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Laser Welding quality for some CoCrMo Dental Aloys

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Introduction

Removable partial dentures are such prosthesis, which can be inserted and take it out voluntary, by patient, in and from oral cavity. These components are consisted from a metallic part and an acrylic one (Baba et al, 2005), (Bertrand et al. 2004), (Bortun et al. 2008), (Bridgeport et al. 1993). Many problems are met when removable partial dentures made of cobalt based alloys are reoptimized by laser welding (Ghiban B., 1999), (Ghiban B., 2007), (Ghiban B., Bortun C.M., 2009). The aim of present paper is to make a correlation between welding parameters and macro and micro-structural aspects form some cobalt based alloys used for removable partial dentures.

Material and Methods

Two dental alloys, such as alloy "C" and WIRONIT were investigated in order to put in evidence main structural characteristics after laser welding. Chemical compositions of experimental melts, in cast state with dimensions 10x20mm and thickness of 0,4mm - 1mm, are shown in table 1. The welds were made in butt joint configuration without filling material. Equipment parameters of laser welding are adjustable: impulse power, period and frequency. Different investigations were made on welded samples: macrostructural analysis made on a stereomicroscope type OLIMPUS SZX and microstructural analysis made on Reichert microscope. Stereomacrostructural analysis was made using different magnification, putting in evidence the structural discontinuities. Metallographic analyses were made on Reichert microscope, in two states, etched and non etched, using IMAGE PRO soft for image processing.

Alloys	Chemical composition, % with Co base					
	C	Cr	Mo	Ni	Fe	Si
"C"	0.29	26.5	5.35	0.60	0.64	0.97
Wironit	0.35	26.4	5.38	0.85	0.74	0.89
ISO 5832/4/	Max 0.35	26.5 -30	4.5-7	Max 1.0	Max 1.0	Max 1.0

Tab. 1: Chemical composition of the experimental alloys

Results

Results concerning the macrostructural features of welded samples made on stereomicroscope type Olympus are given in figure 1, for "C" alloy, and in figure 2, for Wironit alloy. Microstructural analysis results are given in figure 3 for alloy "C" and figure 4 for Wironit alloy.

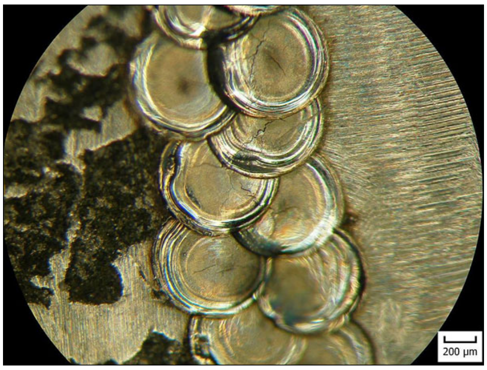

Fig. 1a: Stereomacrostructural aspect of "C" alloy samples, weld on both faces with an initially small spot, then a big spot in zigzag, after applying different welding parameters: power 0.8, frequency 3 and time 1.4 s

Fig. 1b: Stereomacrostructural aspect of "C" alloy samples, weld on both faces with an initially small spot, then a big spot in zigzag, after applying different welding parameters: power 1.5, frequency 1 and time 1.7 s

Fig. 1c: Stereomacrostructural aspect of "C" alloy samples, weld on both faces with an initially small spot, then a big spot in zigzag, after applying different welding parameters: power 2, frequency 1 and time 1.7 s

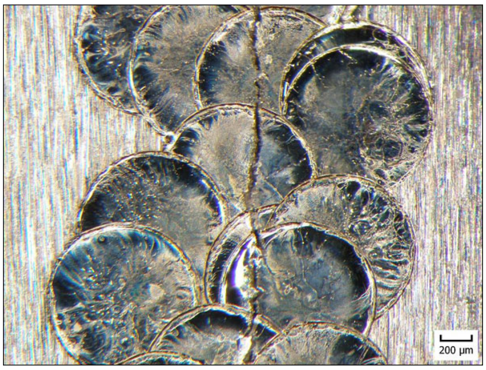

Fig. 2a: Stereomacrostructural aspect for Wironit alloy samples, weld on both faces with an initially small spot, then a big spot in zigzag, after applying different welding parameters: power 0.8, frequency 3 and time 1.4 s

