Mechanical Spectroscopy of Nanocomposites of Multiwalled Carbon Nanotubes and Polyamide, Polyethylene, Polyvinyl chloride, Porous Polystyrene

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INTRODUCTION

Acoustic emission (AE) allow to receive the additional information about the process of microcracks [1]. The leading factor of the elastic anisotropy forming is a crystallography orientation and the orientation of grains on the form with the orientation of microcracks, pores [2]. Nondestructive method, which is allow to determine from internal friction difference $\Delta Q^{-1}/Q^{-1}_0$ of elastic vibrations structure defects density N_d and the depth of broken layer h_b, is offered for SiO_2/Si wafer-plates.

EXPERIMENTAL METHODS

Experimental methods were used: metallography optical supervision of microstructure by means of the microscope "LOMO MVT", atomic-force microscopy (AFM) with high resolution. Ultrasonic (US) pulse-phase method for determining of elastic waves velocities using computerized KERN-4 on fig. 1, device KERN-SG on fig. 2, modernized USMV-KNU and USMV-LETI measurement equipments, US invariant-polarization method for determining effective acoustic μ_{il} and elastic constants C_{ijkl} were used [3].

Fig. 1. The window illustration of data treatment of elastic waves velocities measuring by the impulse phase ultrasound method at frequency $f_\perp \approx 0{,}7$ MGz, $f_\parallel \approx 1$ MGz and appearance of measurement equipment KERN-4

US device KERN-SG, computer device KERN-4 measuring of velocities is consist in measuring block and computer with operation system "Windows XP" [4]. The program KERN-4 ensures the management of measured block basic subsystems, the reflection of receiving signal in digital oscilloscope regime, which remember, and the calculation of US velocity V and indication of its size on indicators. The measuring block is consist of generator, force magnifier, management-1 module, management-2 module, receiver, power module. The management block is consist of the generator created pair impulses selection scheme, which follow with clock rate, the standard and measuring impulses forming scheme and synchronization scheme of deflection. The frequency range f = 0,3÷2 MGz. Acoustic emission (AE) equipment technique at the frequency $f_\parallel = 0{,}200 \div 0{,}500$ MHz α = 70 dB for measuring of elastic waves velocities in rock was used.

