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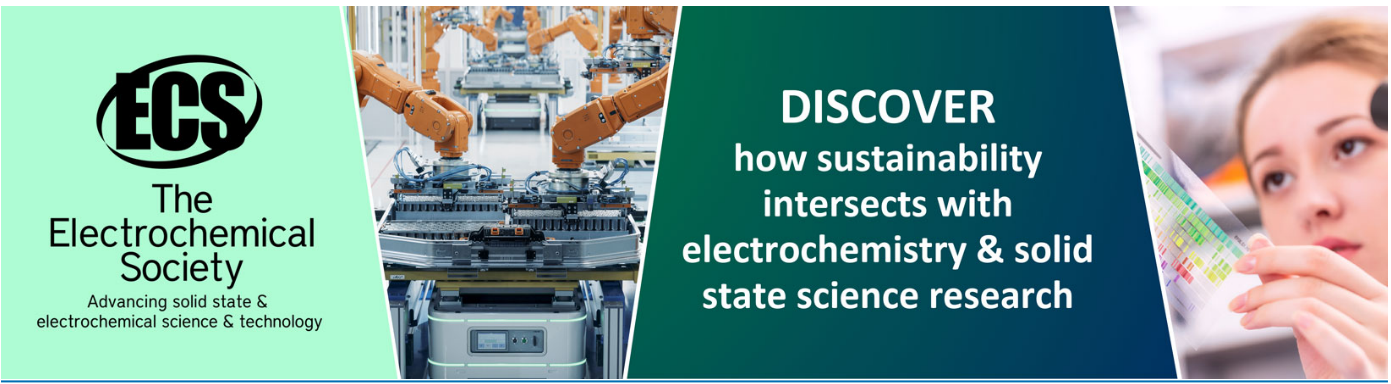

Study on possibility for the improvement of corrosion resistance of metals using laser-formed oxide surface structure

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Abstract. The laser processes of oxidation are currently known and used extensively, in particular, to improve corrosion resistance of metals possessing certain properties and composition. In this regard, actuality is the methods of laser oxidation of metals and the determination of their modes of treatment in each specific case. Increase of corrosion resistance ST20 can carried out with the formation on the surface oxide films, as well as by reducing surface roughness. Studied various modes of processing of the steel surface. Corrosion resistance investigated for protecting a metal. Defocusing the beam to allow the surface treatment of a wide beam in the low temperature mode of processing. For further study of the irradiated surface on the corrosion resistance was conducted by chemical treatment in acid. Estimated phase composition of films formed under laser treatment simulated in the program astics. The study to increase the corrosion resistance of steel and titanium, have shown that under the chosen methods of processing of materials degradation observed.

1. Introduction

Every year about one third of steel produced is lost due to corrosion, and the tenth part of it was dissipating in the form of corrosion products. The damage caused by corrosion consists of direct and indirect losses. These are included: the cost of corroded equipment cost of replacement or repair machines and equipment, the cost of damaged of the reactants and products of chemical processes, payments to victims of accidents involving corrosion damage workshop equipment, etc. to take full account of economic and moral losses extremely difficult. In this regard, one of the urgent tasks of the modern world is the creation of corrosion-resistant materials for prolonged use in particularly harsh conditions. These materials were using in fuel and nuclear energy, space technology and oil and gas industry and in other industries.

Now there are works, for example, [1-5], in which they consider the protection of metals from corrosion due to the creation of, surface micro - or nanostructures when exposed to Femto - or picosecond lasers. However, the introduction of these lasers in industrial production is problematic due to the high complexity of their maintenance. More preferred are fiber lasers. Easy control of parameters such laser systems, pointing accuracy of the laser radiation to the treatment area and excellent technical and economic parameters, and in particular, reliability and long service life. However, for surface protection it is advisable to use the laser oxidation [6], which allows creating on the metal surface a dense oxide structure. Despite a certain amount of work on this subject [7, 8] significant challenges remain that need to be addressed. To them in the first place, is the quality of oxide surface structure, and mean treatment time (oxidation).

Thus, the study of physicochemical processes occurring on the surface of metals under laser irradiation, and introduction of technologies for the protection of metal from corrosion in the industry are actual

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scientific and practical task. Based on all of the above, the purpose of the investigational work is to improve the corrosion resistance of steel and titanium by forming a protective oxide film by laser radiation near infrared (1.07 μm). [9]

2. Research and results

In the process there were determined the optimal regimes of laser processing the surface of the metal during formation of the oxide film by radiation of a fiber laser. The study was conductING using two materials, namely Ti and ST20. To conduct the experimental work was used ytterbium fiber laser with wavelength 1064nm. General view of the laser setup is presented in Fig.1, where PC - personal computer; SW - software; BEADS - the control unit deflectors; RL is a beam expander; OS - deflecting system; BKL the control unit of the laser; BPL - power pack laser; FS - focusing system. This wavelength allows processing of most metals.

