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Cooper-Carbide Composite Layer Obtained By Laser Beam Remelting

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ABSTRACT

The paper presents some investigations about the influence of the laser welding parameters on the melting of single and dual pass weld in the case of thin carbide composite layers deposited on the copper sample. The additional WC powdered material was embedded into the copper sample surface, using the laser beam remelting process. The structural characteristics and geometric thickness of the melted zone were measured in order to establish the correlation between the penetration and the carbide distribution for different values of welding parameters. At the same time, the extension of the dilution phenomena was estimated, depending on the values of the linear energy at welding.

INTRODUCTION

Copper and its alloys constitute one of the major groups of commercial metals. They are widely used because of their excellent electrical and thermal conductivities, outstanding corrosion resistance, ease of fabrication, and good strength and fatigue resistance. Other useful characteristics include spark resistance, metal-to-metal wear resistance, low-permeability properties, and distinctive color [1].

One of the copper application, the electrodes for spot welding, are often subjected to wear from plastic deformation, heating, material shredding. In order to achieve those characteristics, it is important to maintain a clear geometry of the electrodes' welding area to ensure good conditions for creating the welding point [2, 3].

In order to increase the electrodes' durability, the main methods proposed to create the thin composite layers can be pulverization of the melted metal in which ceramic particles are embedded, facing with band electrodes of carbides composite core using the induction effect as a thermal source, deposit of thin straps (bands) obtained through ultra-rapid solidifying (rolls used for roll welding), deposit of a Cu-WC alloy composite layer using LASER beams [4]. Nowadays, the electrodes used for spot and seam welding are made from rolled profiles (round or plate), thermally treated, from Cu-Cr-Zn or Cu-Cr-Be alloys, metal cuts. In this case, the material usage coefficients are only 40 %. Another possible solution is

to fabricate electrodes whose active areas are made from Cu-CW sintered tips, brazed with silver alloys on Cu-Cr-Zr or Cu-Cr-Be alloys support. The disadvantages of this technological solution are the silver consumption and the limited work temperatures (600 – 800°C) [5].

The solution proposed in the paper is the development of new electrodes for spot welding reinforced using laser beam remelting and carbides embedding, that are not toxic for people and the environment, since they do not contain metallic elements such as Cr, Be, Zr. Their use allows a productivity enhancement at welding, due to the reduction of the equipment downtime [6].

EXPERIMENTAL DETAILS

1. Materials

The main paper objective was to obtain ecologic and economic bimetallic electrodes designed for the electric spot welding, having the edge made by composite materials (Cu-WC). A fundamental element of the research theme was the realization of the electrode body – composite layer interface, in order to ensure a high intensity electric current without losses and excessive local heating. To achieve the composite layer, on the surface of copper samples (Fig. 1) there were processed three grooves with 500 microns depth, then carbide powder (WC) with average grain of 13 microns (Fig. 2) has been deposited into the grooves. Before carbide deposition, the metallic surfaces were cleaned using pure propane.



Fig. 1: The copper samples for laser remelting

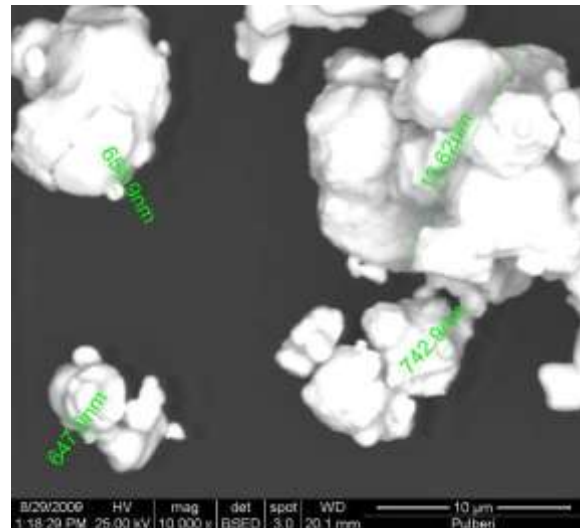


Fig. 2: The SEM aspect of tungsten carbide

2. Equipments

The Laser equipment used for remelting the carbide layers on the copper samples was a flash lamp pumped Nd: YAG low power ROFIN laser, with a wavelength of 1.06 µm (fig. 3).



