# Evaluation of WC-9Co-4Cr laser surface alloyed coatings on stainless steel


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## Introduction

- WC belongs to the group of advanced ceramic materials with great industrial importance and well known as hardfacing material with Co or Ni alloys as binders.
- WC cermets decarburize with the formation of CO or $CO_2$ which result in the formation of pores in the coating. This could limit the wide-scale industrial recognition of this composite.
- Laser surface alloying gives a perfect adhesion of coating to the matrix with minimal heat affected zone.
- With the addition of Cr and optimum laser processing parameters, a pore and crack free coatings can be fabricated.
- Therefore, it would be of scientific and commercial interest to investigate the addition of Cr to WC cermet.

## Objective

- To evaluate the influence of Cr addition to WC-Co cermet by laser surface alloying.

## Experimental

- A pure agglomerated and sintered WC-9Co-4Cr with average particle size of 26 μm was used as the reinforced powder.
- The surface melting operation was conducted using a 4.4 kW Nd:YAG laser with laser power of 2.0 kW, scanning speed of 0.6 to 1.2 m/min, beam size of 3 mm and shield gas flow rate of 2 L/min.
- Microstructural characterization of the coatings was performed to identify the phases present and the coating thickness.
- The Vickers hardness was determined using a 100gf load.

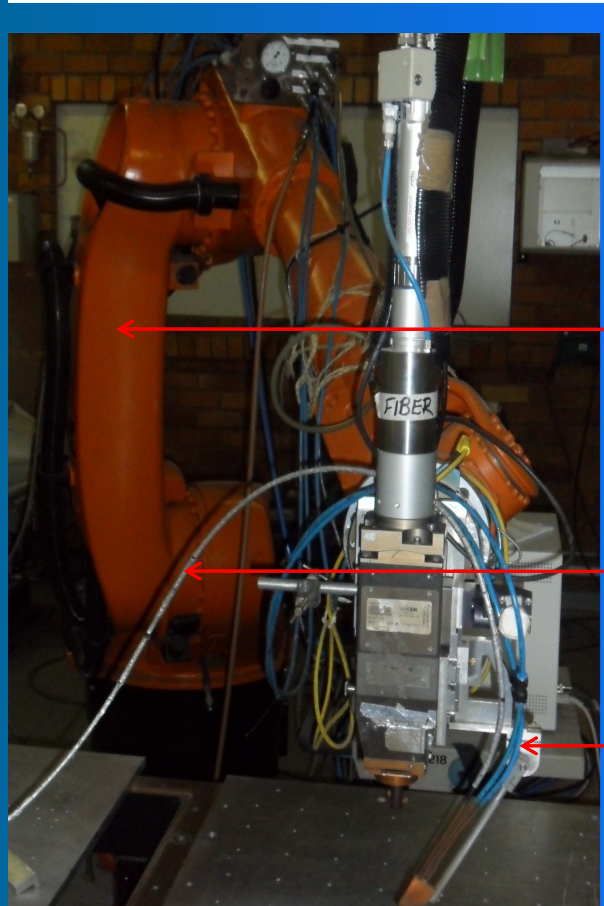


Figure 1 Nd:YAG laser


Figure 2 Vickers Hardness tester

## Results

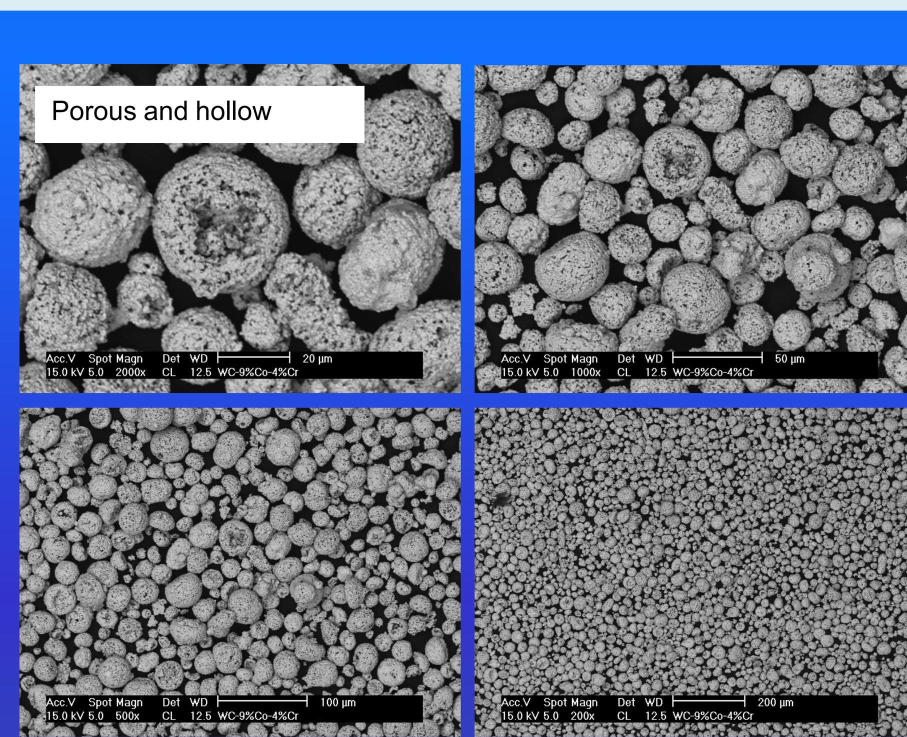


Figure 3 Microstructures of WC-9Co-4Cr powder at different magnifications

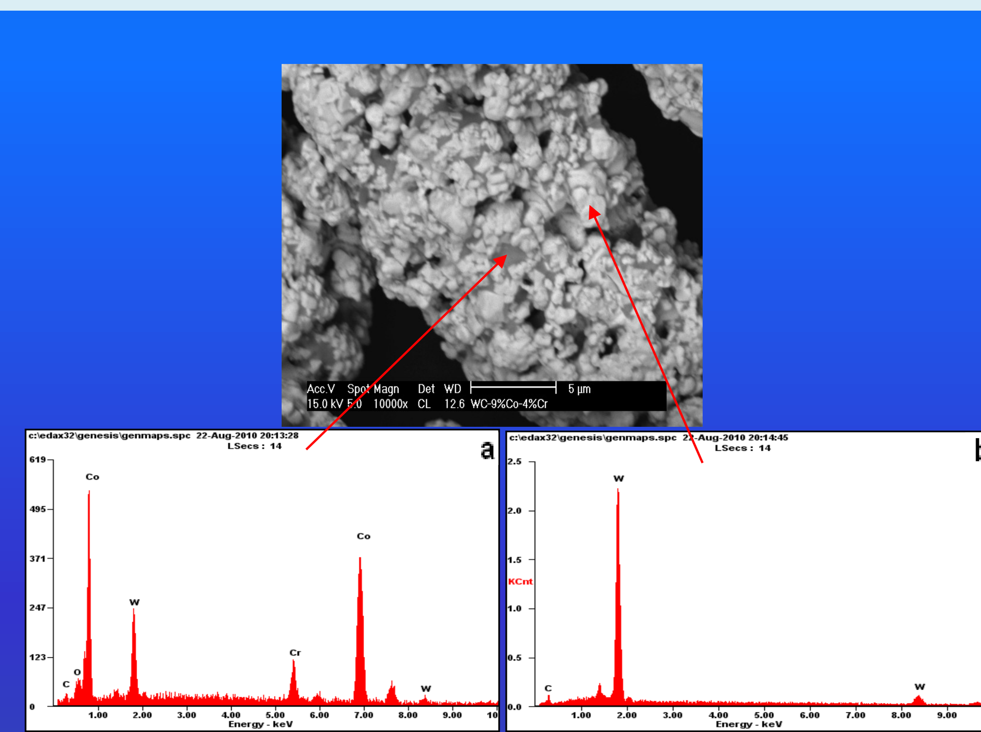


Figure 4 SEM and EDS results of WC-9Co-4Cr showing (a) Co-Cr binder and (b) WC

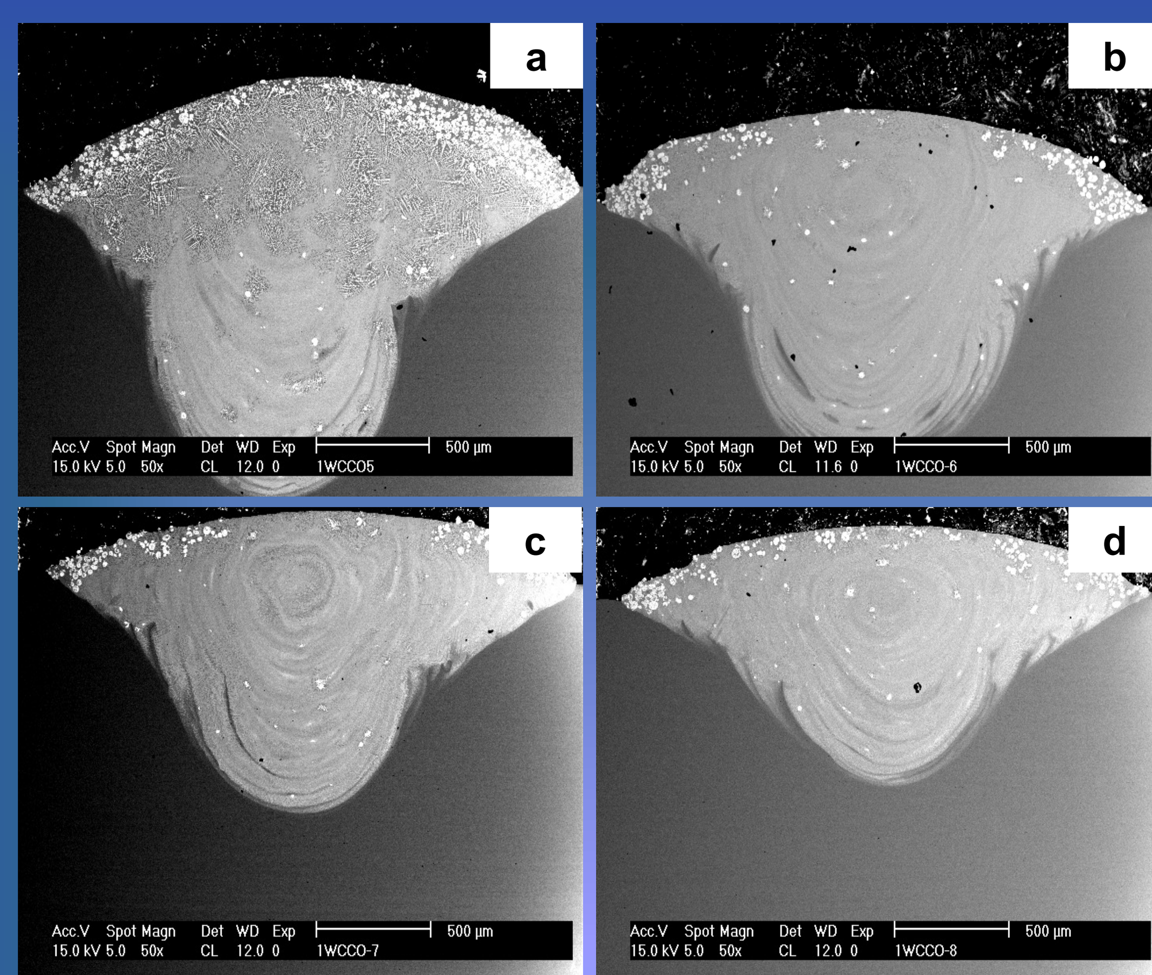


Figure 5 SEM micrograph of 304L stainless steel alloyed with WC-Co-Cr at laser power of 2.0 kW and scanning speed of (a) 0.6 (b) 0.8 (c) 1.0 and (d) 1.2 m/min

