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Laser Cladding of Bronze on Aluminum Alloy

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تغليف البرنز على سبيكة الومينيوم باستخدام الليزر

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Abstract:
Laser cladding is considered as a strategic technique, since it can yield surface layers that, compared to other hard facing techniques, have superior properties in terms of, pureness, homogeneity, hardness, bonding and microstructure.
A clad layer of bronze (6:6:3) formed on the Zl-105 aluminum alloy surface -using a high power CW CO2 laser. Effects of laser scanning rates on the quality of produced clad layer studied. The microstructure of clad layer examined using optical and scanning electron microscope. The produced phases and the chemical composition of the clad layer analyzed using XRD, and EDS. microhardness test profile indicated a significant improvement in the hardness of the bronze coating on the Zl-105Al.

Keywords: Laser cladding, Aluminum alloy, Bronze clad layer, Microstructure, Microhardness.

الملخص
تعتبر تقنية التغليف باستخدام الليزر ذات أهمية إستراتيجية حيث تنتج طبقة سطحية بخواص مميزة من حيث النقاء والتجانس والصلادة والارتباط والبنية الدقيقة مقارنة بتقنيات أخرى. تم استخدام ليزر ثاني أكسيد الكربون المستمر لتكوين طبقة من البرنز (6:6:3) على سطح سبيكة الالومينيوم Zl-105 . تم دراسة تأثير سرعة المسح على جودة الطبقة الناتجة. البنية الدقيقة لطبقة الغلاف أختبرت باستخدام المجهر الضوئي والمجهر الماسح الإلكتروني. الأطوار المتكونة بطبقة الغلاف تم تحليلها باستخدام انحراف الاشعة السينية وحيود طيف الطاقة. إختبار الصلادة أوضح تحسن ملحوظ في طبقة غلاف البرنز.

الكلمات المفتاحية: التغليف باستخدام الليزر ، سبيكة الومينيوم ، طبقة غلاف البرنز ، البنية الدقيقة ، الصلادة الميكروية.

Introduction:

Due to their low density and good corrosion property aluminum alloys are widely used in the automotive and aerospace industries. However their surface tribological properties such as wear are not good enough for many technical applications [1]. In order to increase their applications investigations made to improve their surface strength.
Laser surface modification introduced a method in which the surface properties of many metals and alloys have been improved significantly without effecting the bulk properties [1]. Laser surface melting, alloying and laser cladding techniques have been applied on aluminum alloys to modify their surfaces microstructure and to improve wear and corrosion resistance of the treated surfaces [2].
Laser surface cladding of Al-Si and Ni mixture and hard powders on the aluminum alloys produced a clad layer with dendritic microstructure and large degree of hardening [3]. Intermetallic compound or intermetallic matrix composites formed on the Al surface by laser cladding to study the effects of laser on the different clad layers and effect of the produced clad layers on the wear resistance of the Al [4].
In this paper bronze clad layer coated on the Zl-105 Al surface using a high power CW CO_2 laser to improve its microstructure and surface hardness.

Experimental procedure

Specimens of Zl-105 aluminum alloy (50×10×5mm) were used as substrates. The chemical composition of the Zl-105Al alloy and the bronze cladding powder are shown in table 1. The aluminum alloy samples were painted with carbon to improve their absorbtivity. About 3 mm thickness of bronze (6:6:3) powders preplaced on the Zl-105 Al. A CW CO_2 laser with an average power of 3.4 kW and 6mm beam diameter scanned the preplaced powder and the aluminum alloy substrate at different scanning rates as showing in table (2). Cross-sections of the coatings were cut and prepared for microstructure analysis. The characterization of the treated samples carried out using optical microscope and scanning electron microscope SEM. XRD, and EDS used to identify the produced phases and their chemical composition on the clad layer. The hardness profile along the depth of the cross section in the coating was tested using a Vickers hardness tester with load of 100g and a loading time of 15 seconds.

Table (1): Chemical composition of Zl-105Al substrate and bronze cladding powder.

Aluminum Zl - 105	Mg	Si	Cu	Al
Wt. %	0.35 ~ 0.6	4.5 ~ 5.5	1.0 ~ 1.5	Balance
Bronze	Sn	Pb	Zn	Cu
Vol.%	6	6	3	Balance

Table (2): Processing parameters of bronze laser surface cladding of on Zl-105Al.

