EFFECT OF HIGH-SPEED DYNAMIC DEFORMATION AND SEVERE PLASTIC DEFORMATION BY HIGH PRESSURE TORSION ON THE STATE OF GRAIN BOUNDARIES IN Ni, Nb AND LOW-ALLOYED BRONZES

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The most important microstructural components of any polycrystalline materials affecting their bulk properties are grain boundaries (GBs) [1]. In a number of early works, it was suggested that GBs in ultrafine-grained (UFG) materials processed by severe plastic deformation (SPD) are in a strongly "nonequilibrium" metastable state [2.3]. According to Valiev with co-authors, these "nonequilibrium" GBs are responsible for the improved mechanical properties of materials processed by SPD, which exceed the properties expected only based on the grain refinement [4,5].

In the present work, the state of grain boundaries in Ni, Nb and low-alloyed bronzes processed by dynamic channel-angular pressing (DCAP) and high pressure torsion (HPT) has been studied by electron microscopy, scanning tunneling microscopy and nuclear gamma-resonance spectroscopy. The studies have shown that in all the investigated materials, the grain boundaries after deformation are in the deformation-modified (nonequilibrium) state. This, in particular, is evidenced by the increased relative energy of the grain boundaries in them compared to the relaxed boundaries in the original state. This is illustrated by Fig. 1, which shows histograms of distribution of grain boundaries over their relative energies in hafnium bronze in the initial quenched state and after deformation by DCAP and HPT.

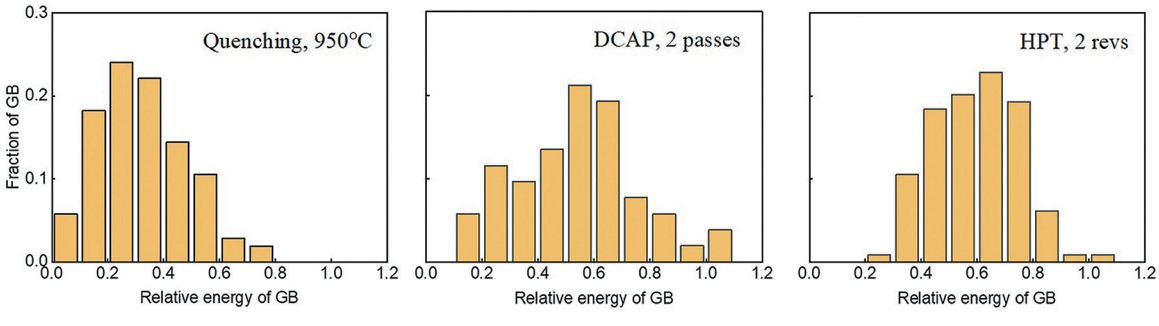

Fig. 1. Distribution of grain boundaries by relative energies in hafnium bronze in the initial quenched state and after deformation by DCAP and HPT

The studies have shown that the nonequilibrium state of grain boundaries, characterized by their relative energies, increases with an increase in the strain degree. Various contributions to strengthening in the studied materials have been analyzed: the structure refinement, nonequilibrium grain boundaries, development of twinning and dispersion hardening.

The work was carried out within the framework of state assignment of Ministry of Science and Higher Education of Russian Federation for the IMP UB RAS.

References

1. **Sutton, A. P.** Interfaces in Crystalline Materials [Text] / A. P. Sutton, R. W. Balluffi. – Oxford : Clarendon Press, 1995.

2. **Valiev, R. Z.** Grain boundary structure and properties under external influences [Text] / R. Z. Valiev, V. Yu. Gertsman, O. A. Kaibyshev // Phys. Stat. Sol. (a). – 1986. – Vol. 97. – P. 11–56.

3. **Nazarov, A.** On the structure, stress fields and energy of nonequilibrium grain boundaries [Text] / A. Nazarov, A. Romanov, R. Z. Valiev // Acta Metall. Mater. – 1993. – Vol. 41. – P. 1033–1040.
4. **Valiev, R. Z.** Bulk Nanostructured Materials from Severe Plastic Deformation [Text] / R. Z. Valiev, R. K. Islamgaliev, I. V. Alexandrov // Progress in Materials Science. – 2000. – Vol. 45, No. 2. – P. 103–189.
5. **Valiev, R. Z.** Producing bulk ultrafine-grained materials by severe plastic deformation JOM [Text] / R. Z. Valiev, Y. Estrin, Z. Horita et al. – 2006. – Vol. 58, No. 4. – P. 33–39.