THE KOIWA-HASIGUTI DYNAMIC RELAXATION IN NANOSTRUCTURED AND POLYCRYSTALLINE ZIRCONIUM

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The study of physicomechanical properties 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 metallic materials down to the nanostructured (NS) state changes essentially such important physical and technological characteristics as elastic moduli, strength and plasticity, the Debye temperature, the Curie temperature, corrosion resistivity, etc. In many cases, NS metals have much higher operational characteristics in comparison with coarse-grained (CG) analogs and may be regarded as perspective constructional materials.

The temperature dependences of acoustic properties of NS and CG zirconium are investigated in the temperature range of 100–340K. The effect of severe plastic deformation (SPD) and subsequent annealing on key parameters of the Koiwa–Hasiguti (KH) acoustic relaxation in zirconium is studied in detail. It is established that due to SPD the relaxation strength considerably increases, and the temperature and the width of the corresponding relaxation peak systematically decrease with the reduction of the mean grain size in the samples. Annealing leads to a partial recovery of the relaxation strength and the peak temperature back to the initial values in undeformed samples but the relaxation peak width shows an additional decrease. The majority of the effects observed can be explained by changes in dislocation subsystems of the samples during SPD and annealing. An influence of a random scatter of the relaxation time on the main parameters of the KH peak is established using the statistical analysis based on the lognormal distribution. It is shown that the parameter of the lognormal distribution β determines the width, height, and asymmetry of the peak and also allows estimating the relaxation strength from the peak height. An algorithm for retrieving the parameter β from experimental data is presented. Fig. 1 shows a satisfactory agreement between the theoretical and experimental curves, in particular, in what concerns the width of the peak. It should be noted, however, that there is a significant asymmetry in the experimentally observed peaks. This could be caused by various reasons. The main of them is the presence of other relaxation processes in Zr in the temperature range $T<T_P$ which deform the low-temperature branch of the KH peak.

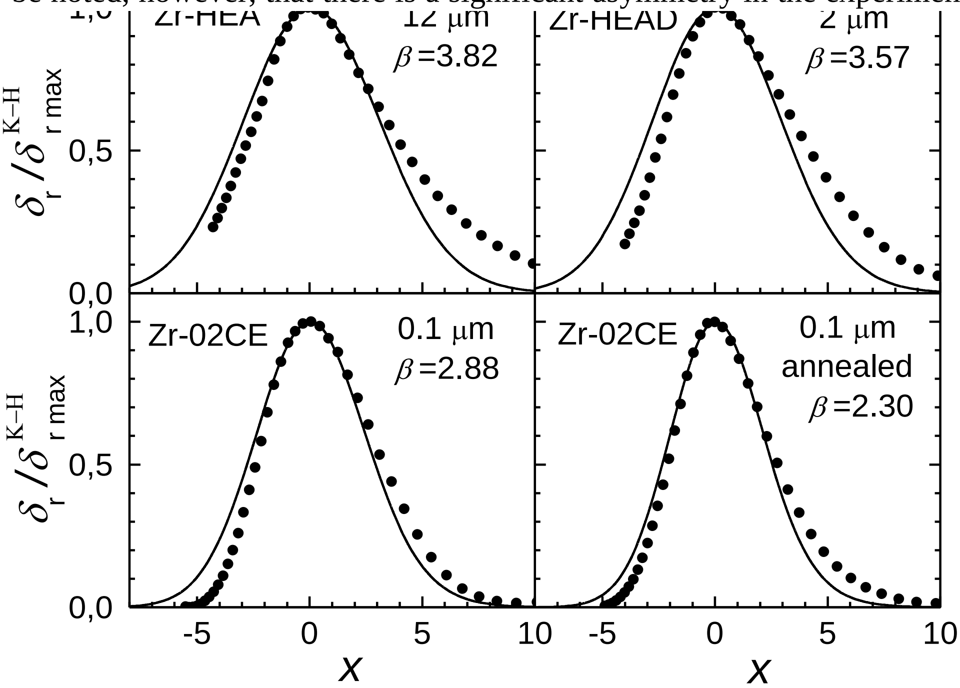

Fig. 1. Experimental (points) and theoretical (solid lines) dependences of the normalized relaxation component of the decrement.