Fig. 3: The laser equipment used for remelting and the image of the remelting process

3. Parameters

The laser remelting parameters used for obtaining the composite layer are presented in table 1. As can be seeing in fig. 3, during the laser beam remelting, some carbide particles become fluid and are sputtered from the remelting area. As can be seeing in table 1, only the focal spot value has been changed, in order to extend the remelting area. After the first remelting pass, each melted zones were remelted by another superficial laser remelting process, using the same parameters value.

Table 1 The laser remelting parameters

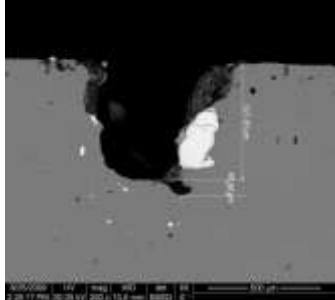
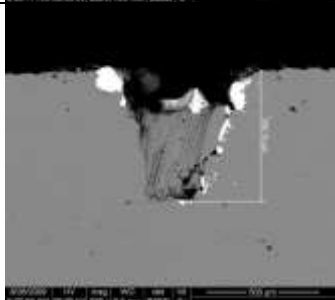
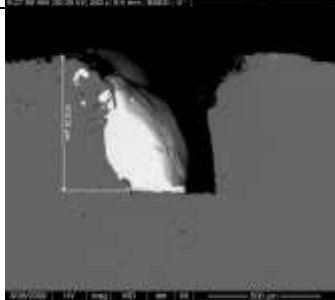
Parameters Sample	U [V]	Pulse time [ms]	Pulse frequency, [Hz]	Focal spot, [mm]
1	370	3	2	7
2	370	3	2	15
3	370	3	2	20

4. Microscopically analysis

After laser remelting, the samples were cut-off using a diamond disc, and then were prepared for SEM analysis (polishing and etching by immersion). For each remelted zone, the penetration (table 2) was measured and examined, at different magnifications, the structure of the mixed zones and carbides distribution (fig. 4, 5, 6).

In order to estimate the dilution phenomena, some chemical analysis along the mixed zones has been done using EDAX ZAF quantification technique (table 3).

