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ALUMINIUM MATRIX REINFORCED WITH DISPERSED TiC AND INTERMETALLIC Al-Ni PARTICES

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Aluminum-based alloys have poor tribological properties when compared to other metallic alloys. One of the techniques employed in enhancing the mechanical properties is the incorporation of hard secondary phases with a high elastic modulus [1,2]. The resulting alloy is a composite with new properties. This work investigates the reinforcement of the aluminum matrix with TiC ceramic and in-situ synthesized Al-Ni intermetallic particles. A combination of laser surface alloying and laser particle injection methods were used. The ceramic TiC and nickel particles were deposited into a molten aluminum surface. The surface melt was created by a moving laser beam.

The substrate material was aluminium AA 1200. Pre-mixed TiC and Ni was used as starting powders. The aluminium substrate was melted by Nd:YAG (λ=1.064μm) laser. The laser power and beam diameter were kept constant at 4.0kW and 3.0mm. The laser beam scan speed was varied from 1.2 to 2.0m/min. The processed thin layers were investigated by optical microscope and on the scanning electron microscope (SEM).

Figure 1 shows a typical morphology of the transverse section of a modified surface layer obtained with a single pass of a laser with scan speed of 1.6m/min. The depth of the modified surface layer increased with decreasing laser scan speed due to longer dwell time of the laser beam on the surface. A high volume fraction of TiC particles was injected into the molten aluminium surface. Surface cracks were observed when the laser scan speed was too slow, yet very few TiC particles were injected when the scan was too fast.

The Al-Ni phase diagram is made up of two solid solutions (Al and Ni) and five inter-metallic phases (Al_3Ni, Al_3Ni_2, Al_3Ni_5, $AlNi_3$ and AlNi). Among all these metastable phases, the Al_3Ni phase is the first to be formed followed by Al_3Ni_2 [3,4]. The stoichiometric AlNi was not formed. Figure 2 shows a high magnification SEM micrograph of this layer. The microstructure indicates the formation of Al-Al_3Ni eutectic and faceted Al_3Ni metastable phase. Some Ni particles dissolve into the Al melt to form the Al-Al_3Ni eutectic. The faceted Al_3-Ni phase crystallized as the eutectic mixture cooled. The XRD data of the sample showed the presence of Al_3Ni_2 phase near the Ni particles. This phase is formed when more Ni particles are dissolved and saturate the molten aluminium. In these experiments the single crystal Al-Ni phase was not detected. TiC dendrites were also observed in the microstructure.

In conclusion, an aluminium matrix composite reinforced with dispersed TiC and Al-Ni intermetallic articles was formed by laser surface alloying. The microstructure and compositional analysis shows that the coatings consisted of TiC particles, Al_3Ni and Al_3Ni_2 intermetallics along with Ni solid solution reinforcements.

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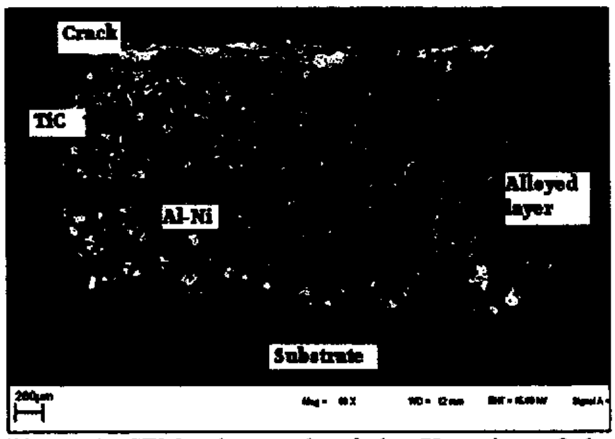

Figure 1. SEM micrograph of the X-section of the alloyed laser alloyed layer processed at scan speed of 1.6 m/min.

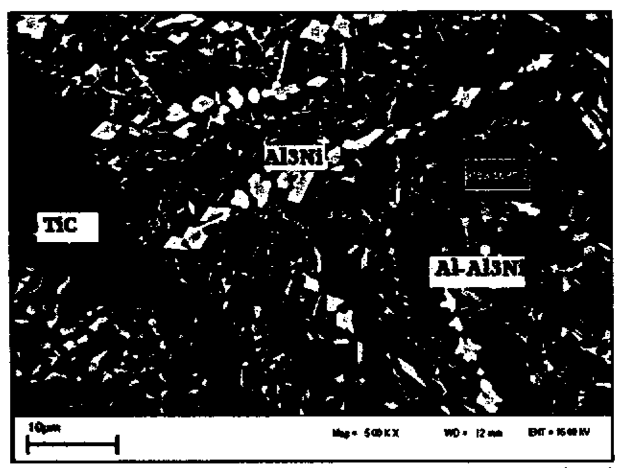

Figure 2.SEM micrograph showing Al-Al_3Ni, Al_3Ni and TiC dendrites.

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