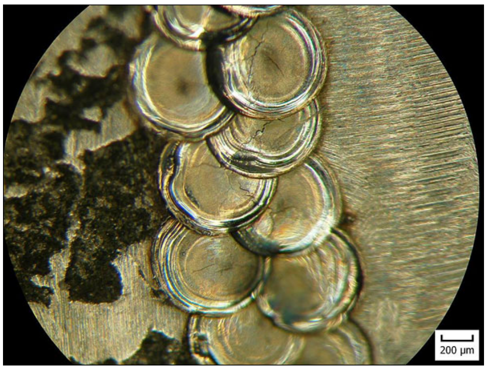

Fig. 2b: Stereomacrostructural aspect for Wironit alloy samples, weld on both faces with an initially small spot, then a big spot in zigzag, after applying different welding parameters: power 1.5, frequency 1 and time 1.9 s

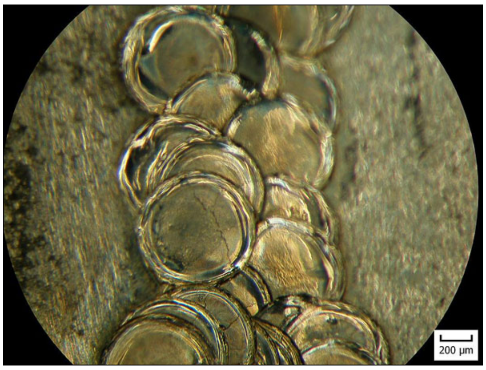

Fig. 2c: Stereomacrostructural aspect for Wironit alloy samples, weld on both faces with an initially small spot, then a big spot in zigzag, after applying different welding parameters: power 2, frequency 1 and time 1.9 s

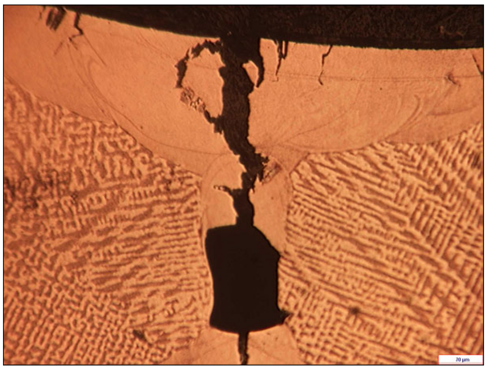

Fig. 3a: Microstructural aspect of "C" alloy sample, weld on both faces with an initially small spot, then a big spot in zigzag, (attack HCl+ K2S2O4, x200), with different laser parameters: power 0.8, frequency 3, time 1.4 s

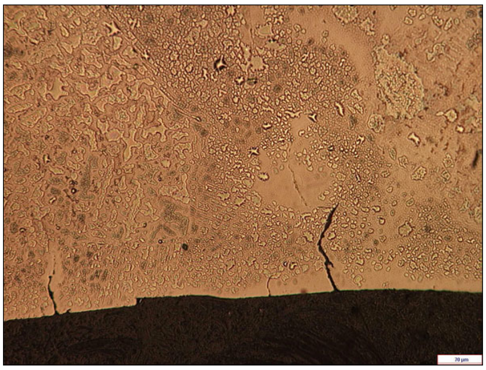

Fig. 3b: Microstructural aspect of "C" alloy sample, weld on both faces with an initially small spot, then a big spot in zigzag, (attack HCl+ K2S2O4, x200), with different laser parameters: power 1,5, frequency 1, time 1,9s

