IDENTIFICATION OF FEATURES OF DEFECTIVE STRUCTURES IN CONDENSED MATTER MATERIALS AND MONITORING OF THEIR BEHAVIOR WITH THE HELP OF ACOUSTIC WAVES

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Currently one of the most urgent material problems is the problem of studying the structure and properties of solid materials non-destructive way, the definition of the boundaries of their applicability. In the end, the structure determines the condition of the material actually given by a superposition of the physical parameters of the selected volume. Changing these values allows judging the state of the surface layers of solid materials. Effective methods control the state of these layers are AMD-methods [1,2]. The essence of the work was to develop methods for studying the state of the materials and in the assessment of the level of exposure of diffusion processes. Objects of study – ceramic materials and steels of various types.

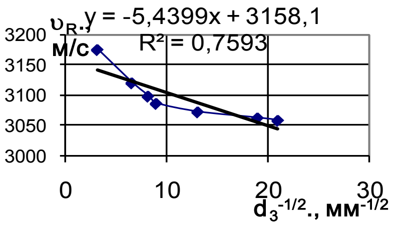
In the mode of acoustic imaging has got the image of the grain structure of the steel and grain size was calculated strength characteristics. After the diffusion treatment was varied grain structure, and hence the values of the parameters of the material. To ensure the objectivity and reliability of the measurements experiments were carried out on model objects with known characteristics-sticks (single crystals, glass, pure metals). Developed and applied a method of calculating parameters of the samples by the values of speed and attenuation coefficients of surface acoustic waves (saw) [3]. It is possible to obtain study materials for the correlation of velocities of surfactants on the parameters of the effect on the material (temperature, time).

The essence of acoustic microscopes is that used as a probing signal as the acoustic waves. Excited by the piezoelectric transducer in the acoustic line plane acoustic wave incident on the surface of a spherical acoustic lenses (curvature radius R), refracted, converted to spherical and focuses at the focal point. In the presence of the object, the acoustic wave (AW) is reflected and contains information about its properties. The piezoelectric transducer is both the source of radiation, and the receiver. He, like all electronic highway works in pulsed mode, the mechanical scanning of the object allows point-by-point to generate an acoustic image. Thus, if the sample is mechanically scanned in the x-y-plane perpendicular to the axis of the acoustic lens (Z) to form an image. The scan mode of the acoustic lens along the Z axis, allows to obtain a set of interference dependences of the output signal V of the piezoelectric transducer from the distance lens-object (V(Z) curves) [4].

Measuring values of ΔZ_N for V(Z)-curves based on geometric representations [5] expected velocity values of surface acoustic waves in the object (υ_R). In the above expressions λ_R is the length of the surface acoustic wave, θ_R – angle Rayleigh, υ_l – the speed of longitudinal waves in an immersion fluid, λ_l – length of longitudinal wave in immersion liquid; *f* is the frequency SAM; *N* is the number of maxima on V(Z)-curve. Value υ_R, and the height of the main maximum of V(Z)-curves are informative characteristics of the object, allowing to calculate its physical-mechanical parameters (e.g. elastic modulus E and G, porosity, density, level of defects, etc.). [6].

In the present work for the analysis of the materials was used as a method of acoustic imaging (in combination with optical images), and method V(Z)-curves to determine the thickness of layers of materials with altered properties, obtained by the diffusion treatment, assess the level of homogeneity and density of the materials. For experiments was chosen such common materials as steel, the surface layers of which were subjected to diffusion effects. In particular, these steel grades 30ХГТ, 40ХН, 40ХНМА, 38ХМЮА, etc.

In Fig. 1-4 presents obtained with AMD-methods based on physical parameters of the surface layers of the grain size of the microstructure of the material.



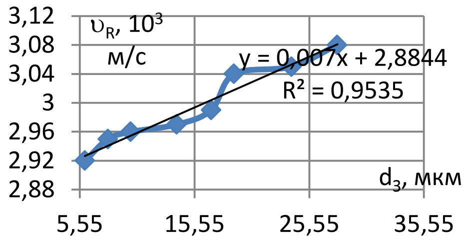
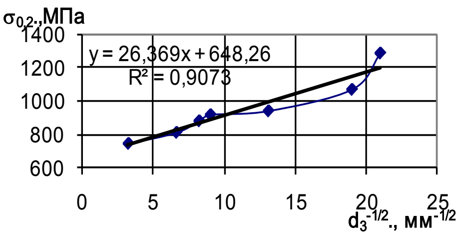


Figure 1- The dependence of the velocities of surface acoustic waves (υ_R) on the grain size of steel 18ХГТ

Figure 2 - The dependence of the rate of SAW in the sample steel (38ХМЮА) on grain size (υ_R determined by the method of V(Z)- curves, as d_3 from acoustic images).

The experiments have evaluated strength characteristics of steels. As the strength criterion was chosen yield strength □□□. Experiments have shown that for the investigated steel (08Х18Н10Т, ст.70, 15Х2НМФА, 06Х14Н8МД2Т etc.) of such strength as □□subject to the law of Hall-Petch: $\sigma_{0,2} = \sigma_0 + kd_3^{-1/2}$, where σ_0 and k are constants for a given material. In this case, the analysis of the dependence □□- d_3 was simplified as made the calculation test results for the two grain size constants σ_0 and k, and their use – define □□for any d_3. The obtained experimental curves (st. 18ХГТ and 38ХМЮА) is shown in Fig.3 and 4. Calculation □□enabled a comparison of the values obtained by the traditional, destructive method and with AMD- methods. Practically, the results coincided within the error of measurements.