Table 2 Penetration measurement of the remelted zones

Sample	Average penetration [μm]	SEM image
1	527.45	
2	590.10	
3	616.34	

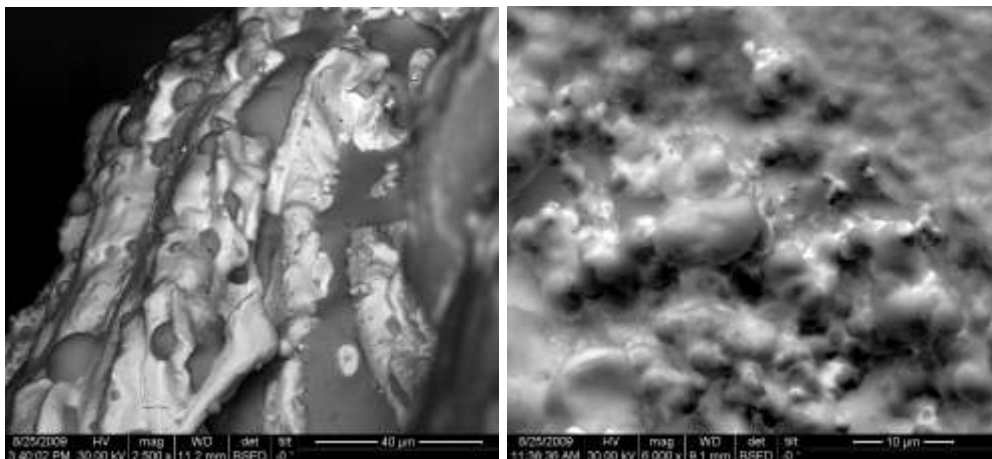


Fig. 4 The mixed remelted zone for sample 1

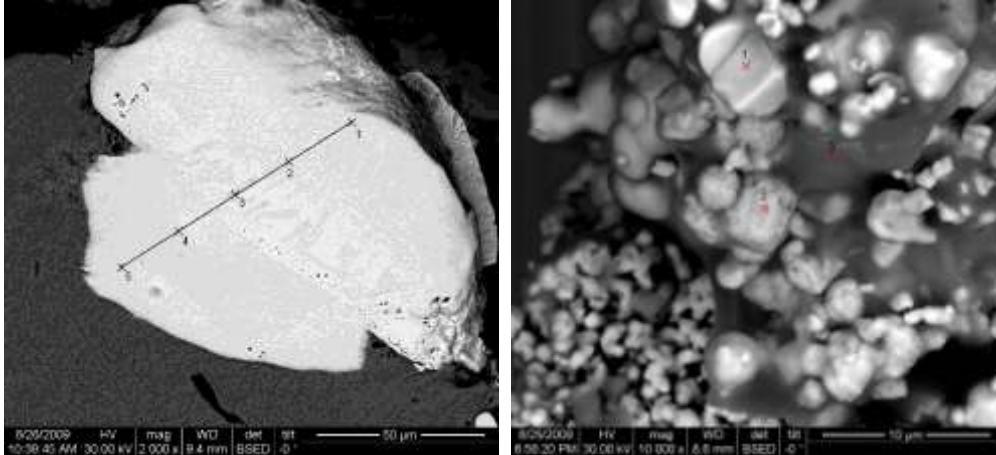


Fig. 5 Carbide interface and remelting effects of sample 2

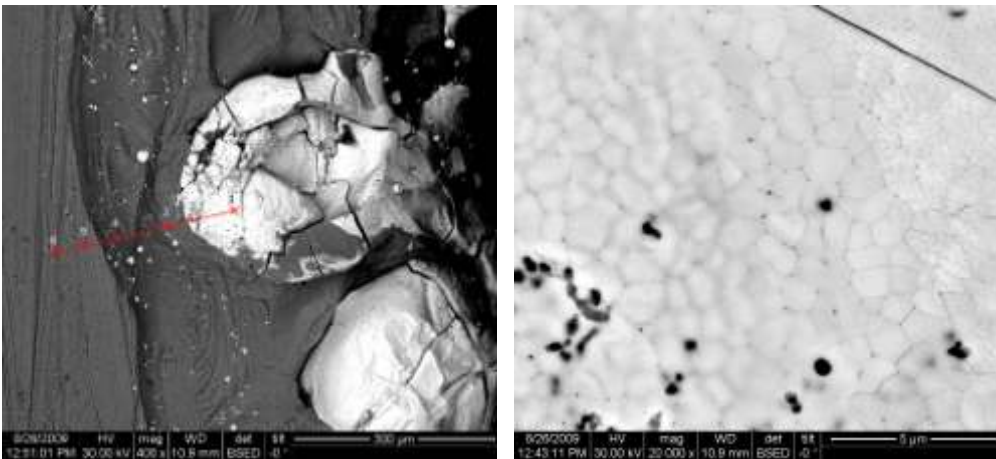


Fig. 6 Overview of the remelted zone of sample 3

Table 3 EDAX ZAF Quantification (Standard less)

Element	Wt %					
	Sample 1		Sample 2		Sample 3	
	Carbide zone	Cooper zone	Carbide zone	Cooper zone	Carbide zone	Cooper zone
C	0.69	0.70	0.12	0.70	0.41	0.21
Cu	7.82	92.62	10.10	92.21	1.88	99.50
W	87.89	3.31	89.78	7.09	97.71	0.29

Analyzing the values of major elements (Cu, C, W) of the laser remelted areas is found that the tungsten dilution occurs into the copper matrix, on the less extensive areas. For a low value of the focal spot (7mm) it is found that a fragmentation effect of carbides and mechanical mixing with copper matrix, at a moderate amount of penetration (about 527microns) (Fig. 4).



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By increasing the value of focal spot to 15 mm, the tendency is to constitute formations rich in W particles, having a coherent interface with the metallic matrix and cellular growth appearance during solidification (Fig. 5).

With increasing the value of focal spot to 20mm, there is an increase in penetration of remelted zone and an extension of the dilution effect. Also, there is a trend of fragmentation of tungsten rich particles (Fig. 6).

CONCLUSIONS

- Laser beam welding allows the obtaining of composite layers of tungsten carbide embedded into the copper matrix, applying two successive remelting passes.
- The carbide particles form melted interfaces (cellular growth like) can be fragmented during solidification.
- Carbide tends to agglomerate during the laser beam remelting process and form some large coherent plackets with the copper metallic matrix.
- The extension of the dilution phenomena is limited to about 50 μ m, depending on the values of the linear energy at welding.

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