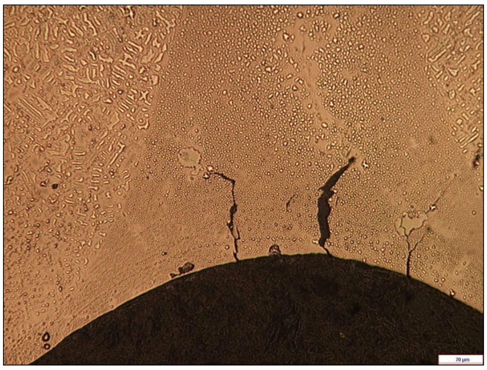

Fig. 3c: Microstructural aspect of "C" alloy sample, weld on both faces with an initially small spot, then a big spot in zigzag, (attack HCl+ K2S2O4, x200), with different laser parameters: power 2, frequency 1, time 1,7 s

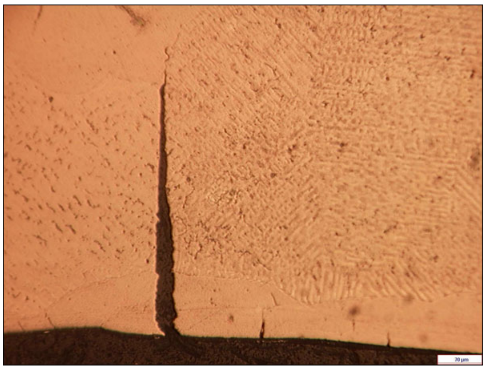

Fig. 4a: Microstructural aspect of alloy "Wironit", weld on both faces with an initially small spot, then a big spot in zigzag, (attack HCl+ K2S2O4, x200), with different laser parameters: power 0.8, frequency 3, time 1.4 s

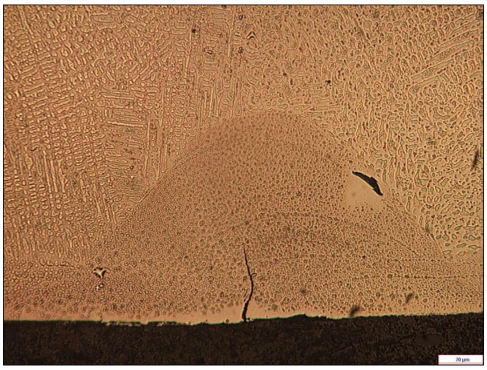

Fig. 4b: Microstructural aspect of alloy "Wironit", weld on both faces with an initially small spot, then a big spot in zigzag, (attack HCl+ K2S2O4, x200), with different laser parameters: power 1.8, frequency 1, time 1.9 s

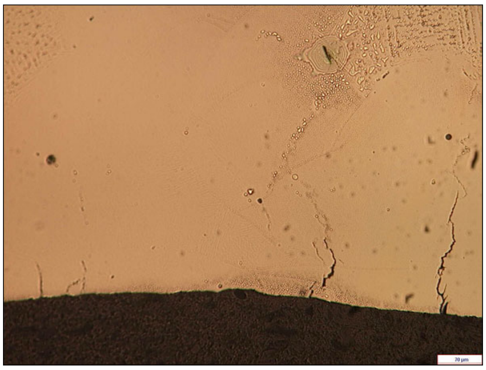

Fig. 4c: Microstructural aspect of alloy "Wironit", weld on both faces with an initially small spot, then a big spot in zigzag, (attack HCl+ K2S2O4, x200), with different laser parameters: power 2, frequency 1, time 1.9 s

