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Electron scanning microscopy analysis of fracture surfaces in laser welded samples of hardmetals

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Hardmetals of tungsten carbides in a cobalt matrix have been attempted to weld in similar joints by Nd/YAG laser in continuous wave mode. The combination of mechanical and thermo-physical properties of these materials poses a significant difficulty in welding these materials, especially for grades with low Co content, as 6 to 12% in volume. However, grades with higher Co content also showed a poor weldability. In fact, when welding hardmetals with a Co content of 25% in volume, a large amount of pores was observed on the fracture surface.

Analysis under scanning electron microscopy showed these pores were coated with a thin film. Observations with energy dispersive spectroscopy (SEM-EDS) revealed this film is rich in cobalt and is highly unstable. Figure 1 shows the characteristics of the film around a pore evidencing its corrugated aspect originated during rapid cooling conditions verified during laser welding.

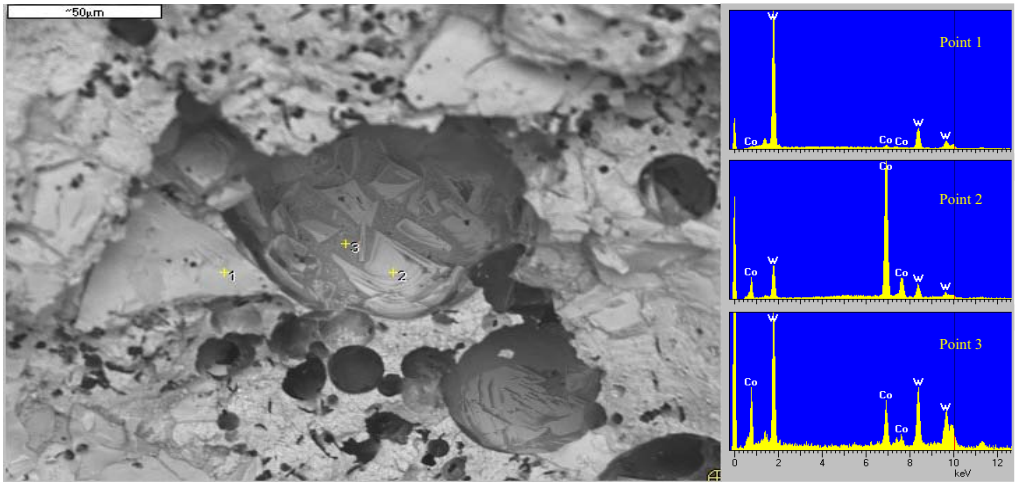

Fig. 1. SEM backscattering image of a fracture surface in a laser welded sample. Local EDS analysis shows a Co-rich film coating pores walls.

Shatov et la. [3] studied cracking mechanisms in cemented carbides and identified a brittle intertranscrystalline fracture of the carbides followed by a ductile rupture of the binder at the interface binder/carbide.

Analysing the fracture surface of GD 50 laser welds under SEM it can be seen that fracture is mostly due to transcrystalline fracture through the carbide crystals identified by a river like marking pattern as shown in Fig. 2.

Disperse microporosity was observed at the root of the weld. When there was a lack of penetration this microporosity was seen along the plate thickness due to insufficient gas protection and material reaction with air environment.

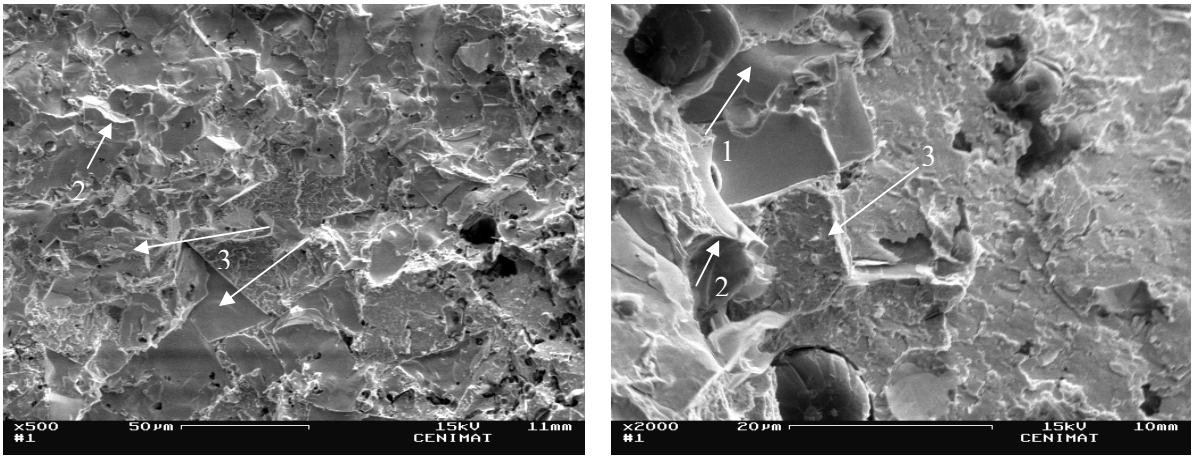

Fig. 2. Fracture surface observation of GD 50 in SEM with secondary electron beam showing three fracture modes: (1) fracture along carbide phase; (2) intercrystalline carbide; (3) transcrystalline carbide.

Fracture occurs on the fusion zone parallel and transverse to the weld direction in a brittle like mechanism showing transcrystalline cracks and intergranular ones.

Small pores were seen on the surface which are not the major cause for failure since induced residual stresses computed are above the material strength.

References

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