LASER ALLOYING OF ALUMINIUM TO IMPROVE SURFACE PROPERTIES

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Aluminium is vastly used in industry due to its low cost, light weight and excellent workability, but lacks in wear resistance and hardness. Laser alloying is used to improve the surface properties such as hardness by modifying the composition and microstructure of the surface without affecting the bulk properties of the material [1,2]. The process involves melting the substrate surface and injecting the powder of the alloying material into the melt pool. Process parameters such as laser power, beam spot size, laser scan speed and powder feed rate have to be controlled to achieve the desired surface properties.

In this investigation the surface of aluminium *AA 1200* was laser alloyed using a 4.4kW Rofin Sinar Nd:YAG laser to improve its hardness and wear resistance. The alloying was performed with different Ni, Ti and SiC powder weight ratios at 10mm/s laser scanning speed. The powder feed rate was 2-3g/min depending on the powder composition. The laser spot size was 4mm. The shielding gas used was argon at a flow rate of 4L/min.

The microstructures formed after laser alloying were examined using optical and scanning electron microscopy. The phases were identified by XRD and EDX analytical techniques. The microstructure of an aluminium laser surface alloyed with a powder containing 33.3wt%Ni + 33.3wt%Ti + 33.3wt%SiC is shown in Figure 1. The phases observed were α-Al, SiC, TiC, Al_3Ni, Al_3Ni_2 and Al_3Ti.

Table 1 shows the hardness values for aluminium and the laser alloyed surfaces. There was an increase in surface hardness after laser alloying. This increase was attributed to the formation of intermetallic. The highest hardness of 477.6 ± 105.6$HV_{0.1}$ was achieved after alloying with 70wt%Ni + 10wt%Ti + 20wt%SiC. The increase in hardness was due to the formation of the Al_3Ni, Al_3Ni_2, Al_3Ti, TiC, Ti_5Si_3 and Al_4SiC_4 intermetallic phases. The SiC formed a metal matrix composite (MMC) with aluminium. The reaction of SiC and Al results in the formation of Al_4SiC_4 and/or Al_4C_3 phases [9,10]. The aluminium carbide phase (Al_4C_3) is extremely brittle and reacts with water to form aluminium hydroxide. The Ti competed with Al for C resulting in the formation of TiC instead of Al_4C_3.

Figure 2 shows the wear rate of aluminium AA1200 and the laser alloyed surfaces. The wear resistance was improved after laser alloying. The surfaces alloyed with 20wt%Ni + 30wt%Ti + 50wt%SiC had the lowest wear rate due to high SiC content.

References

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2. Riabkina-Fisherman M, Zahavi J (1996), Applied surface Science 106: 263-267.

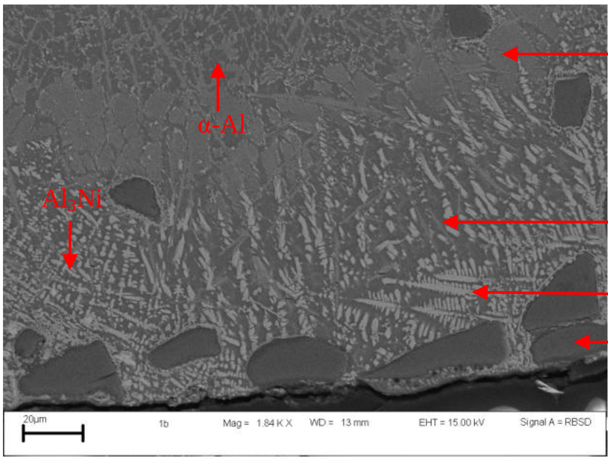

Figure 1: SEM micrograph of a surface laser alloyed with 33.3wt%Ni + 33.3wt%Ti + 3.3wt%SiC.

Table 1: Hardness of Al and the laser alloyed surfaces.

Powder Composition	Hardness ($HV_{0.1}$)
Aluminium	24.0 ± 0.4
33.3wt%Ni + 33.3wt%Ti + 33.3wt%SiC	95.5 ± 16.9
80wt%Ni + 15wt%Ti + 5wt%SiC	149.8 ± 12.9
50wt%Ni + 20wt%Ti + 30wt%SiC	94.4 ± 16.0
20wt%Ni + 30wt%Ti + 50wt%SiC	77.1 ± 21.4
70wt%Ni + 20wt%Ti + 10wt%SiC	356.8 ± 43.4
10wt%Ni + 70wt%Ti + 20wt%SiC	165.3 ± 49.5
70wt%Ni + 10wt%Ti + 20wt%SiC	477.6 ± 105.6
30wt%Ni + 40wt%Ti + 30wt%SiC	249.0 ± 118.4
40wt%Ni + 40wt%Ti + 20wt%SiC	205.7 ± 46.3

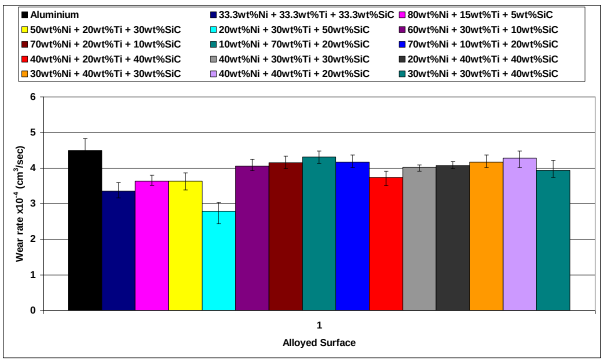

Figure 2: Wear rate of Al and the laser alloyed surface.

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