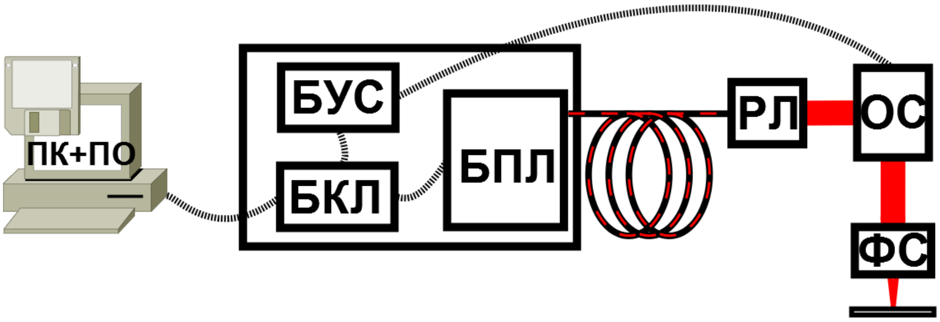

Figure 1. The block diagram of the laser system.

Increase of corrosion resistance ST20 can be carrying out with the formation on the surface oxide films, as well as by reducing surface roughness. This was investigating in various regimes and surface treatment of steel. Since these processes depend on T surface, the irradiation process was controlling by using an infrared camera, presented in Fig.2.

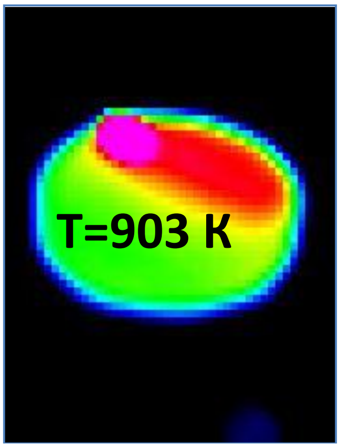

Figure 2. Termediary ST20

After the surface treatment of the steel examined using optical microscope (Fig.3). Thus T in the area of impact (1) reaches the optical 629, 85 S. the photos shown the change in appearance of the structure depending on the temperature. The field of laser radiation exposure are different from those that were establishing outside the zone of laser radiation, but also subjected to heat treatment.

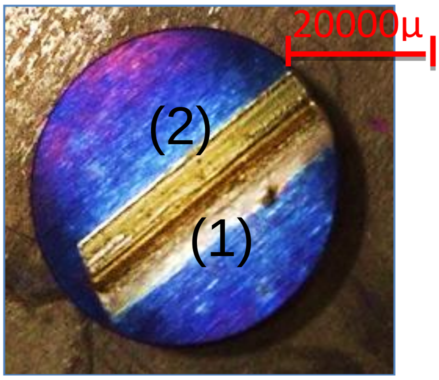

Figure 3. Optical photograph of the surface stali 1) the heat-affected zone; 2) zone of impact of laserradiation

The surface of the steel were determined using a profilometer. The surface roughness stale decreased, which follows from the data presented in table 1.

Table 1. The change of surface roughness of steel 20.

	Raw material	The presence of the oxide layer
Ra	0,53	0,48
Rz	3,66	2,66

For the study of the irradiated surface on the corrosion, resistance was conducting by chemical treatment in acid. As a chemical reagent is a mixture of copper sulfate and hydrochloric acid. In Fig.4A presents, the area was not treating with acid (1) and chemical treatment: (2A) t=10 s and (2B) t>10 s. In the course of the study, it was founding that the surface was covering with a special protective layer (Fig. 4).

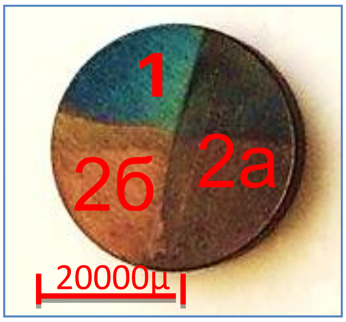

Figure 4. a) the acid treated surface

Figure 4.b) the area of interaction of the acid with theuntreated surface

Because of the research revealed the feature of laser oxidation of steel, comprising forming the modified surface structure in the field of thermal impacts that have not been exposing to laser irradiation. In Fig.5 these patterns are halos surrounding impact area. The temperature in these areas was less than half that in the field of radiation exposure.

