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Stimuli and Mechanisms of Diffusion Mass-Transport in the Processes of Structural-Phase Changes in Metallic Materials under High-Rate Deformation

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1. Introduction

In papers [1-3], the role of the atomic diffusion processes in the structural-phase changes (transformations) in metallic nanomaterials under high-rate (intensive) plastic deformation is discussed. As is shown [1, 3], the thermodynamic stimuli and the diffusion direction are not described by using the conventional phase diagrams. Particularly, it concerns the results [3] of the ball milling of crystalline alloys-compounds ($La_{50}Ag_{50}$, $La_{45}Ag_{55}$, $La_{38}Co_{62}$, $La_{43}Ni_{57}$, $La_{34}Ni_{66}$, $Cr_{50}Zr_{50}$) leading to a decomposition (demixing) of the alloys into nano-regions of the constituent elements. Obviously, such a demixing of the alloys can be realized only through the atomic diffusion processes, which seems to build up the concentration gradients and to increase the system free energy (if the conventional phase diagrams are used [3]).

2. Discussion - analytical results

In the present paper, a possibility of the exhibition of the deformation-induced phase diagrams is considered (on the basis of analysis of the related experimental data [2-12]), in connection with revealing of the thermodynamic stimuli of the diffusion processes in question. The diagram changes can be related to the well-known fact [4] that there occur different phases of different abilities and mechanisms in storing the deformation energy; hence, a meta-stable phase can receive the thermodynamic (stationary) stability under the high-rate plastic deforming of the material. The peculiarities and micro-mechanisms of the anomalously enhanced diffusion processes and the phase diagram changes in materials under high-rate ($\sim$1-10^4 s^{-1}) deforming for a large diapason of deformation degree (from $\sim 0.1\%$ up to $\geq 100\%$) are discussed. Particularly, the contribution of the "non-equilibrium" grain boundaries in the enhanced diffusion processes in metallic nanomaterials under intensive deforming is considered, as well.

3. Conclusion

These urgent fundamental problems are still "open questions", and their further studies seem necessary for optimizing and developing some modern nanotechnologies.

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