APPLICATION OF THE METHOD OF EXOELECTRON EMISSION
IN METAL SCIENCE

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The surface structure existing during deformation of metals and alloys is of the greatest importance in the creation of structural materials with high contact strength. Although the thickness of the surface layer is only a few tens of microns, the layer determines the beginning of the destruction of metals and has a great influence on the working life of machine parts [1].

Exoelectron emission is one of the promising methods of studying the surface structure and its susceptibility to the formation of defects.

At the present time, several types of electron emission from metal surfaces are known. Heating induces thermoelectron emission; strong electric field induces autoelectron emission; irradiation with electromagnetic or particle radiations leads to the emission of photoelectrons and secondary emission. The term exoelectron emission has been used since the publication of [2]. The essence of the phenomenon is that electron emission occurs during the time and after the time of mechanical treatment of metal surfaces and this emission dies out with time. The damping period varies from several minutes to several tens of hours, depending on the type of metal and the type of deformation.

Kramer [2] assumed that the electron emission from the surface of deformed metal is the consequence of exothermic processes occurring on the surface. Therefore, the emitted electrons were called exoelectrons. Further investigations did not confirm this assumption, but the term persists [3].

At the present time, exoelectron has been studied in many pure metals (Be, Al, Zn, Mg, Ni, Fe, Co, Cu, Pt, Pd, Au, Cr, W). It was found that mechanical treatment of the surfaces of these metals with sandpaper, grinding, polishing, and also elongation, bending, torsion, and cyclic and impact stresses induce exoelectron emission [2-9]. The study of exoelectron emission resulting from deformation of technical alloys was initiated in [10]. It was proven experimentally that the value and the kinetics of the exoelectron emission depend on the degree, the type, and the character of deformation. This dependence agrees with the hypotheses according to which the centers of emission are places of maximum piling up of defects [9-14].

The correctness of these hypotheses is confirmed by a number of experimental results. For example, in [13] a zinc single crystal was covered with an autoradiographic emulsion of high resolving power and the layer was later stretched. After this, one could see darkening induced by exoelectrons which corresponded exactly to the lines of the crystal and repeated the etch pits of traces of dislocations observed along the slip lines. It was found that excitation with ultrasonic vibrations stimulate the exoelectron emission [14]. The emission peaks occurring when the intensity of the ultrasonic vibrations on the motion of dislocations. The authors in [13,14] consider that the emission centers are the places where the dislocations come to the surface, since it is well known that next to the dislocations and in places of maximum pile ups of defects the work function of electrons is much lower than on undeformed areas of the metal [15-17].

In what follows we describe the results of our investigation of exoelectron emission from the surface of technical alloys under different types of stresses. The apparatus for the measurement of the exoelectron emission and the method of preparing the samples was described in [18]. It was shown in [18] and [19] that the exoelectron emission method makes it possible to record plastic deformations in microvolumes. Therefore, it is of interest to investigate emission in the case of local deformations of the surface of the metal.

We used for our investigation the stable austenitic alloys N36 and G38.
Fig. 1. Exoelectron emission of nickel and manganese austenite under local static stress.

Fig. 2. Power of the exoelectron emission of nickel and manganese austenite resulting from different periods of microimpact.

Fig. 3. Emission capacity of austenite under the influence of local deformation of the grain (1) and the grain boundary (2): a) nickel austenite of N36; b) manganese austenite of G38.

Table 1. Maximum Emission in Pulses/min

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Static stress</th>
<th>Dynamic stress</th>
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<tbody>
<tr>
<td>N36</td>
<td>525</td>
<td>710</td>
</tr>
<tr>
<td>G38</td>
<td>330</td>
<td>570</td>
</tr>
</tbody>
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Figure 1 shows the variation of the exoelectron emission in the case of local static stress of the N36 and G38 alloys. The curves have a characteristic maximum which indicates the inversion of the emission: the emission current increases after the stress is relieved. This phenomenon was also observed in [8,9].

The study of exoelectron emission after dynamic stressing of these alloys resulted in similar curves. Table 1 gives the data on the emission capacity of the deformed section under local static and dynamic stresses recalculated per cm² of surface.†

Table 1 shows that the exoelectron emission is more intense in the case of dynamic than in the case of static stress and that for the manganese austenite the increase in the intensity resulting from impact is greater than for the nickel austenite. The exoelectron emission capacity of the N36 alloy is higher than that of the G38 alloy under static as well as dynamic stress.

This difference is even more pronounced in the case of microimpact [19].‡ The emission properties of the deformed surface can be characterized by the total number of emitted exoelectrons. This number is proportional to the area under the emission curve.

If one divides this number by the emission time and the deformed area of the surface one obtains a parameter which characterizes the emission power. The dependence of the emission power on the time of the microimpact

*Static stress was produced by pressing with a cone with a 90° angle on a 5-ton Amsler press.
†Dynamic stress was produced by impact from a free-falling cone weighing 20 kg from a height of 0.5 m.
‡Microimpact was achieved by the method described in [20].