EFFECTS OF THE PREHEATING LASER TREATMENT ON MICROSTRUCTURE AND CORROSION RESISTANCE OF Ti6Al4V BIOALLOY

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Abstract

The laser remelting of the Ti6Al4V alloy was made on specimens pre-heated at elevated temperatures. The laser treatment effected in change of microstructures of surface layers and an appearance of blisters and numerous cracks. The corrosion tests demonstrated the decrease in corrosion resistance for each preheating temperature. The observed effects were attributed to negative influence of excessive compressive stresses with no substantial relation of cracking phenomenon on pre-heating and its temperature.

Keywords: *titanium alloys, laser treatment, corrosion*

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Introduction

A few works were devoted to the laser melting of Ti alloys, even if this surface treatment was extensively applied for titanium and Ti-6Al-4V andTi-6.8Mo-4.5Fe-1.5Al alloys, using the high power CO_2 and YAG lasers, and short pulse Cr-F UV laser [1-3]. It was assumed that very short pulses of laser beam would result in substantial heating of the alloy and then in fast cooling in air in conditions corresponding to the ultrafast quenching. The relatively smooth, crack free nanocrystalline surface layer was obtained containing a significant amount of martensite.

The authors found in previous work [4] that the CO_2 laser treatment in liquid nitrogen resulted in nanocrystalline surface layer with a great number of surface cracks, on the contrary to other research. In order to avoid the cracking followed by decrease in corrosion resistance, the effect of pre-heating was investigated in presented research work.

Materials and methods

The Ti6Al4V alloy used in this study was of chemical composition shown in TABLE 1. The mechanical properties of the alloy were: yield stress 1010MPa, tensile strength 1072 MPa, relative elongation 10%. The microhardness of material reached 370-410 HV0.05. The microstructure of the cast Ti6Al4V alloy contained the α and β phases as shown in FIG.1.

TABLE 1. Chemical composition of the Ti6Al4V alloy (wt.%)

Ti	Fe	V	Al	C	O	N	B	Y	H
rest	0.16	4.05	6.40	0.01	0.185	0.005	max 0.001	max 0.001	0.0035

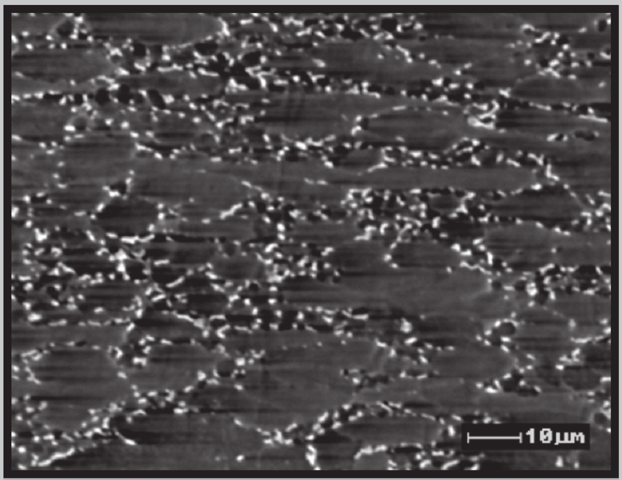

FIG.1. Microstructure of the Ti6Al4V alloy (as recived)

The remelting was carried out with the THRUMPF TLF 6000 Turbo laser at the Center for Laser Treatment of Metals at the Kielce University of Technology. The laser beam dimension 1x20 mm, power input 5000 W and scanning velocity 1 m/min were used. Before laser remelting, the specimens were heated at temperature 200, 300, 400, 450, 500 and 550°C in air and after 1h heating immediately subjected to laser remelting.

The microscopic examinations were made with the scanning electron microscope JEOL on surfaces and at cross-sections of preheated and laser remelted specimens. The cross-sections were prepared after polishing the specimens with grinding papers, No.2500 as a the last. No etching was applied.

The corrosion tests the Ti-6Al-4V alloy were made by the potentiodynamic method in Ringer's solution (8.6 g NaCl, 0.3 g KCl, 0.33 g $CaCl_2$ in 1 dm^3 water) mixed with magnetic stirrer, at 37±1°C. The Atlas 9131 Electrochemical Interface and Atlas 9121 Frequency Response Analyser were used.

Results and discussion

The surface and cross-section of the alloy after preheating at 200°C is shown in FIG.2. The behaviour of the alloy at each pre-heating temperature was similar. The very complex structures of the remelted layer were observed, similar to those obtained at liquid nitrogen. Particularly, the network of cracks appeared in all specimens. The cracks sometimes propagated across subsurface layer, sometimes stopped in deeper zones, usually finished in middle area. Blisters were also present and observed as penetrating further into the middle zone. The cracks were also similar to those observed for laser remelting at ultrafast cooling and related to very high stresses occurring during cooling after laser treatment even for The blisters may be attributed to presence in air, that may be absorbed by melted alloy.

