On the liquid-like local state in deformed metallic materials, relevance to physics of the diffusion and other anomalies

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On the basis of results [1-8] of thermodynamic analysis of a number of experimental data, the process of periodical formation of the liquid-like state in nanoregions of the extremely "non-equilibrium" grain boundaries (ГЗ$_3$; Figs. 1, 2) and in other defect regions in metallic materials under the superplastic deformation and under the intensive plastic deformation is considered. The liquid-like state is characterized by an anomalously high diffusion coefficient ($D^*_{Г33}$, as in a liquid phase) and anomalously low shear modulus (in comparison with the glass-like amorphous structure). The physics of its influence on processes, including the diffusion ones, and materials properties is also considered.

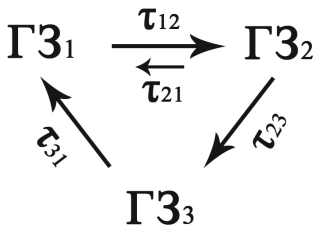

Fig. 22: Three extreme states of grain boundaries (ГЗ)

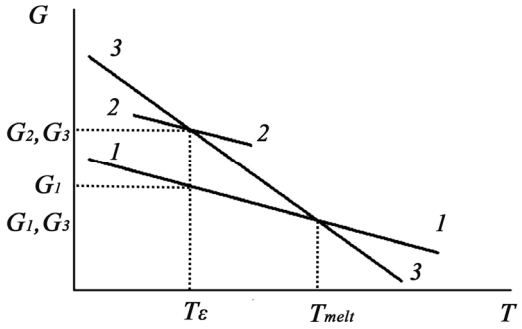

Fig. 2: Temperature dependence of the free energies (G)

According to data [9], the superplasticity deformation rate ($\dot{\varepsilon}$) for Zn–22%Al alloy is described as:

$$\dot{\varepsilon} = A(D^*_{Г3}G^*b/kT)\,(b/d)^p\,(\sigma/G^*)^n, \qquad (1)$$

where $\dot{\varepsilon} = 0.01\ s^{-1}$; A = 15; $G^* = 40$ GPa; $b = 0.28$ nm; $T = 503$ K; $d = 2.5$ μ; p = 2; σ = 8 MPa; n = 2.

Hence, $D^*_{Г3} = 8\cdot10^{-6}\ sm^2s^{-1}$; the obtained diffusion quantity (as $D^*_{Г33}$) is typical for a liquid phase.

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