength, f is the US frequency. The logarithmic decrement of US attenuation δ oscillations with the amplitude $A = A_o e^{-\delta x}$ is equal to:

$$\delta = \ln(A_{n+1}/A_n), \quad (2)$$

The shear modulus $G = \rho V_\perp^2$, where ρ is the specific density, $V_\perp$ is the quasitransversal US velocity.
The Poisson coefficient μ is equal to ratio of relative transversal $\varepsilon_\perp$ compression to relative longitudinal lengthening ε_l and equal [1]:

$$\mu = -\varepsilon_\perp/\varepsilon_l = -(\Delta X/X)/(\Delta l/l) = -(\Delta X/\Delta l)(l/X), \quad (3)$$

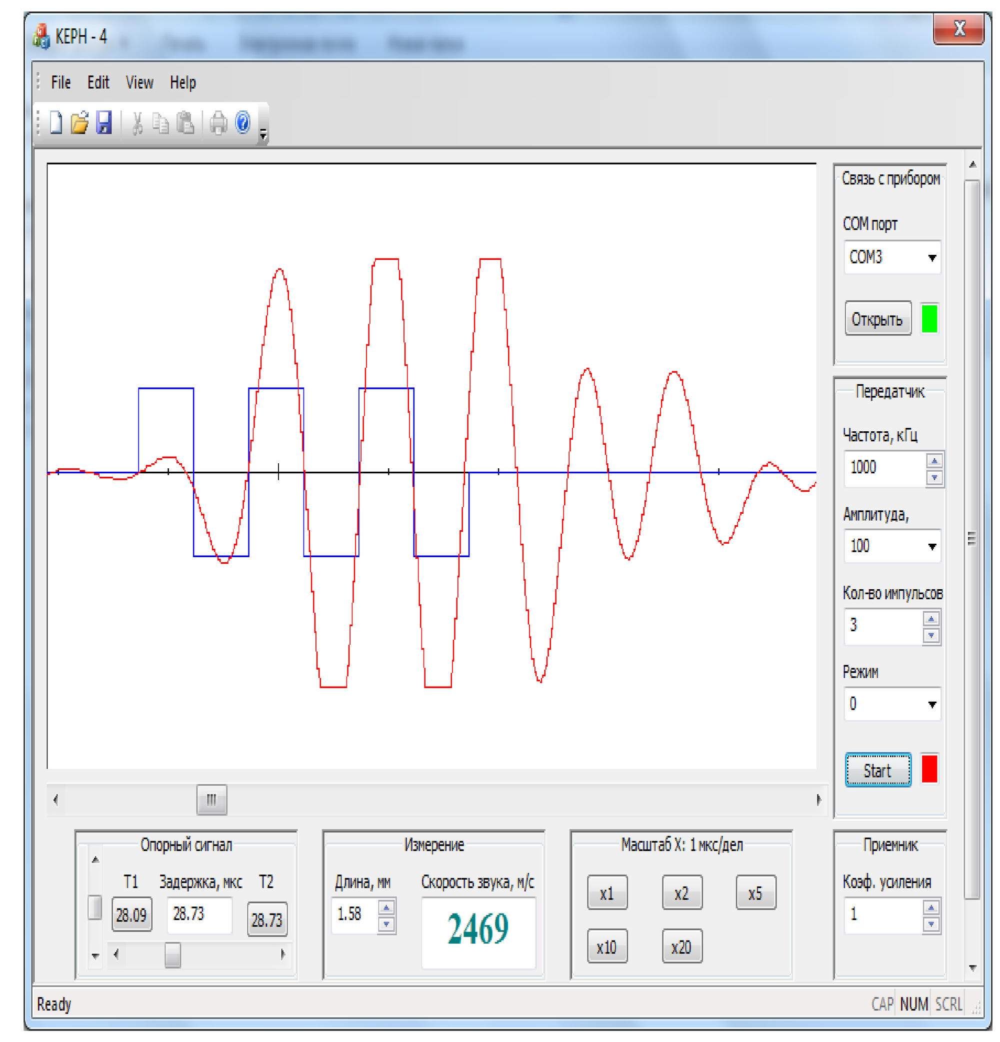
$$\mu = (1/2V_{2_l} - V_{2\perp})/(V_{2_l} - V_{2\perp}). \quad (4)$$

Therefore, the elastic waves, that elementary oscillators excite, can't carry the energy. There are stand waves. One oscillator produce 3 waves: 1 longitudinal and 2 transversal. Debye temperature θ_D was determined after the formula [2]:

$$\theta_D = h/k_B(9N_A\rho/4\pi A)^{1/3}/(1/V_{3_l} + 2/V_{3\perp})^{1/3}, \quad (5)$$

where k_B - Boltzmann constant, h - Plank constant, N_A - Avogadro number, A - middle gram-molecular mass, ρ - density, $V_\parallel$ - longitudinal US velocity, $V_\perp$ - transversal US velocity.