The polarization curves obtained for the Ti6Al4V alloy in Ringer's solution after preheating at different temperatures are shown in FIG.3. The laser remelting resulted in a slight shift in polarization curves and increase in corrosion current, likely because of high compressive stresses.

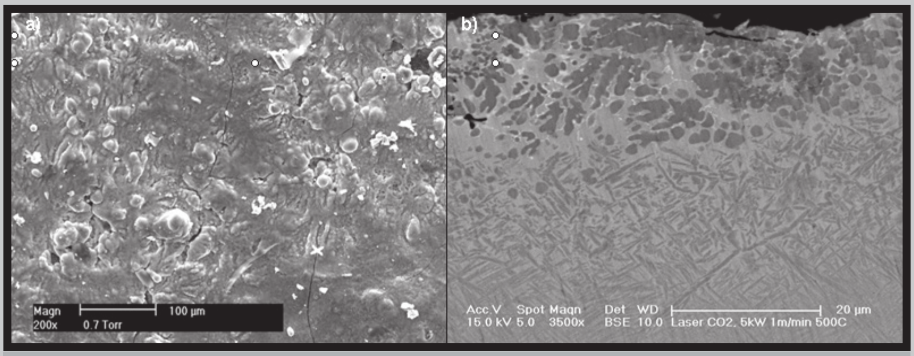

FIG.2. Microstructure of the laser remelted the Ti6Al4V alloy (200°C preheating, 5000 W power, 1 m/min scan velocity): a) surface, b) cross–section of the surface layer

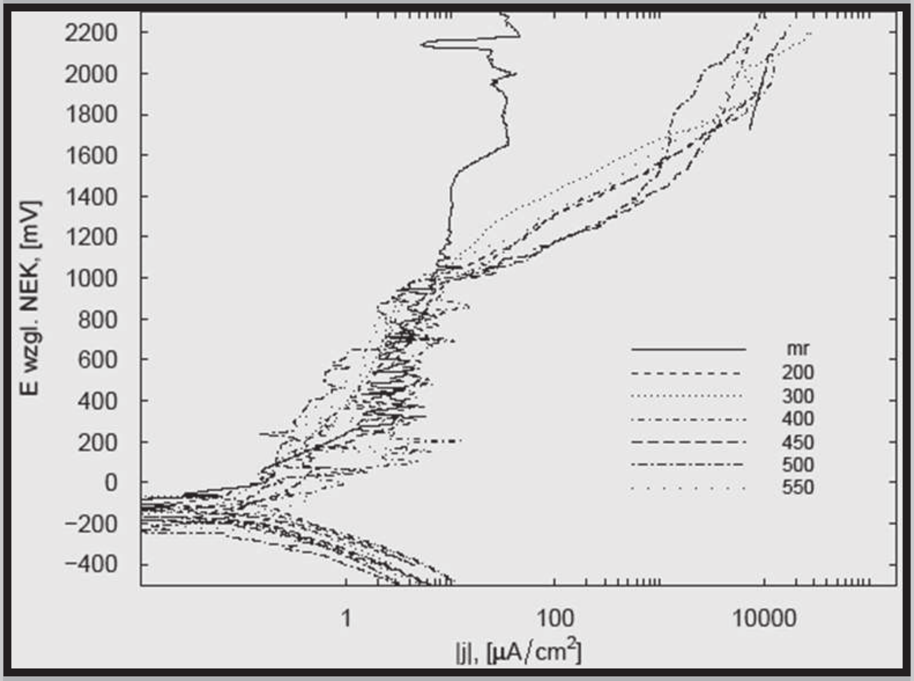

FIG.3. Potentiostatic curves of the Ti-6Al-4V alloy after laser remelting of pre-heated specimens (numbers mean temperature of the heat)

Conclusions

1. The laser remelting of the Ti6Al4V alloy with high power laser results in thick and rough surface layer. The small grain surface layer is created with appearing surface cracks and blisters.

2. The laser remelting with preheating of specimens causes the decrease in corrosion resistance of the Ti6Al4V alloy, scarcely dependent on pre-heating temperature.

3. The observed corrosion effects may be attributed to high stresses causing the formation of numerous surface cracks which may act as corrosion tunnels.

4. The remelted in any way the Ti6Al4V alloy can be used for implants in conditions of high wear but the decreasing corrosion resistance excludes such application before the surface cracks are removed by any mechanical finishing treatment

References

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