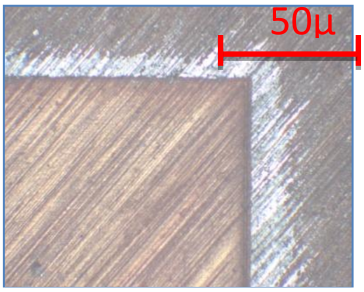

Figure 5. The haloing in the area of temperatures below TPL

For possible research, areas were presenting for protecting metal were investigating on the corrosion resistance. Before chemical processing of this region was creating during laser irradiation in the mode of defocusing. Defocusing the beam to allow the surface treatment of a wide beam in the low temperature regime treatment (Fig.6). According to the results of chemical treatment, you may notice that in the field of action of laser radiation, degradation of material was observing. Thus, the selected method of treatment of steel can improve its corrosion resistance.

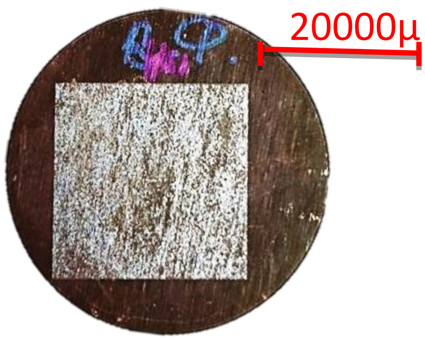

Figure 6. Processing stale in the low temperature regime

As for steel, was carrying out search of laser processing parameters, with the aim of improving the corrosion resistance of titanium. For further study of the irradiated surface on the corrosion, resistance was conducting by chemical treatment in acid. In the course of the study the following results were obtained:in Fig.7a shows the appearance of the surface of Titan to interact with a chemical reagent. In Fig.7b clearly shows that the appearance of the titanium sites, which were exposing to laser radiation, virtually unchanged, in contrast to the plots that were not subjecting to irradiation. Thus, the difference between irradiated and non-irradiated area amounted to 0.17 µm.

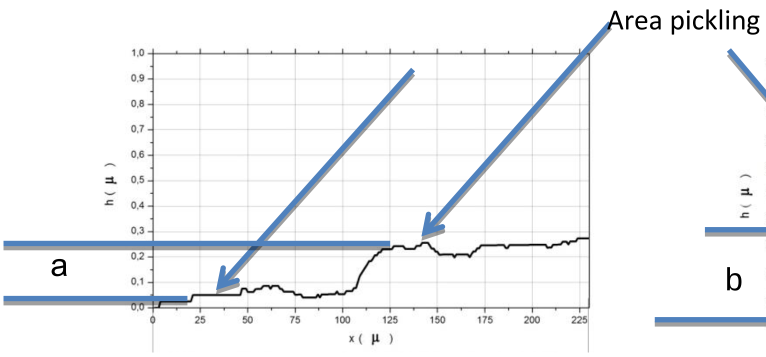

Figure 7. The titanium surface a) before

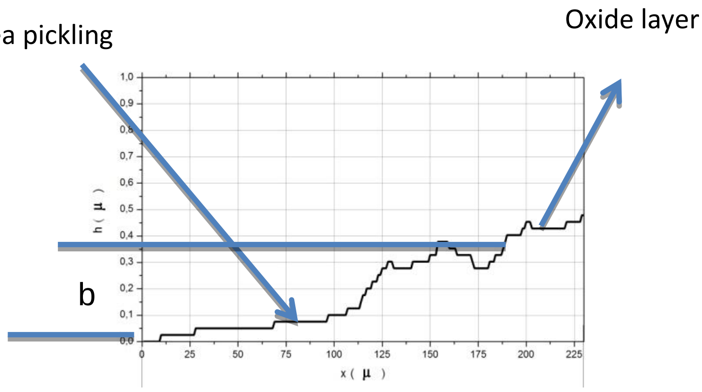

Figure 7. The titanium surface b) after interaction with a chemical reagent

3. Conclusion

In the course of the study solved the problem by definition of optimum modes of laser processing the surface of the metal during formation of the oxide film by radiation of a fiber laser.
Was investigated the corrosion resistance of the treated surface material. To improve the corrosion resistance of steel and titanium were choosing, certain modes of surface treatment of metals. The desired protective layers were obtaining because of established conditions.
The proposed methods and approaches for the protection of metal from corrosion may be applicable to virtually all metals.

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