The transversal US velocity $V_\perp = 768 \pm 30$ m/sec, shear module $G = \rho V_\perp^2 = 578$ MPa, the longitudinal US velocity $V_\parallel = 2485 \pm 30$ m/sec, dynamical elastic module $E = \rho V_\parallel^2 = 6{,}057$ GPa, Poisson coefficient $\mu = 0{,}44$ nanocomposite polyethylene with low density high pressure $(C_2H_4)_n$ + 3% MWCNT were determined from the oscillogram in fig. 4.



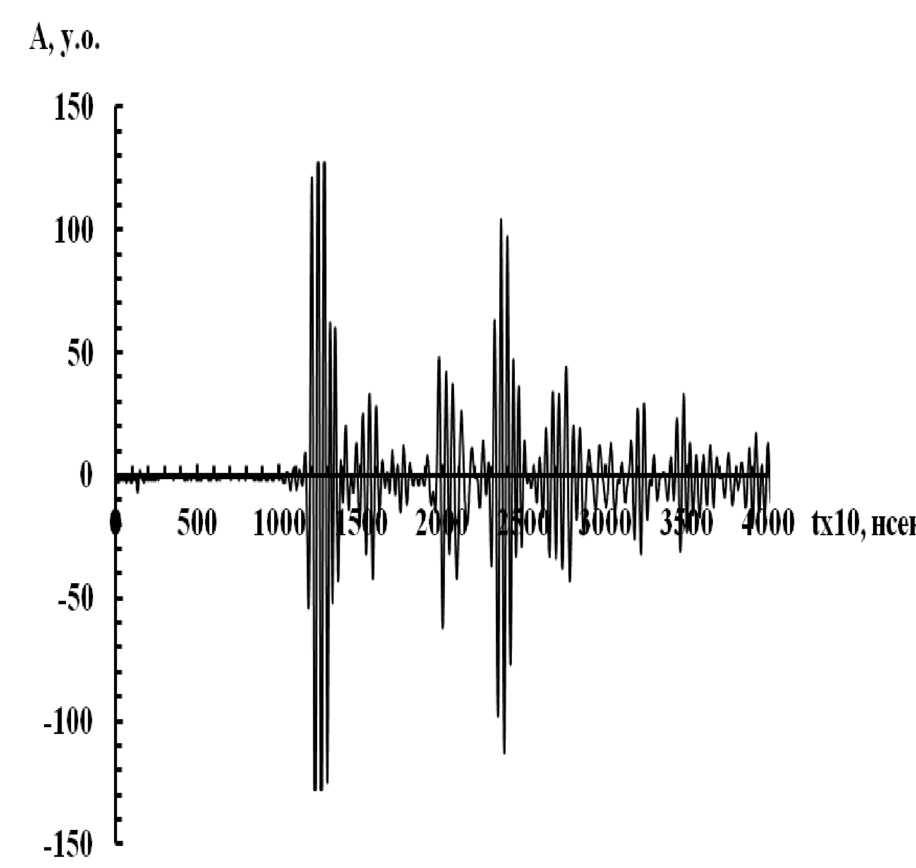


Fig. 4. The illustration of the window for processing data of longitudinal elastic wave velocity measuring $V_\parallel = 2469$ m/sec in nanocomposite polyethylene + 0,7% MWCNT by by impulse-phase ultrasonic method on frequence $f_\perp \approx 1$ MHz.

Logarithmic decrement of US attenuation

$$\delta = \ln\left(\frac{A_{n+1}}{A_n}\right) = \ln\left(\frac{102}{98}\right) \approx (4{,}00 \pm 0{,}1) \times 10^{-2}$$

CONCLUSIONS

1. As the result of the mechanical study the presence of the strong effect between low-density polyethylene $(C_2H_4)_n$, polyvinyl chloride $(C_2H_3Cl)_n$ and multiwalled carbon nanotubes and colouring agents DBSQ was confirmed.
2. The increase of the nano composite crystalline degree at growth of multiwalled carbon nanotubes concentration filling with the nanotubes of matrix results in the decline of content of well-organized phase.
3. The measuring of internal friction background Q^{-1}_0 after different heat treatments gives information about the changing of the fields of the heat tension σ_i after the solution satiation and before.

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