

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

Yury S. Nechaev

I.P. Bardin Central Research Institute for Ferrous Metallurgy, G.V. Kurdyumov Institute of Metals Science & Physics, Moscow, Russia
yuri1939@inbox.ru

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 (Γ_{33} ; 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 ($D^*_{\Gamma_{33}}$, 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.

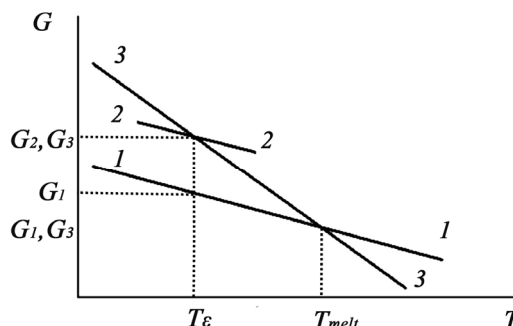
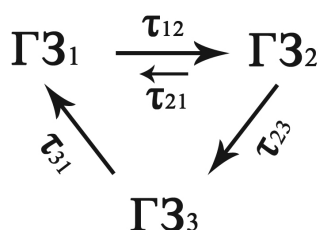


Fig. 22: Three extreme states of grain boundaries (Γ_3) Fig. 2: Temperature dependence of the free energies (G)

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

$$\dot{\epsilon} = A(D^*_{\Gamma_3} G^* b / kT) (b/d)^p (\sigma/G^*)^n, \tag{1}$$

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

Hence, $D^*_{\Gamma_3} = 8 \cdot 10^{-6} \text{ sm}^2\text{s}^{-1}$; the obtained diffusion quantity (as $D^*_{\Gamma_{33}}$) is typical for a liquid phase.

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The work is supported by the Russian foundation of the basic research (project 17-08-00515).