CHANGE OF PARAMETERS OF THE KOIWA-HASIGUTI DYNAMIC RELAXATION IN NANOSTRUCTURED AND POLYCRYSTALLINE ZIRCONIUM AFTER SEVERE PLASTIC DEFORMATION AND ANNEALING

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Investigation of high-fragmented polycrystals with the mean grain size of order 100 nm is of interest both from the fundamental and technological points of view. Fragmentation of polycrystalline materials changes essentially most important physical and technological properties and in some cases nanostructured (NS) materials have much higher operational characteristics in comparison with coarse-grained polycrystalline ones and may be regarded as perspective constructional materials.

Severe plastic deformation (SPD) is one of the simplest and accessible methods of obtaining high fragmented metals. SPD methods allow obtaining large and practically pore-free bulk samples. However SPD prepared samples are not in thermodynamically equilibrium state due to a huge number of deformation defects, first of all, high dislocation density. This can be regarded as one of the main reasons for the significant change of physical properties of NS metals during formation of NS states as well as at subsequent thermal and mechanical treatments. Instability of the NS materials is a serious restriction for their wide application as elements of constructions subjected to extreme working loads and temperatures.

Experimental study of elastic and inelastic properties of the NS metals and alloys in a wide temperature range using acoustic spectroscopy methods provides important information on their dislocation structure. These methods offer nondestructive way of obtaining elastic and inelastic characteristics, possess high structure sensitivity, selectivity and reproducibility. In the present work, the temperature dependences of acoustic properties of nanostructured and polycrystalline zirconium are investigated in the temperature range 100 - 340 K. Zr and Zr-based alloys find wide application in nuclear power engineering thanks to an optimal combination of important physical parameters.

The effect of SPD and subsequent annealing on key parameters of the Koiwa-Hasiguti acoustic relaxation in zirconium is studied in detail. It is established that due to intensive plastic deformation the relaxation strength considerably increases and the temperature and width of the corresponding relaxation peak systematically decrease with the reduction of the mean grain size in the samples. An influence of a random scatter of the relaxation time on the main parameters of the Koiwa-Hasiguti peak is established using the statistical analysis based on the lognormal distribution. It is shown, that the parameter β of the lognormal distribution determines the width, height and asymmetry of the peak and also allows estimating the relaxation strength from the peak height. An algorithm of retrieving of the parameter β from experimental data is presented.

To obtain information on the structure stability of the samples, they were annealed in vacuum at 425 K for 1 hour. Annealing leads to a partial recovery of the relaxation strength and the peak temperature back to the initial values in undeformed samples. This effect is more pronounced in the most fragmented samples. This indicates that the structures forming during most complicated SPD schemes are less resistant to the heat treatment. At the same time, the width of the relaxation peak does not show any recovery. That indicates further homogenization of the dislocation structure due to reducing the total dislocation density and lowering the level of internal stresses.