

Retention of Nanostructures in Plasma Spray formed Hypereutectic Al-Si Alloy Bulk Components

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The retention of nanostructures of two different plasma spray formed V2000-90B and V1999-50ksi hypereutectic Al-Si alloy bulk components is reported. The Al-Si powder as a starting material was fed internally and externally through the flame spraying system. The different nanostructures of the two spray formed samples were reported. Scanning and transmission electron microscopes provide an insight in the nanostructure of the plasma sprayed samples. The fine and homogeneous microstructures were obtained in the plasma spray formed samples compared to that of the conventional casting method.

In the process of aluminum spray forming, a microstructured aluminum powder, in this case Al -21 wt% Si powder (figure 2), is fed either externally or internally through the plasma gun that expels the powder through an inert gas across a tungsten-cathode/copper anode combination. This results in a plasma flame and high velocity molten particles being ejected from the system and deposited on the mandrel. The nozzle of the apparatus contains an arc that ionizes a gas stream of hydrogen and argon, forming the plasma with temperatures above 10,000 K. The sprayed deposit is removed from the mandrel by mechanical or chemical means, sometimes by a process of cryogenically quenching the mandrel. The mandrel usually has a thermal expansion coefficient less than that of the spray-formed composite, hence separating the two. The mandrel may be nickel-coated and super polished to result in the spray-formed component with an equal and opposite mirror polish upon removal from the mandrel. This leads to development of the application towards optical devices.

The V2000-90B sample (Figure 3) indicates the fine distribution of silicon-rich phase. The sample also designates the complete retention of the nanocrystalline structure as indicated by the SAD image of dot and ring pattern, and its EDS distribution at that distinguished area (aluminum major peak, silicon secondary peak).

The V1999-50ksi sample showed the presence of stacking faults within the grains, which impede the dislocation motion and thus enhances the tensile strength (Figure 1). The SAD (750mm) shows a clearly distinct ring pattern, which indicates the retention of the nanocrystalline structure (Figure 1).

With external feeding (V2000-90B), a less densely separated distribution and more porosity of the nanostructure compared to that of the internal feeding sample (V1999-50ksi) was observed. The differences in density and porosity can be due to higher temperatures that are encountered during internal spraying. Furthermore, manipulating the process variables can vary the overall stiffness and strength of the sprayed components/coatings.

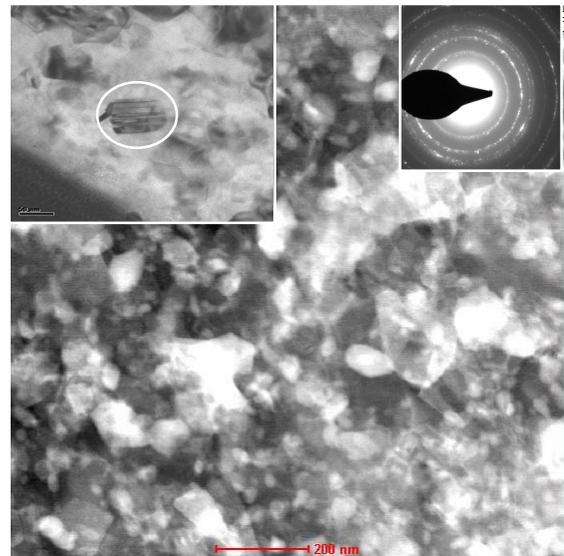


Fig.1 – TEM micrograph of V1999-50ksi sample showing SAD 750mm image (upper right). Stacking faults (upper left). Note the fine distribution of silicon.

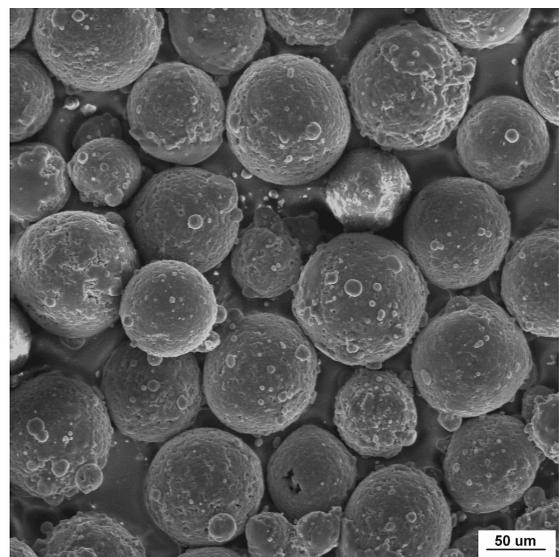


Fig. 2 – Optical micrograph of starting Al- 21wt% Si powder fed through apparatus.

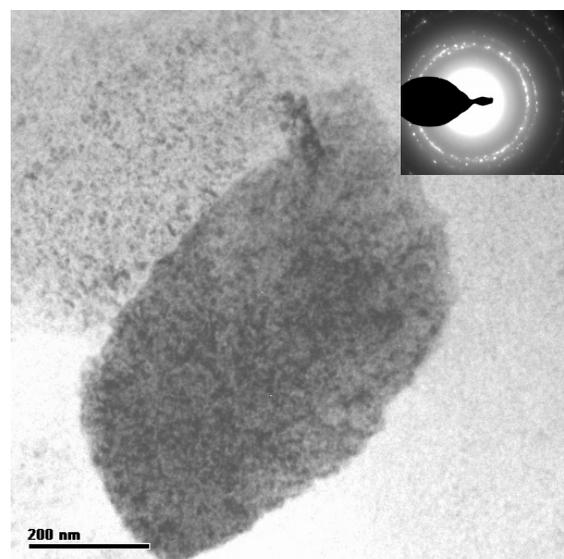


Fig. 3 – TEM micrograph of V2000-90b sample with SAD dot and ring structure designation (upper right).