Al –Zl 105	P (KW)	D (mm)	Scanning rate mm/sec.
S1	3.4	6	3
S3	3.4	6	5
S4	3.4	6	6
S5	3.4	6	7

Results and discussion:

Bronze clad layer produced on the aluminum Al-Zl 105 alloy at laser scanning rates above 200 mm/min. The produced bronze clad layer at 5mm/sec scanning rate contains more pores and cracks than the bronze clad layer produced at higher scanning rates (6mm/sec, and 7mm/sec). At scanning rates lower than 5mm/sec no clad layer produced because the bronze powder melted and dissolved completely in the aluminum melt pool. The longer interaction time between laser and the bronze melt pool at 5mm/sec scanning rate led to the deposition of more heat in the laser processing zone and the production of more pores and cracks in the produced bronze clad layer Figure.2 (a). The number of pores and cracks reduced in the clad layer at scanning rates 5mm/sec (6mm/sec and 7mm/sec) Figure 2 (b) and (c) as result of the reduction of laser melt pool reaction time .[1,2]

The main phases on the bronze coatings are Cu and Cu8Sn31as indicated in the XRD spectrum Figure 1.

The bonding between aluminum Zl-105 and the bronze clad layer is free from porosity and cracks due to the good diffusion bonding occurred at the melt pool in the interface region[5] Figure 3.

The rapid resoldification of the laser rapidly melted bronze powders on the aluminum Zl-105 alloy surface produced a clad layer with homogeneous refined dendritic microstructure figure 4 (a). The microstructure of the clad layer consists of two main phases, the dark gray matrix and the white distributed particles in it as shown in the SEM micrograph Figure 4 (b).

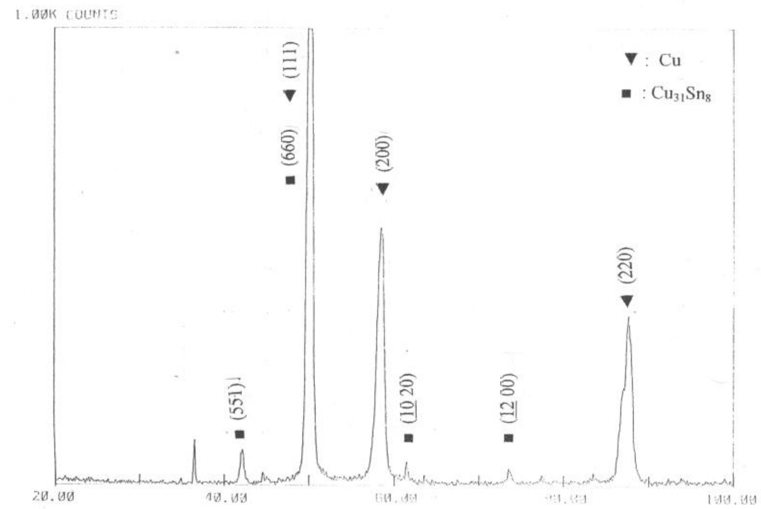


Figure (1) : XRD spectrum of the bronze laser clad layer on the Zl-105Al alloy.

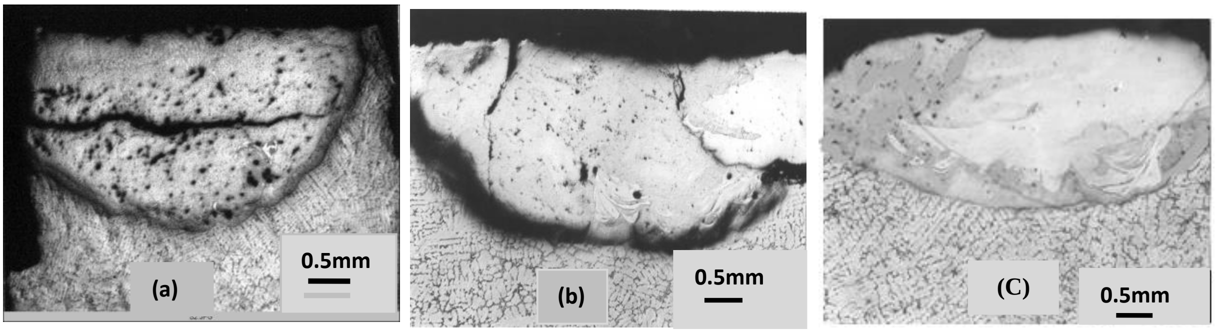


Figure (2) : Bronze clad layer produced at 5, 6 , 7 mm/sec laser scanning rates onthe Zl-105 Al.