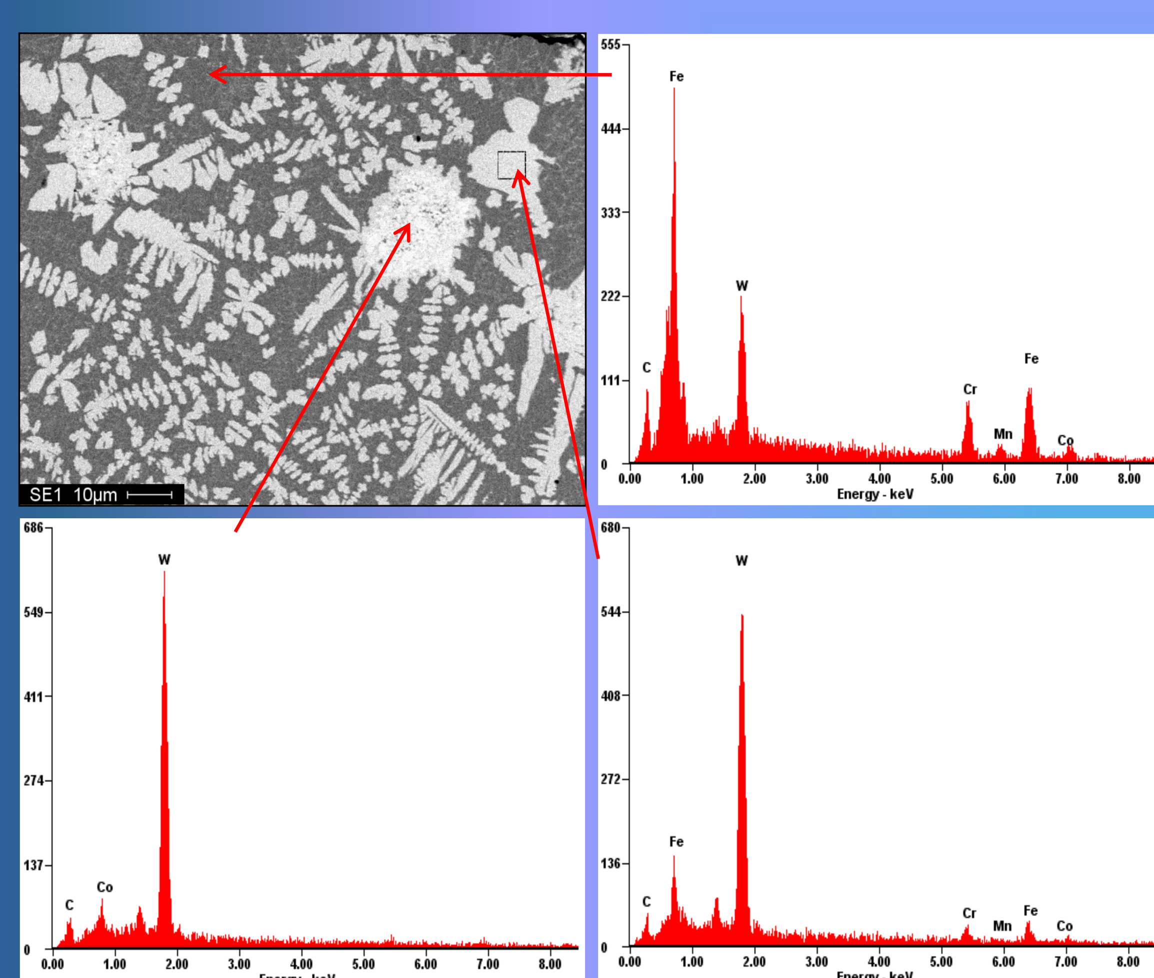

Figure 6 SEM image and EDS point analysis of phases present at laser power of 2.0 KW and scan speed of 0.6 m/min