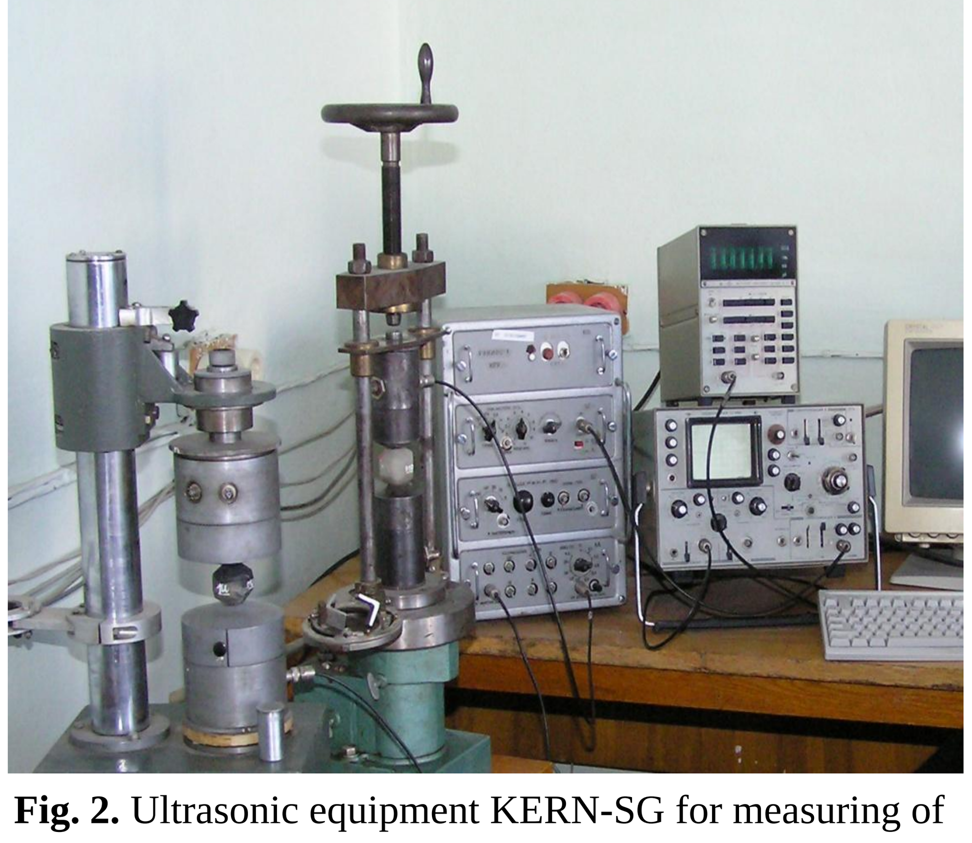

Fig. 2. Ultrasonic equipment KERN-SG for measuring of elastic waves velocities $V_\parallel$, $V_\perp$

RESULTS AND DISCUSSION

The influence of ultrasonic (US) deformation ε_{US} was studed on inelastic internal friction (IF) Q^{-1} and elastic modulus E of nanocomposite polyamide-6 (PA-6) $(NH(CH_2)_5CO)_n$ + 1.7% methylene dye blue squaring (DBSQ) on fig. 3.

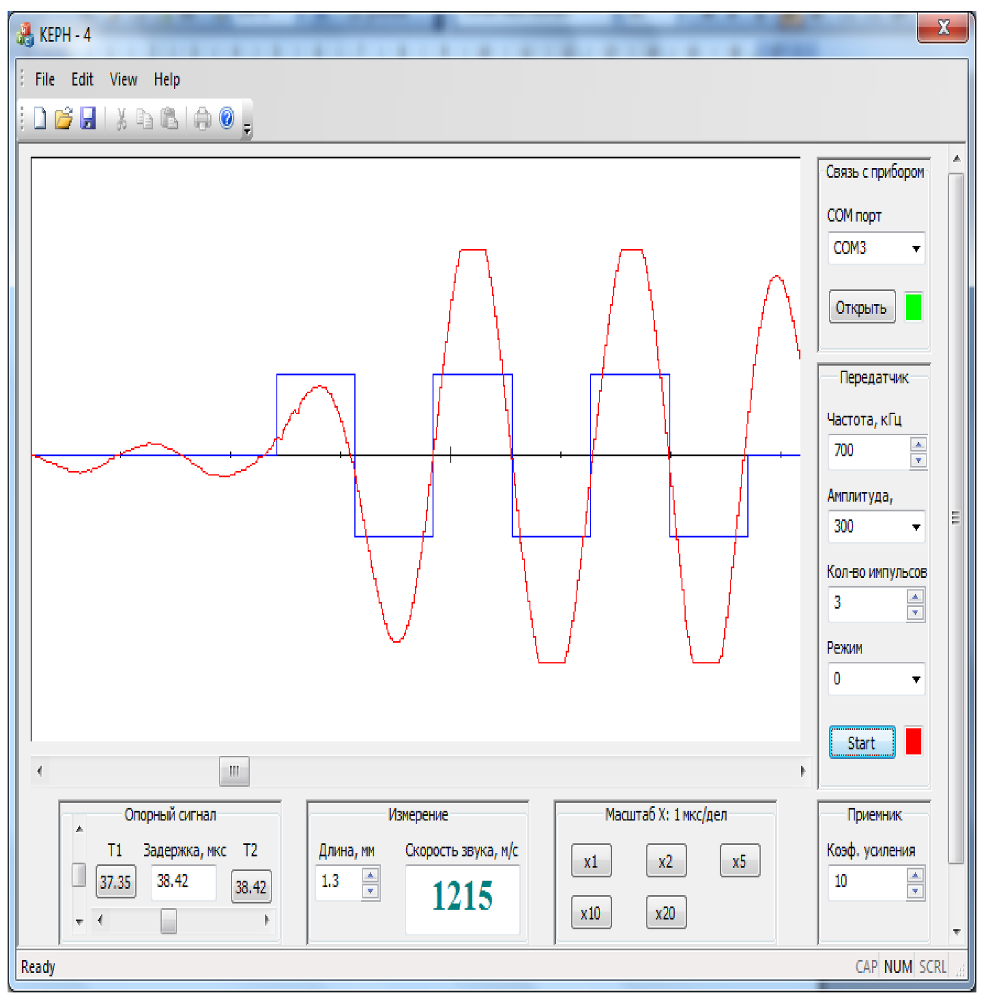

Fig. 3. Illustration of the window for processing data of quasi-transversal elastic wave velocity measuring $V_\perp$ = 1215 m/sec in nanocomposite polyamide-6 (PA-6) $(NH(CH_2)_5CO)_n$ + 1.7% methylene dye blue squaring

