Ti-Al Intermetallic Compound Developing by in-situ Alloying using SLM Process

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Intermetallic compounds are considered as materials having the properties between those of metals and ceramics. Their strength, Young's modulus and yield stress are higher than metals but lower than ceramics. However, their ductility is lower than that of metallic alloys and better than for most of ceramics. Ti_3Al having low density and high oxidation resistance with high mechanical properties at high temperature is suitable for aerospace applications. However, manufacturing of parts having complex shape is a limitation for application of such materials. Selective Laser Melting (SLM) opens new horizon for manufacturing of near net-shape parts made of difficult-to-form materials. However, one of the limitations of this process at present is availability of the powder. In-situ alloying of conventional Ti6Al4V powder was explored at CSEM to obtain Ti_3Al based alloy.

Intermetallic compounds were largely studied to explain their mechanical resistance and improve their ductility [1,2,3,4,5,6]. Ti_3Al Intermetallic compound having low density, high temperature mechanical properties and high oxidation resistance is used in aircraft engines and airframes [6]. High yield strength of Ti_3Al is explained by its Do19 ordered structure and lack of a significant number of dislocations which have Burgers vectors with a c-component.

As nearly all intermetallic compounds, manufacturing of complex-shape parts is a challenge if not impossible for Ti_3Al compound because of its low malleability and machinability. More than 80% of Ti_3Al produced parts are fabricated by machining with production cost about ten times more than aluminum alloys. SLM permits to fabricate parts having complex shapes and could be a solution for fabrication of intermetallic compounds. However, this manufacturing process suffers from limitation of alloyed powder availability. In-situ alloying is a method which can overcome this limitation and permits to develop intermetallic-based materials.

Present investigation focused on developing the process for manufacturing the Ti-Al intermetallic by in-situ alloying. Ti6Al4V powder was used as the base material which was blend with 6wt% of pure Al. The mixed powder was used as the feedstock for developing the process of in-situ alloying using SLM process.

BSE micrograph and XRD spectrum (Figure 1) of as fabricated material shows presence of at least two phases, hexagonal α' and orthorombic α''

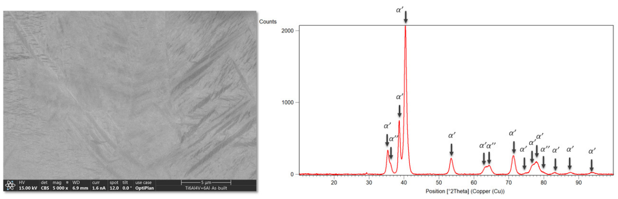

Figure 1: As built microstructure and XRD pattern. The main phases detected are, hexagonal α' and orthorhombic α''.

More detail investigation by Transmission Electron Microscope (TEM) and corresponding EDS analysis shows (Figure 2) presence of ordered TiAl based phase.

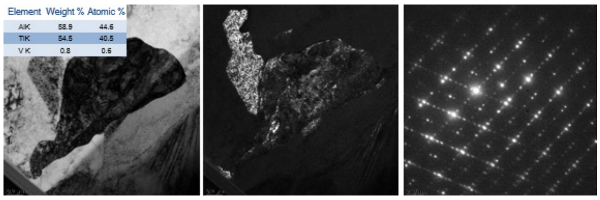

Figure 2: TEM micrographs and diffraction pattern corresponding to ordered structure.

As built samples were heat treated at 900°C 1 hr under Ar atmosphere. The main objective of the treatment was on the one hand to homogenize the alloy and on the other hand to precipitate the Ti_3Al phase.

Figure 3 shows the XRD spectrum and TEM micrographs confirming intermetallic Ti_3Al ordered structure formation.

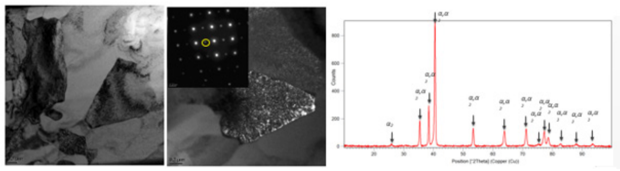

Figure 3: TEM micrographs, corresponding diffraction pattern and XRD pattern shows presence of Ti_3Al ordered structure in annealed samples.

Microhardness was measured on samples before and after the heat treatment. Measurements show that microhardness increases from 390 HV for Ti6Al4V to 460 and 487 for Ti6Al4V+ 6wt%Al as-built and annealed, respectively.

In conclusion, in-situ SLM alloying permits to fabricate the intermetallic Ti-Al when the powders are not commercially available. Process optimization permits to control the microstructure and improve the mechanical properties. Further investigation to characterize the mechanical properties and relate them to the microstructure and process is planned.

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