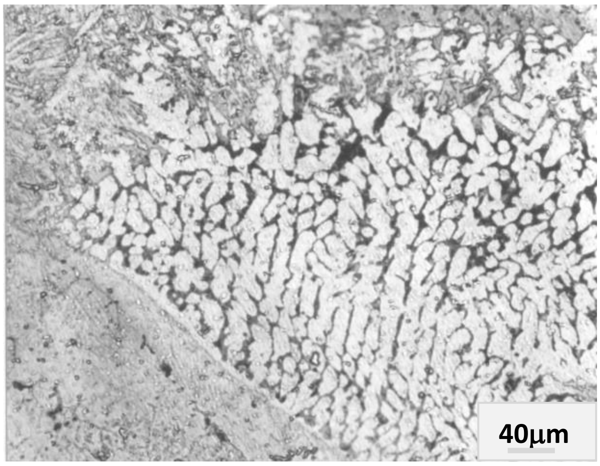
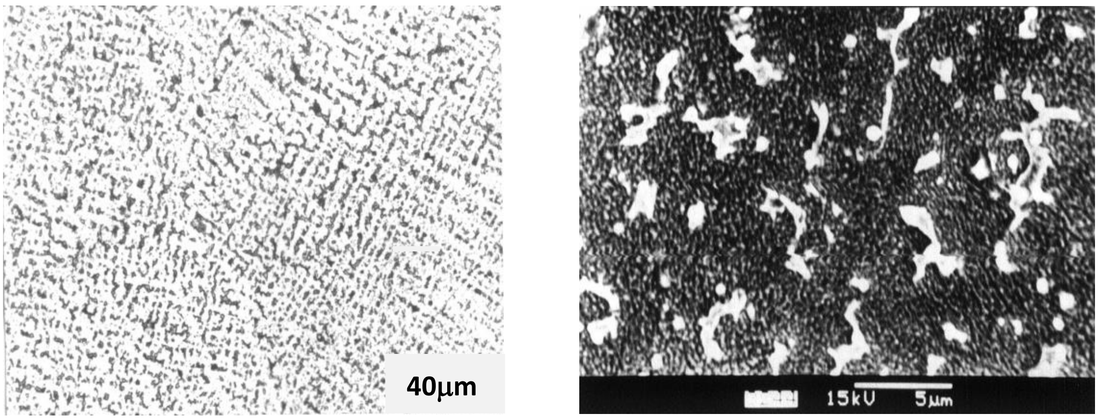


Figure (3): Interface between cladding layer and Al Zl-105 aluminum substrate.



(a) **(b)**

Figure (4) : OM and SEM micrograps of the bronze clad layer microstructure.

The EDS analysis indicated that the present of high percentage of tin and copper in the gray matrix and copper in the white distributed particles .[5]

The microhardness test carried out on the bronze clad layer and aluminum Zl-105Al alloy indicates a significant improvement in the hardness as shown in the hardness profile Figure 5. The hardness on the clad layer surface reached up to 450HV. A gradual decrease in the hardness as we move deeper from the surface far from the laser-processing zone to reach as low as 150HV-100HV on the interface region and lower than 100HV on the Zl-105 aluminum alloy.

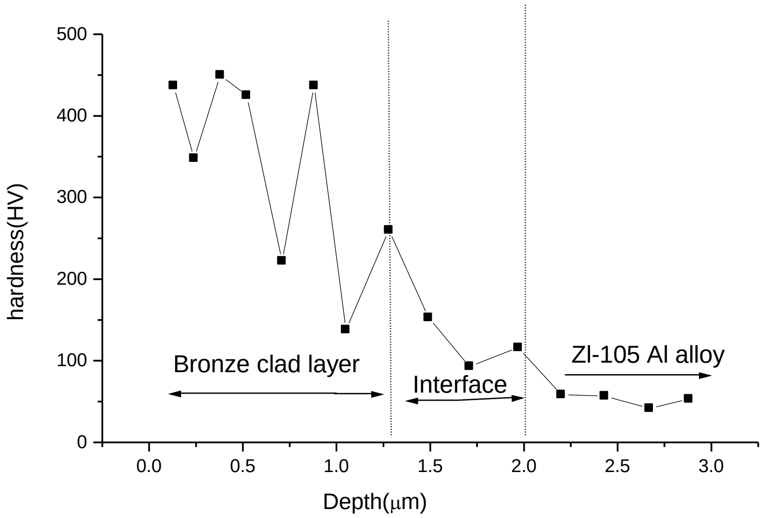


Figure (5): Microhardness distribution of the bronze clad layer and the Zl-105Al.

Conclusion

A bronze laser clad layer with a good bonding to the surface of Zl-105 Al alloy produced at laser scanning rates higher than 200mm/min on the Zl-105Al. The observed pores and cracks on the clad layer reduced at higher laser scanning rates. Significant hardness improvement obtained on the bronze clad layer.

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