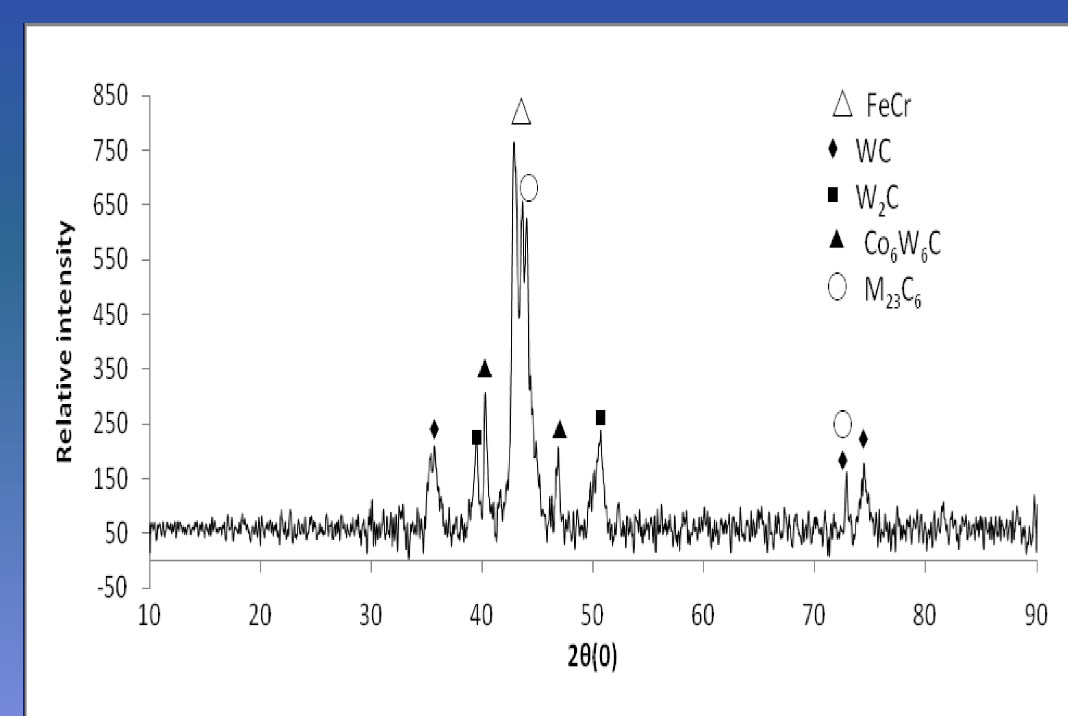


Figure 7 X-ray diffraction pattern of coating layer alloyed with WC-9Co-4Cr

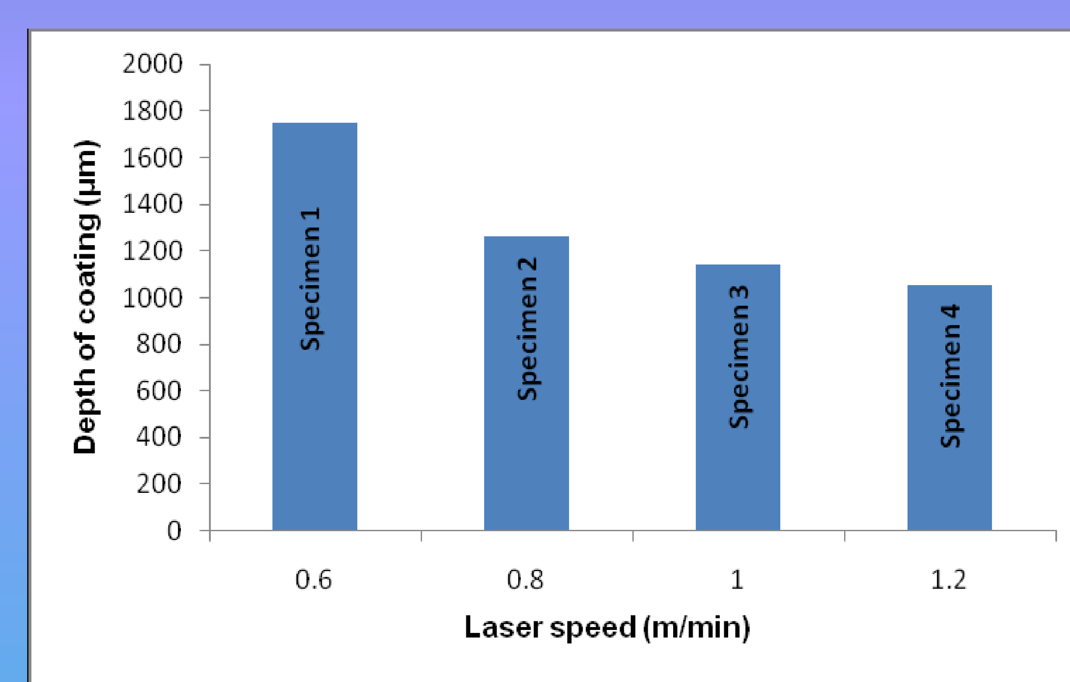


Figure 8 Depth of alloyed layers with respect to Scan

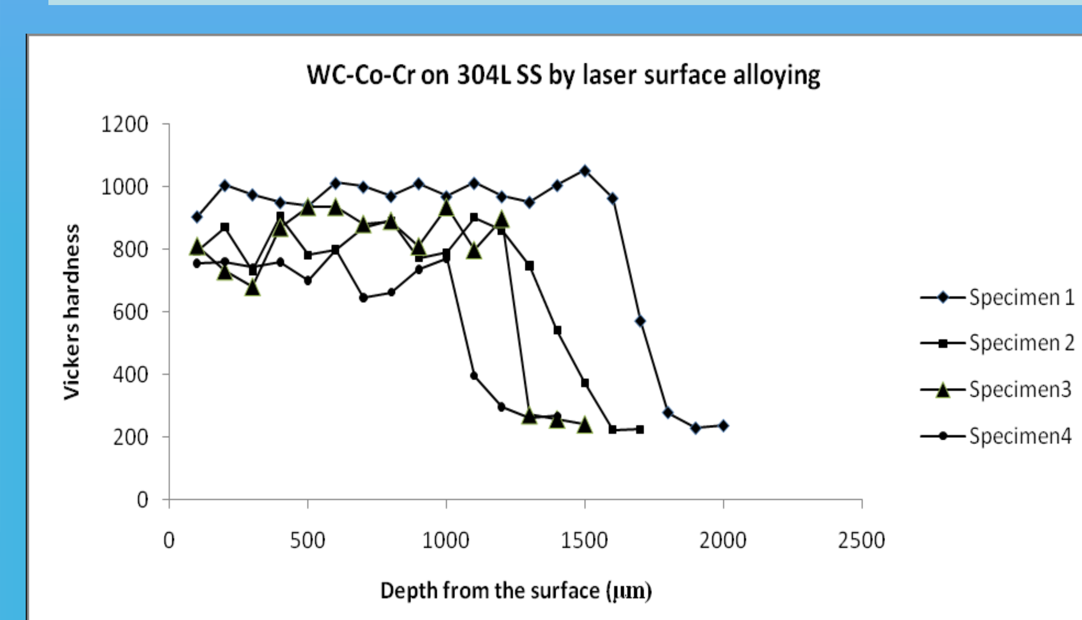


Figure 9 Microhardness distribution of coating layers

## Discussion

- The variation in thickness is depended on the laser power and scan speed. At lower scan speed, the laser irradiate the sample longer, thus wide and deep melt pool forms.
- The high wettability of WC and strong convection aids the intensive mixing and uniform distribution of carbides in the melt pool.
- The presence of undissolved carbides at the surface is due to rapid solidification of the meltpool.
- A coated layer without cracks and pores was formed on sample a.
- Since the amount of $W_2C$ is small, the effect of decarburization on the mechanical properties of the coating layer will be very small.
- Microhardness values obtained for the samples are 955, 816, 804 and 617 $Hv_{0.1}$respectively
- The different value of the hardness in the matrix was influenced by the laser speed for the entire specimen as more carbides is expected at lower scan speed.

Table 1 Hardness values

| SAMPLE (TIC+304L) | AVERAGE VICKERS HARDNESS ($Hv_{0.1}$) COATINGS | MATRIX | DEPTH (μm) |
|---|---|---|---|
| a | 955 | 246 | 1750 |
| b | 816 | 236 | 1260 |
| c | 804 | 242 | 1140 |
| d | 617 | 250 | 1055 |

## Conclusions

- 304L can be fabricated by laser surface alloying without pores and cracks at laser power of 2.0 kW and scan speed of 0.6 m/min.
- The microhardness value of the matrix can be improved significantly from 246 to 1331 $Hv_{0.1}$