EFFECT OF PULSED ELECTRIC CURRENT TO DEFORMATION OF AMORPHOUS AND NANOCRYSTALLINE METALLIC ALLOYS, AGED IN ACIDIC ENVIRONMENTS

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Abstract – The influence of aggressive media (20 % solutions H_2SO_4 and HNO_3) intermittent discharge on the strain-based amorphous alloys and cobalt nanocrystalline iron-based alloy, which occurs depending on the σ-ε by passing electrical current pulses. Fitted values depending stress relief in the material density of the pulsed electric current. Investigated the structural and morphological state of the alloy surface after exposure to aggressive media of different concentrations.

I. INTRODUCTION

Expanding the range of application of amorphous and nanocrystalline alloys sets targets for the study of the structure and properties of these materials after various influences. This may be both stationary and non-stationary thermal field pulse and static electric and magnetic fields, and different environment leading to oxidation and corrosion. With its high levels of corrosion resistance, metallic glasses show a significant sensitivity to the effects of hydrogen and corrosive environments, resulting in embrittlement of these materials [1]. The transmission pulse electric current at a high density metallic glass deformation accompanied by a reduction of mechanical stress diagrams fixed on σ(ε) [2]. The purpose of this paper is to study the deformation of amorphous and nanocrystalline metallic alloys by pulsed electric current after exposure to corrosive environments.

II. RESULTS AND DISCUSSION

The object of the study were chosen amorphous metal alloys based on cobalt (AMAG - 172 AMAG - 180) and nanocrystalline alloys based on Fe (AMAG - 200) obtained by spinning. Sample sizes: ~ 3,5 × 0,02 × 40 mm. Corrosive environment is a 20% solution of sulfuric and nitric acids. Samples were preincubated for 40 minutes. Then the samples produced by uniaxial stretching tensile testing machine Instron-5565 with a speed of 0.1 grippers mm / min while a pulsed electric current duration τ = 5 ms, and the current density $j = 10^8$-10^9 A/m^2.

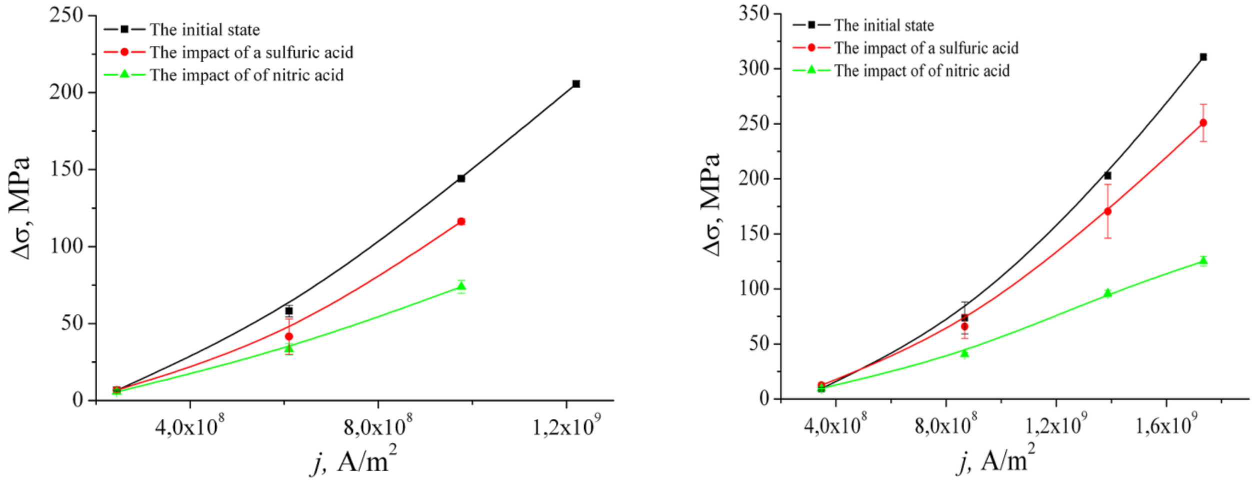
Deformation of the AMC while passing an electric current pulse on the charts load accompanied by the phenomenon similar electroplastic effect, the well-studied for crystalline structures [3-4]. At the time of the current pulse in the diagrams σ-ε there is a short (~ 1.1 s), the decline of stress $\Delta\sigma$ followed by complete recovery of stroke depending on σ-ε.