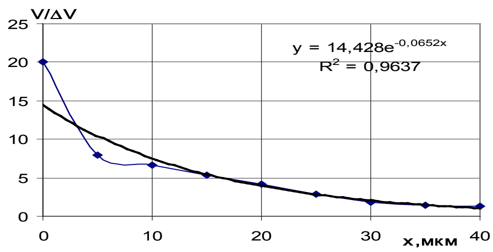


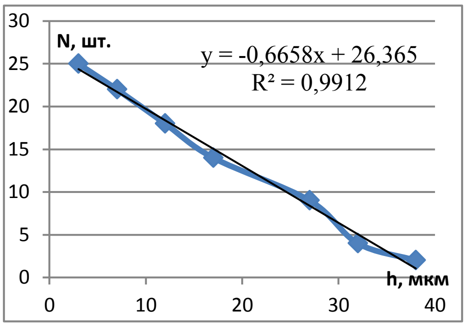
Figure 3 - The dependence of the yield stress on grain size steel 18HGT

Figure 4- The experimental dependence of the inverse absorption coefficient AW (V/ □V%) for steel 18HGT by distance to the center of the cracks.

The next stage of research was devoted to determining the sensitivity of the SAM to the micro-defects in crystalline materials. It is experimentally shown that AMD-methods ensure the detection of micro-defects (with sizes of 0.2-0.4 μm) in the surface layers of a thickness of several hundred micrometers. The change in height of the main peak in the region of the defect size of 200-250 nm and can reach more than 50-70% (Fig.4).

The next stage of research was devoted to the study of corrosion damages with AMD-methods. For research were selected samples of steels subjected to pitting corrosion. It is this type of corrosion is the most dangerous, as its lesions are stress concentrators. This files most often on the material surface pitting is not shown, and in the manufacture of thin sections for studies of the surface layer often not visible. Experiments to assess the possibility of detection and characterization of microdefects of the type of pitting AMD-methods were conducted on samples of steel 08Х21Н6М2Т and 06Х14Н6МД2Т.

According to the series of acoustic images of own structure based on the number (N) of detected pitting depth imaging (Fig.5). These relationships allow us to estimate a non-destructive way as the maximum depth of the microdefects, and the speed of their origin. When scanning the sample surface in the V(Z) along the X axis with a step of 10-20 μm can to get a set of topographical curves representing the information about the coordinates and sizes of pitting. In Fig.6 shows the results of the analysis subsurface layer with SAM, confirming the depth of the pitting 40-60 microns.



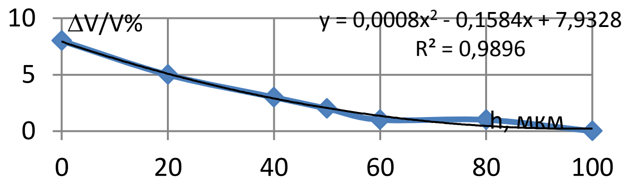
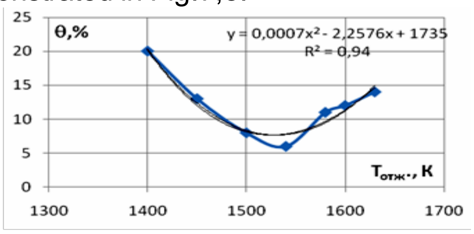


Figure 5 - The dependence of the number of identified pitting on depth imaging

Figure 6 - Changing the level of attenuation of AB in the sample probing depth.

The next stage of experimental studies devoted to the study of piezoceramic obtained by sintering technology. Based on images of the size and shape of the grains has allowed to identify some of the strength characteristics of PZT- ceramics. The method of analysis obtained by using the images of SAM is quite promising, as is compatible with the computer technologies, allowing to express to calculate structure parameters (porosity □, density □, dis and so on.). However, even more informative AMD-methods based on the use of V(Z)-curves [5] are demonstrated in Fig.7,8.



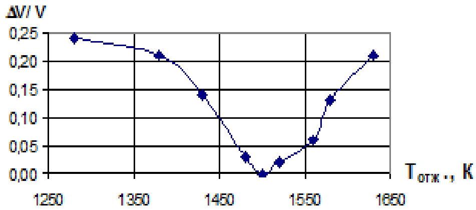


Figure 7- Change curve of porosity depending on the annealing temperature for PZT-22

Figure 8 - The change in the level of absorption in samples of the piezoelectric ceramics, St-02, depending on the annealing temperature.

Based on the method of V(Z) - curves studied according to υ_R (and $\theta_п$) from $T_{отж.}$ Fig.8 shows the results of measurements of acoustic characteristics of the samples (ΔV/V%) for the piezoelectric ceramics and the curve of the porosity of the same samples obtained using a number of comparative methods (Fig.7). All these curves have extremum in the temperature range of annealing 1510-1530 K.

The obtained results demonstrate the effectiveness of the use of AMD-methods for identification of features of defective structures in condensed matter materials and monitoring of their behavior.

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