Conclusions

Interesting aspects may be drawn from stereomicrostructural analysis. At very low spot power, about 0,8, at both alloys the join is not realized by welding, the fracture of the component taking place (see figure 1a, and figure 2a). By increasing of the spot value, at about 1,5, the join become better, no fracture of component taking place (see figure 1b for alloy "C", and figure 2b for Wironit alloy). At higher spot power, about 2, the laser welding become better and only fine radial cracks being observed at the stereomicroscope. Microstructural analysis may reveal different behavior of these alloys after laser welding. So, laser welding of alloy "C" at low spot power (about 0,8) put in evidence the bad join of the components, with multiple cracks, missing join in the center of the sample, (figure 3a). At higher spot power for welding of the "C" alloy, in weld metal many carbides are precipitated and also only fine cracks, generated through welding, up to 40 µn;m may be met, only at one part of the sample (figure 3b). At spot were about 2 for alloy "C" a heterogeneous dendrite structure may be seen and in welded metal the existence of generated cracks by laser beam, from the top to the center of the sample with length about 40-80 µn;m (figure 3c). Similar aspects concern structural fractures may be reveal from Wironit alloy analysis. So, at low spot power parent metal consists in solid solution with dendrite segregation, but the join is not possible to be made as is shown in figure 4a. At 1,8 spot power the structure of the parent metal consists in big dendrites with different orientation, and in welded metal many cracks with transcrystalline propagation, length 200 µn;m and distance about 5-8 µn;m, figure 4b. At high spot power, about 2, the parent metal has a dendritic structure, with different orientation of the grains with closed axes and big length and in welded metal there are met on both sides cracks, about 70 µn;m, with a propagation in zigzag (figure 4c).

One may remark that with application of different welding parameters, welding join results can be either good or bad. In general, the parameter with a great influence is the spot power, which varies from different values: 0,8; 0,9; 1; 1,5, 2 or higher. Both alloys, either "C" alloy, or Wironit alloy have a similar behavior by initially applying of a small spot power. Applying an initially small spot, at a smaller value than one leads to a failed join. The sample did not join, breaking may appear at different steps: immediately after welding, or during the preparation of sample for macro- or microstructural analyses. Summarized results concerning structural behavior of laser welding cobalt based alloys are given in table 2. One may reveal the conclusion that when a spot power is applied above two value, joins start to be good, complete, without any cracks in weld metal.

Spotpower (frequency 3, time 1.4)	Cobalt alloy	
	"C" alloy	Wironit alloy
0.8	failed join, quick fragmented after welding	failed join, quick fragmented
0.9	failed join, fragmented at metallographic preparation	failed join, fragmented during metallographic preparation
0	cracks in weld metal with length about 200µm	after welding the sample is braking during the metallographik preparation

1.5	success join, but with 120µm cracks	success join, fine cracks in weld metal
2	success join, fine radial cracks	success join without cracks in weld metal

Tab. 2: Structural features of different laser welded samples

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This Poster was submitted by Alexandru Ghiban.

