# The mesomechanics of fracture in ultrafine grain titanium and Armco-iron samples

L.S. Derevyagina, V.E. Panin, A.I. Gordienko

Institute of Strength Physics and Materials Science, SB RAS, Tomsk, Russia, lsd@ispms.tsc.ru

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**Introduction.** A large number of publications are devoted to the development of necking in plane samples and to fracture in the neck. However, by addressing this problem pertaining to several structure-scale levels, processes occurring on one scale level only are considered as a rule (analysis of a deformed material state within the neck or the microstructural features of plastic flow and fracture). A detailed study is made of the micromechanisms of plastic deformation and fracture occurring in the neck on the micro-scale level. The regular features of plastic flow, which are responsible for the plastic deformation and fracture in the neck on the meso-scale level, are poorly attested and insufficiently studied. This is mostly due to the absence of express-methods for measuring local plastoelastic strains.

*The goal of the study*. Using the optical-television complex TOMSC developed at the ISPMS, the regularities of local deformed state of material within the neck were analyzed from the onset of necking to sample fracture. The method of setting up the problem was as follows. An attempt was made to relate the fracture process, its stages and the micromechanisms involved to the changes in the local linear and shear deformation components as well as to the rotation mode and deformation rate intensity. The study was performed for the test samples of the ultrafine grain titanium and Armco-iron (α-Fe) that had been treated by equal-channel angular pressing.

**Results**. Necking is found to occur by stages in the deformed samples of ultrafine grain Ti and α-Fe. First a symmetric (or near-symmetric) neck would form which comprises two conjugate localized deformation macrobands. As long as the material is capable of strain hardening, the symmetric neck would continue to develop. Upon further straining, material softening would occur within the main macroband to cause its rapid growth. As a result, the symmetry of the neck becomes disrupted. This is illustrated by the plot of $\varepsilon_{xy}$ growth in macrobands 1 and 2 (Fig. 1). By the instant of fracture the shear component value, $\varepsilon_{xy}$, becomes 2.5 that of the linear component, $\varepsilon_x$.

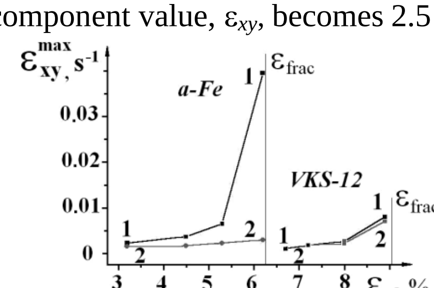


Fig. 1. Changes in the value $\varepsilon_{xy}$ in macrobands 1 and 2 of ultrafine grain α-Fe (asymmetric neck) and steel VKS-12 (symmetric neck)

The linear and shear deformation components reach maximal values in certain segments of the symmetric neck that are distributed over its area. The linear and shear components and rotation deformation mode are aligned in one and the same direction in the asymmetric neck to form a localized deformation macroband having maximal degree of material form changing. The rotation deformation mode plays a decisive role in the fracture process in materials with a symmetric and an asymmetric neck. Thus, ultrafine grain materials undergo fracture by localized shear. The multi-scale mesomechanics of fracture in ultrafine grain titanium and α-Fe is discussed herein.