DSCM P37 APPLICATION OF ACOUSTIC EMISSION TECHNIQUE FOR THE EVALUATION OF MICROMECHANICAL PROPERTIES OF STEEL

D.Z. Grabco[1,*], O.A. Shikimaka[1], C.M. Pyrtsac[1], A.A. Prisacaru[1], S.E. Alexandrov[2]
[1]*Institute of Applied Physics, Chisinau, Moldova;* [2]*Institute for Problems in Mechanics of the RAS, Moscow, Russia*
*E-mail: grabco@phys.asm.md

Acoustic emission (AE) is the propagation of elastic waves by a material, caused by a dynamic local restructuring of its structure. According to modern physical concepts, AE, which occurs when indenting solids, is associated with the processes of nucleation, accelerated motion, and annihilation of crystal lattice defects (dislocations, twins, cracks, etc.). The relationship between mechanical properties and the appearance of AE signals has been extensively studied in ceramic materials, semiconductors, glasses, ionic crystals, and to a lesser extent in metals [1].

In this connection, the correlation between the microhardness, the view of deformed zone around the imprints and the number of AE signals generated under penetration of the Vickers indenter are studied in this paper. The load interval varied within $P = (0.05 \div 2.0)$ N. The tests were carried out on a PMT-3 microhardness tester equipped with a device for exciting and receiving AE signals. The work was performed on steel samples. In the paper [2], it was shown that three stages can be distinguished on the $H(P)$ curves under metal indentation: I - P=(0.05 ÷ 0.5) N; II - P=(0.5 ÷ 2.0) N; III - P=(2.0 ÷ 7.6) N. These stages appeared due to different mechanisms of plastic deformation: stage I took place by the *intra*granular dislocation mechanism (*microlevel*), when $D_{max} < Lav$ (*Dmax* is the diameter of plastic zone around imprint, *Lav* is the average grain value) (Fig.1a). However, when *Dmax>Lav*, then other deformation mechanisms of a higher level are involved in the process (Fig.1b). They are characterized by translation/rotation sliding (*mesolevel*), which occurs by means of the *inter*granular translation, the disclination sliding bands, the rotational motion of grains, etc.

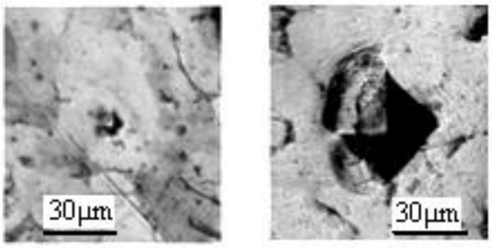

Fig. 1. Indentation images made on the unused steel. Load *P*, N: a – 0.05; b – 2.0

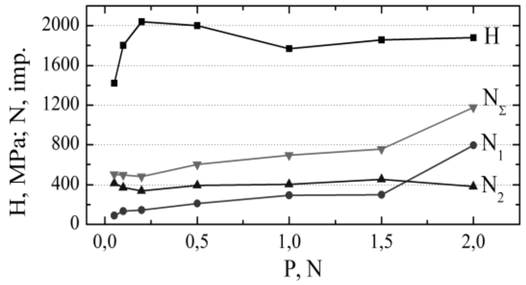

Fig. 2. Hardness (*H*) and AE signal (loading - N_1, unloading - N_2, summary – N_Σ) dependences vs applied load (*P*)

Various deformation mechanisms affected both the course of the $H(P)$ curve and the course of the $N_1(P)$, $N_2(P)$, and $N_\Sigma(P)$ ones (Fig. 2). Moreover, a correlation is observed in the change of the microhardness and the number of AE signals with the load. At stage 1, the microhardness increases with load growth as a result of an increase in the number of dislocations around the imprints and their mutual *intra*granular braking. At this stage, a small number of AE signals occur. With further load growth (stage II), the hardness value stabilizes, and the total number of AE signals N_Σ increases successively. Note, that the increase occur at the loading step (curve N_1), while at the unloading one the number of AE signals remains approximately constant (curve N_2). This indicates that the main processes of the *inter*granular mass transfer take place at the loading step. Relaxation processes in the unloading step are less pronounced.

[1] Yu. Boyarskaya, D. Grabco, M. Kats. Physics of microindentation processes. Chisinau, Stiintsa, 1986, 294 p. (Rus.)

[2] D. Grabco, D. Leu. MSEA, 2010, 527, 6987-6996