Poisson coefficient μ on fig. 4 is equal to ratio of relative transversal $\varepsilon_\perp$ compression to relative longitudinal lengthening $\varepsilon_\parallel$ and equal [1]:

$$\mu = -\varepsilon_\perp/\varepsilon_\parallel = -(\Delta X/X)/(\Delta l/l) = -(\Delta X/\Delta l)(l/X), \qquad (1)$$

$$\mu = (1/2V^2_\parallel - V^2_\perp)/(V^2_\parallel - V^2_\perp). \qquad (2)$$

where $V_\parallel$ is quasilongitudinal US velocity, $V_\perp$ - quasitransversal US velocity.

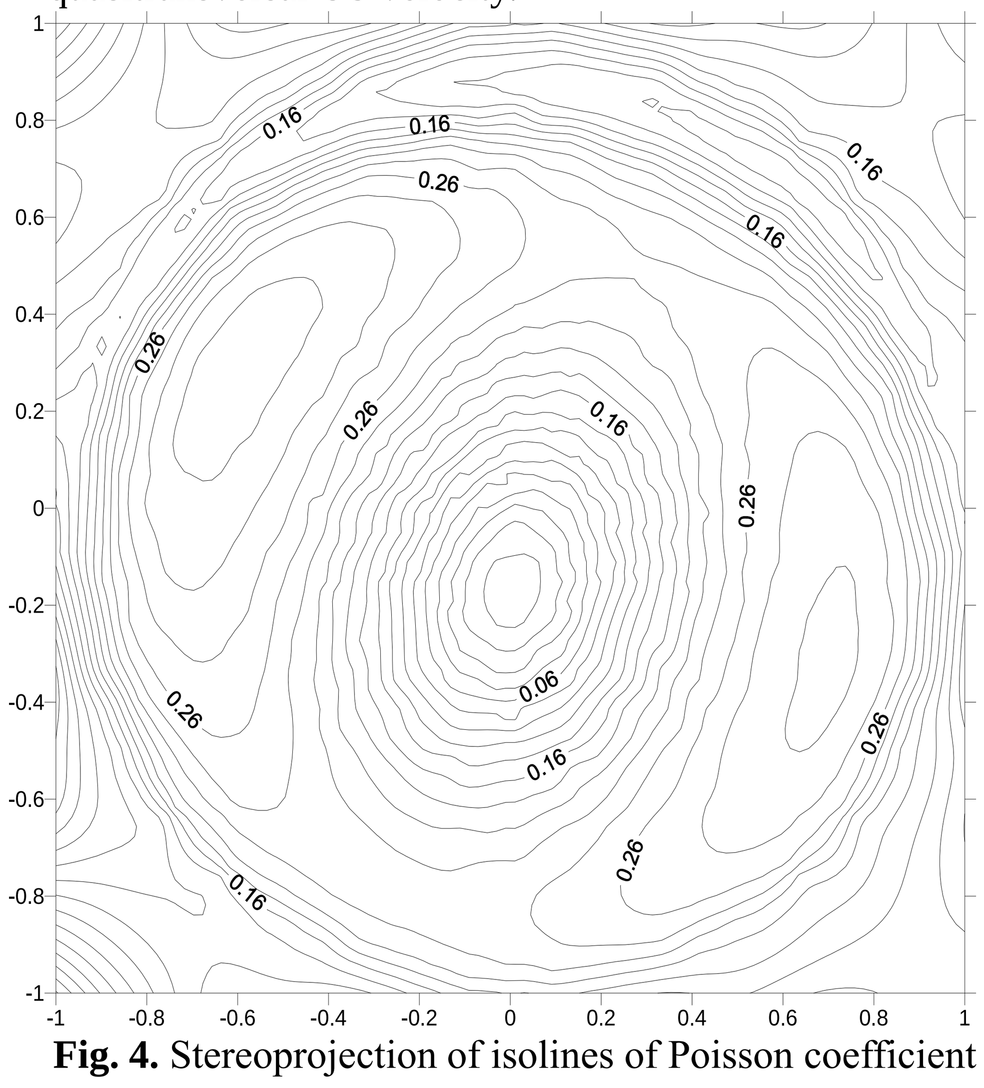

Fig. 4. Stereoprojection of isolines of Poisson coefficient μ SiO_2

The shear modulus $G = \rho V_\perp^2$, where ρ is the specific density, $V_\perp$ is the quasitransversal US velocity. Elastic modulus $E = \rho V_\parallel^2$ is demonstrated on fig. 5.