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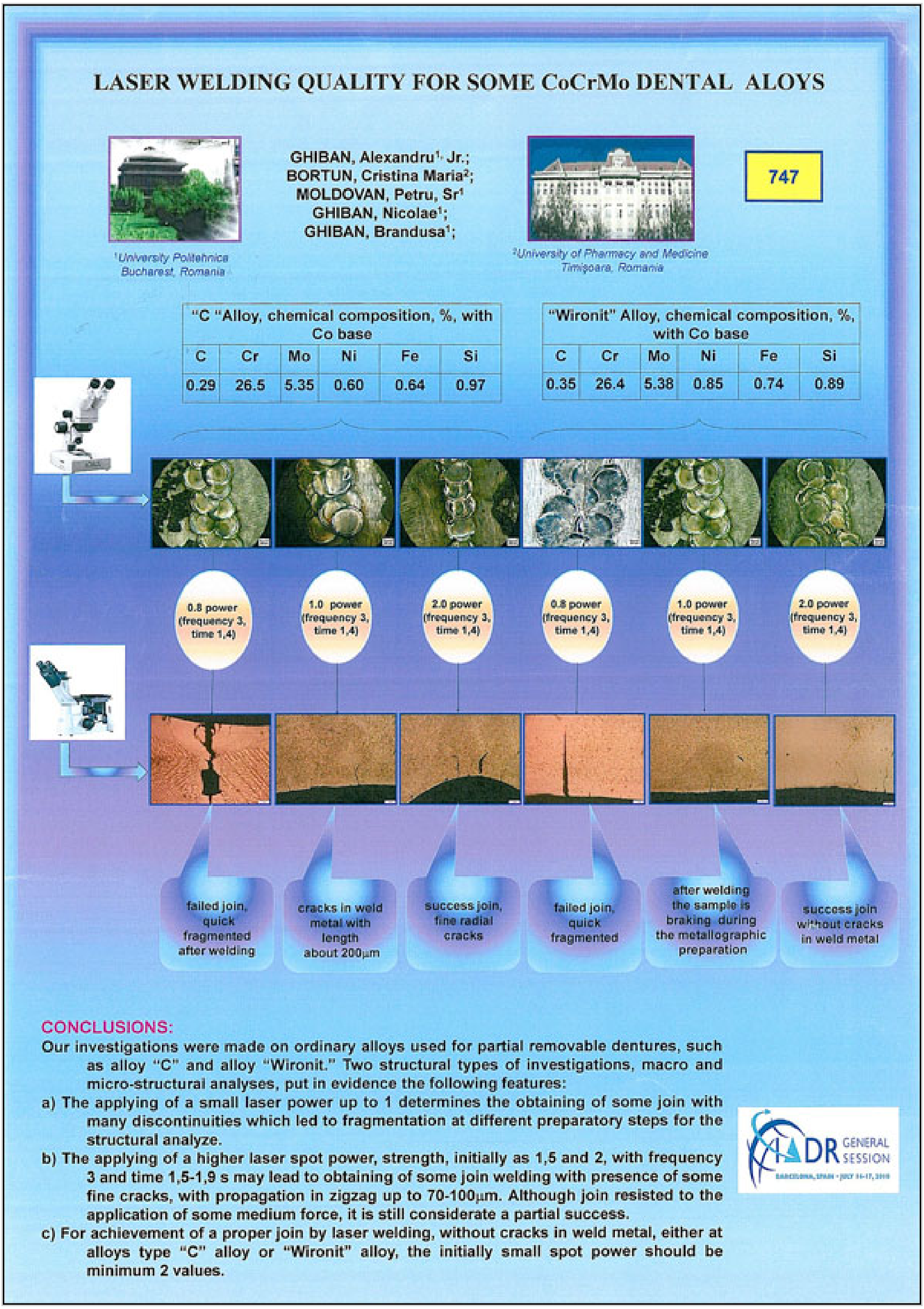
Poster Faksimile:



LASER WELDING QUALITY FOR SOME CoCrMo DENTAL ALOYS

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"C "Alloy, chemical composition, %, with Co base					
C	Cr	Mo	Ni	Fe	Si
0.29	26.5	5.35	0.60	0.64	0.97

"Wironit" Alloy, chemical composition, %, with Co base					
C	Cr	Mo	Ni	Fe	Si
0.35	26.4	5.38	0.85	0.74	0.89

0.8 power (frequency 3, time 1,4)

1.0 power (frequency 3, time 1,4)

2.0 power (frequency 3, time 1,4)

0.8 power (frequency 3, time 1,4)

1.0 power (frequency 3, time 1,4)

2.0 power (frequency 3, time 1,4)

failed join, quick fragmented after welding

cracks in weld metal with length about 200μm

success join, fine radial cracks

failed join, quick fragmented

after welding the sample is braking during the metallographic preparation

success join without cracks in weld metal

CONCLUSIONS:

Our investigations were made on ordinary alloys used for partial removable dentures, such as alloy "C" and alloy "Wironit." Two structural types of investigations, macro and micro-structural analyses, put in evidence the following features:

a) The applying of a small laser power up to 1 determines the obtaining of some join with many discontinuities which led to fragmentation at different preparatory steps for the structural analyze.

b) The applying of a higher laser spot power, strength, initially as 1,5 and 2, with frequency 3 and time 1,5-1,9 s may lead to obtaining of some join welding with presence of some fine cracks, with propagation in zigzag up to 70-100μm. Although join resisted to the application of some medium force, it is still considerate a partial success.

c) For achievement of a proper join by laser welding, without cracks in weld metal, either at alloys type "C" alloy or "Wironit" alloy, the initially small spot power should be minimum 2 values.

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