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PECULIARITIES OF ACOUSTIC PROPERTIES IN ULTRAFINE ZIRCONIUM AT LOW TEMPERATURES

The paper presents the experimental data of the velocity V_l and attenuation coefficient α_l of longitudinal ultrasound (50 MHz frequency) measurements in the temperature range of 78–300 K in polycrystalline coarse-grained and ultrafine zirconium. Ultrafine state with the average size of structural elements (grains, subgrains) ~ 270 nm was achieved using intensive plastic deformation.

The measurements were carried out using impulse bridge method to determine the influence of intensive plastic deformation on the elastic and non-elastic characteristics when the sample is exposed to high-frequency elastic field of small plastic strain amplitude. Generation and detection of ultrasound waves was carried out with the help of lithium niobate piezoelectric transducer. The acoustic contact was achieved due to the use of silicone oil. The measurements were made when being heated in the amplitude free spot of internal friction. Both the velocity and ultrasound attenuation coefficient were measured in parallel.

The experiments proved that in the temperature range of 78–300 K at 50 MHz frequency in ultrafine zirconium, the longitudinal ultrasound velocity is ~ 7% higher than in isotropic coarse-grained zirconium due to the effect of the formatted texture after deformation. The dependence of ultrasound velocity on the ultrasound pointing wave vector direction with regard to the deformation direction, caused by the anisotropy of elastic characteristics in ultrafine zirconium, was found out. The temperature dependence of ultrasound attenuation coefficient shows a wide unplayable internal friction peak at ~ 170 K temperature, caused by the return of the structure at non-equilibrium grain-boundary phase. The comparison of the obtained experimental data after thermal cycling and deformation aging of ultrafine zirconium points to the fact that the intensification of the structural return process after cold hardening is primarily caused by the thermal anisotropy of microstrain.

Keywords: intensive plastic deformation, velocity and attenuation of ultrasound, non-equilibrium grain-boundary phase

Fig. 1. Temperature dependences of the velocity (*а*) and attenuation change (*б*, *в*) longitudinal ultrasound of 50 MHz frequency for zirconium: *1* – for the initial coarse-grained polycrystalline sample of Zr01; *2*, *3* – the propagation of ultrasound is parallel and normal to the direction of deformation in the Zr02 ultrafine sample, respectively

Fig. 2. The temperature dependence of the velocity (*а*) and attenuation change (*б*) longitudinal ultrasound of 50 MHz frequency for the Zr02 ultrafine sample (10-th and 11-th cycle of heating and cooling): *1* – the propagation of ultrasound is normal and *2* – parallel to the direction of deformation

Fig. 3. Temperature dependence of the attenuation change longitudinal ultrasound of 50 MHz frequency for freshly prepared Zr03 ultrafine sample (*1*) and after deformation aging (one year) at room temperature (*2*) one