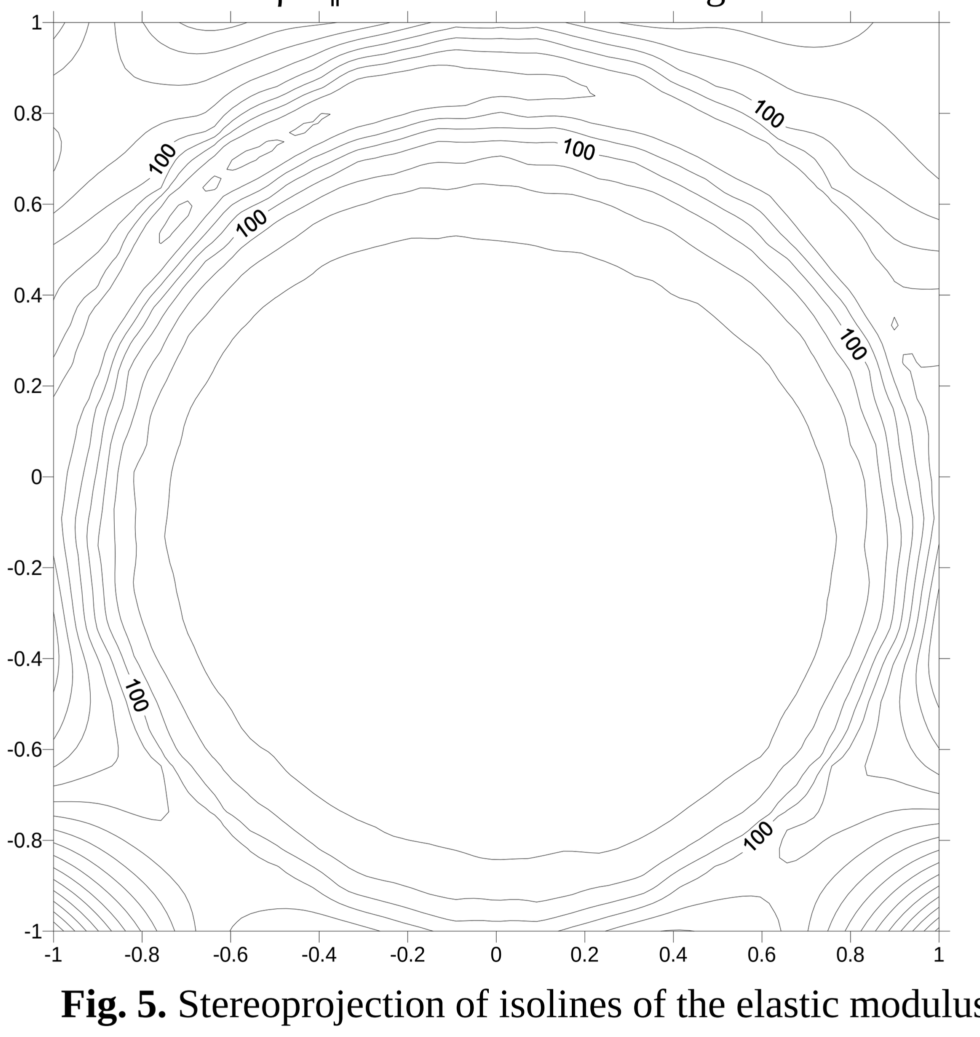

Fig. 5. Stereoprojection of isolines of the elastic modulus E SiO_2

The transversal US velocity $V_\perp$ = 768 ± 30 m/sec, shear module $G = \rho V_\perp^2$ = 578 MPa, the longitudinal US velocity $V_\parallel$ = 2485 ± 30 m/sec, dynamical elastic module $E = \rho V_\parallel^2$ = 6,057 GPa, Poisson coefficient μ = 0,44 nanocomposite polyethylene with low density high pressure $(C_2H_4)_n$ + 3% multiwalled carbon nanotubes (MWCNT) were determined.