The experimentally observed that after soaking in 20% sulfuric acid in amorphous alloys, Co-base, the reset value of the mechanical stresses caused by passing a pulsed current is reduced by $\Delta\sigma \approx 20$ % in comparison with the amount of discharge of the samples in the initial state (Fig. 1 a, b). A delay of 20 % nitric acid solution reduces the amount of stress relief by 30 % compared with the effects of sulfuric acid and 50% as compared with resetting. Effects on the acidic environment nanocrystalline Fe-based alloy does not affect the release of mechanical stress.

Decrease in the discharge of stress may be due to surface phenomena occurring. In Fig. 2b is a view of the surface of the sample after exposure to an acidic environment. It is seen that the exposure to the acid environment of amorphous materials leads to surface oxide formation, the study confirmed that the element composition. It was found that almost the entire area of the specimen surface covered sulfate formations thickness around 3 microns.

The formed oxide film on the surface reduces the metal section of the sample which leads to an increase in resistance and decrease in current acting on the sample. This accordingly causes less heating of the sample, whereby the amount of discharge decreases mechanical stress caused by passing a pulsed current.

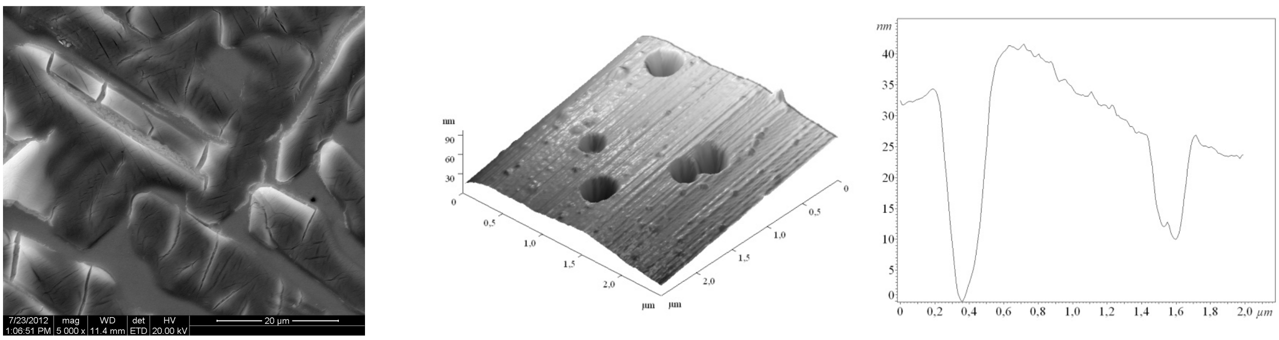
Cobalt metal is capable of absorbing large amounts of hydrogen [5], not forming a compound of constant composition. Therefore, hydrogen is apparently not evaporate and remains in the surface layer of the material, causing embrittlement is observed experimentally.



a) b)

Figure 1 –The dependence of the strain relief of the current density in the alloy: after exposure to a 20% solution of sulfuric and nitric acids: a) AMAG-172 b) AMAG-180

Soak nanocrystal alloy on the basis of iron in the solutions of sulfuric acid leads to the formation of pitting corrosion (Fig. 2). The characteristic size of pitting of the basins is 300 - 350 nm depth ≈ 40 nm. When this takes place decrease the value of the tensile strength of the alloy. So ,for example, after the impact of solution of sulfuric acid and 4 of the current pulse density of 2×10^8 – 2×10^9 A/m2 tensile strength is reduced by 20%.



a) b)

Figure 2 – Sulphate formation on the surface of the AMAG-180 after the impact of the 20% solution of sulfuric acid (a); pitting corrosion on the surface of the nanocrystal alloy AMAG-200 (b)

III. CONCLUSIONS

The acid environment forms sulfate compounds on the surface of amorphous alloys, leading to a considerable reduction in the metal section of the sample, which causes an increase in the resistance of the material, reducing the force of the current, and consequently, leads to lower heating of the sample, therefore, decreases the value of the reset of the mechanical load.

In nanocrystalline alloys, in spite of pitting corrosion, stored value reset mechanical stress by passing a pulse of electrical current.

Change of discharge of the mechanical stress caused by pulse current, in the investigated alloys after soaking in aggressive environments due only to the change of the heating alloys.

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