2. Кисель В.П. В сб.: Всеросс. конф. "Дефекты структуры и прочность кристаллов", Черноголовка, РАН, 4-7.06.2002, с. 29.
3. Кисель В.П. В сб.: "Нетрадиционные природные ресурсы, инновационные технологии и продукты". Сб. научных трудов. Вып. 10. М. , РАЕН, 2003, с. 183-196.
4. Головин Ю.И , Моргунов Р.Б., Иванов В.Е., Дмитриевский А.А. ЖЭТФ, 1999, т. 117, No 6, с. 1080-1093.
5. Блюменфельд Л.А., Калмансон А.Э. ДАН СССР, 1957, т. 117, No 1, с. 72-74.
6. Самойлова О.П., Цапин А.И., Блюменфельд Л.А. Биофизика, 1995, т. 40, вып. 2, с. 383-388.
7. Kissel N.S. and Kisel V.P. Mater. Sci. Eng. A, 2001, v. 309-310, p. 97-101.
8. Kisel V.P.and Barkov T.L., preprint cond-mat/004…. at http://xxx.lanl.gov (2004) -в печати.

UNIVERSAL MECHANISMS OF PLASTICITY AND FRACTURE IN CRYSTALS AND ORGANIC POLYMERS UNDER CONVENTIONAL AND SHOCK-WAVE STRESSES

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The effect of applied compressive/extension stresses, s (s = 0.6S to 95S, where S is the resolved shear stress) and stress rates (10 to 10^6 MPa/sec) on dislocation dynamics was investigated in pure NaCl and InSb single crystals in the temperature range $T = 4\cdot10^{-3}$ to 0.945 T_{melt}, T_{melt} is the melting point. The general damping character of dislocation unpinning, motion and multiplication (work hardening of crystals, WH) under creep and interrupted loadings manifests in the ultimate mean path lengths of individual dislocations (UMPID). Having covered a certain UMPID determined by crystal prehistory and constant test parameters (creep regime), the dislocations exposed to successive exhausting acts of multiplication and fracture thus forming point defects, the slip lines, slip bands, subgrains, grain boundaries, nano- and microcracks, macrocracks in series in all the materials [1-2].

The first important finding of this work is the fact that the dependences of the UMPID versus creep, impulse, impact and shock wave stresses, temperature and impurity concentration are topologically similar to the conventional macroscopic strain-stress WH curves for the same crystals and test parameters. As for microscopic stresses for dislocation motion and multiplication the concentration dependences of flow stresses under fixed strains or fracture stresses at low and ultra-low temperatures and strain rates [2-4] are similar to the same dependences of impact/shock wave stresses and stress rates at normal and elevated temperatures [4-6]. The climb, dislocation cross-slip and athermal bowing mechanisms are confirmed by the same so-called "memory effect" at low (Figs 23-24 in [7]) and ultra-high (s~ 95S, [8]) stresses and stress rates, because dislocation dipoles are left in the wake of expanded dislocation loops along the whole deformation WH – curve. This means that THE SAME MICROMECHANISMS GOVERN THE DYNAMICS OF INDIVIDUAL DISLOCATIONS AND MACROSCOPIC FLOW up to the values of flow in nanostructured (NSC) and fractured crystals.

The second important finding is that the micro-/macro-WH varies nonmonotonously to crystal softening according to the pulse length of the unloadings (restore time), and these dependences are the same for micro-/macroscopic flow up to the extremely high values in NSC crystals [9] and fractured oriented polymers [10]. The last fact and the similarity of the other features of deformation and fracture of crystals and polymers at various length scales corroborate the universality of the micromechanisms of plastic flow and fracture in crystals and polymers due to same dislocation-like defects.

References

1. V.P. Kisel. Physica Status Solidi (a), 1995, vol. 149, No 1, pp 61-68.
2. V.P. Kisel. In: "Mechanisms and mechanics of damage and failure" (ECF-11), Eds. J.Petit et al., EMAS, Warley, UK, 1996, vol.1, pp.145-150. Abstracts of the V Int. Conf. on the Fundamentals of Fracture (ICCF-V),Aug.18-21,1997, NIST,Gaithersburg, Maryland,USA, pp 28-29.
3. N.S. Kissel and V.P. Kisel, Mater.Sci. Engn.A, 2001, vol. 309-310, pp 97-101.
4. A.K. Mukherjee,W.G. Fergusson, et al. J. Appl. Phys.,1966, vol. 37, No 10, pp 3707-371
5. V.P. Kisel. J. Phys. (Paris), 1985, vol. 46, Suppl. No 12, pp C10-(529-532).
6. S.V. Razorenov, G.I. Kanel' et al. Fiz. Metal. Metalloved.,2003,vol. 95, No 1, pp 91-96
7. J.J. Gilman, W.G. Johnson. Solid State Physics, 1962, vol. 13, pp 147-222.
8. E.V.Darinskaja, A.A.Urusovskaja, et al., Fiz. tverd. Tela, 1982, vol.24, No 3, pp 940-941
9. R.Z. Valiev, I.V. Aleksandrov, Doklady Acad. Nauk, 2001, vol. 380, No 1, pp 34-37.
10. V.R. Regel, F.I. Slutsker, E.T. Tomashevskii. Kineticheskaja priroda prochnosti tverdykh tel, Moscow, Nauka, 1974, 560 pp (in Russian).

FEATURES OF SUPERPLASTIC FLOW OF NANOSTRUCTURAL ALLOYS

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The structure and phase state of rods subjected to the equal-channel angular (ECA) pressing under different conditions have been studied by X-ray diffraction analysis, transmission and scanning electron microscopy, including back electron scattering diffraction and orientation image microscopy, technique. A fine-grained structure has been shown to form in the process of pressing. A largest number of grains demonstrate the formation of a dislocation substructure involving subgrains.

A mechanical behaviour has been studied for ECA pressed samples having different structure states. Temperature and strain rate conditions to attain ultimate strains to failure have been defined for samples of each structural state. It has been shown that samples with a developed substructure are subject to a superplastic (SP) straining. Contrary to the expectations the ductility of finest-grained samples turned out low.

Mechanical behaviour of the alloys has been studied in SP straining conditions. Multistage high strain rate SP straining has been shown. Dependencies of the true strain rate on temperature, the true stress and true strain for the straining during hardening stage and softening stage have been established. The activation energies and the coefficients of strain rate sensitivity of stress, which characterize these stages, have been determined. Structural behaviour during SP straining has been studied.