Debye model sets the conditions existence stand waves in solid state. The quantum nature of elementary oscillators takes into consideration. The thermal capacity – parameter of the thermodynamic system equilibrium state in Debye model. The determination method of the distributing function of microcracks orientation is developed from data of the azimuthal measuring of elastic waves velocities V. With the purpose of determination of temperature position of relaxation of shear modulus $\Delta G/G_0$ 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. From the oscillogram on fig. 6 the quasi-longitudinal ultrasound velocity $V_{\parallel[001]}$ = 3610 m/sec, elastic modulus $E_{001} = \rho V_{\parallel[001]}^2$ = 32,71 GPa was determined; "fast" quasi-transverse US velocity $V_{\perp[001]}$ = 2630 m/sec, shear modulus $G_{001} = \rho V_{\perp[001]}^2$ = 17.36 GPa, then Debye temperature θ_D = 247.6 K SiO_2.

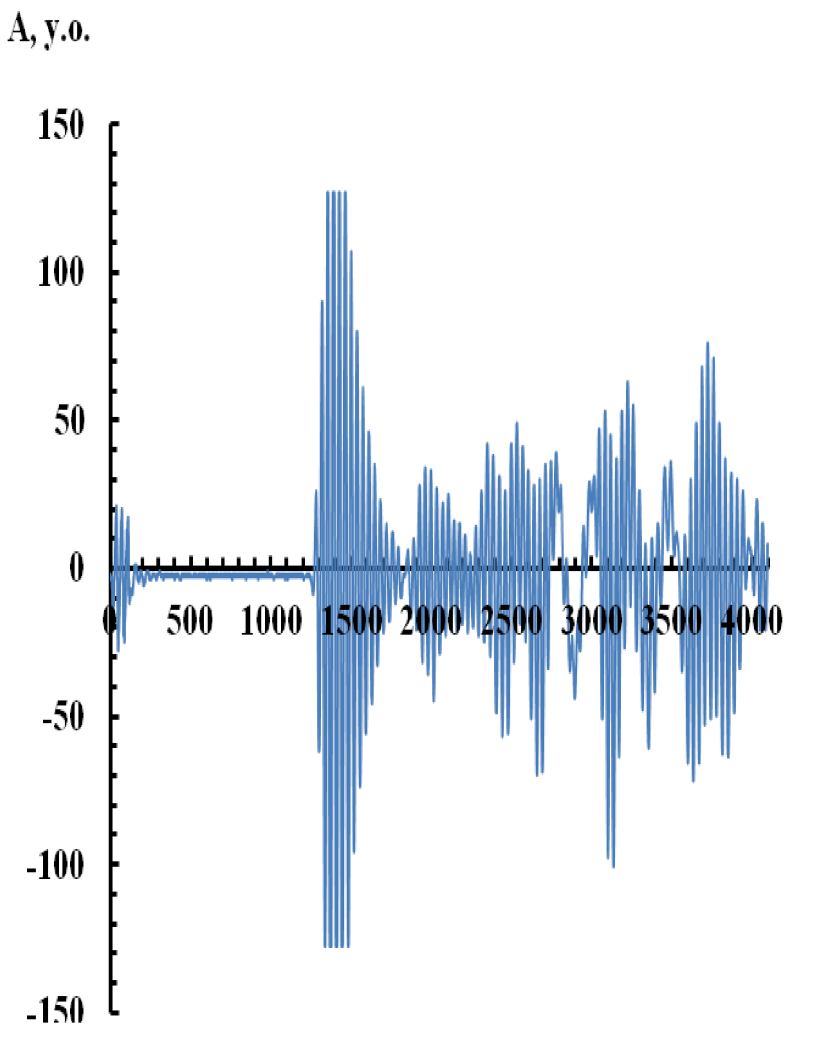

Fig. 6. Oscillogram of impulses with quasi-longitudinal polarization $V_{\parallel[001]}$ in SiO_2

CONCLUSIONS

1. The increase of the nanocomposite crystallinity degree at growth of multiwalled carbon nanotubes concentration filling with the methylene dye blue squaring of matrix results in the decline of content of organized phase.
2. The crater fusion depth Δh at constant intensity I and laser irradiation time t is limited by the local heat-conducting and establishment of "time-equilibrium" distribution of temperature gradients ΔT perpendicular to the crater axis and along it.
3. After laser radiation outcomes of the evaluation of dynamic characteristics interstitial atoms Si_j, vacancy V and O-complexes can be applied for account of a condition of an annealing with the purpose of deriving specific structural defects.

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