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FABRICATION OF ALUMINUM MATRIX COMPOSITE REINFORCED BY SILICON CARBIDE OF VARIOUS MICRO-STRUCTURES

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1. Introduction

Metal matrix composites reinforced with high-strength fibers or particles have played an important role in aerospace and automotive industries [1]. Silicon carbide (SiC) reinforced with aluminum (Al) composites has been studied for their outstanding properties such as good wear resistance, excellent workability and high temperature strength [2]. Typical microstructures produced by various fabrication methods have simple configurations like homogeneous or graded SiC distributions in the matrix phase. In this study, spray deposition process combined with semi-solid powder processing is used to synthesize an aluminum alloy composite and to control its microstructure. Silicon carbide (SiC) reinforced aluminum alloy composites are fabricated with and without microstructure pattern. The influence of different composite microstructure on mechanical properties is analyzed by microstructure analysis, bend test and fracture analysis.

2. Experimental Setup

In the first section of experiment, powders were sprayed onto the aluminum alloy 1100 (Al1100) sheets by spray deposition, and patterned distribution of deposition structures was fabricated. For the second section, powders with the same composition as the patterned composites were prepared by mechanically mixing. The sheets and powders were then consolidated by semi-solid consolidation process, shown in Fig. 1. Twenty layers of Al1100 sheets or 0.25g mixing powders were placed in the die. The materials were heated to the target temperature in a furnace. The load and movement of the upper ram were controlled and measured by a materials testing system. The fabricated composites were prepared into three specimens: one for bend test and two for micro-structural analysis in cross sectional and planar views. Three point bend tests were performed in the MTS. The microstructures of the polished and etched samples were observed with an optical microscope and a scanning electron microscope.

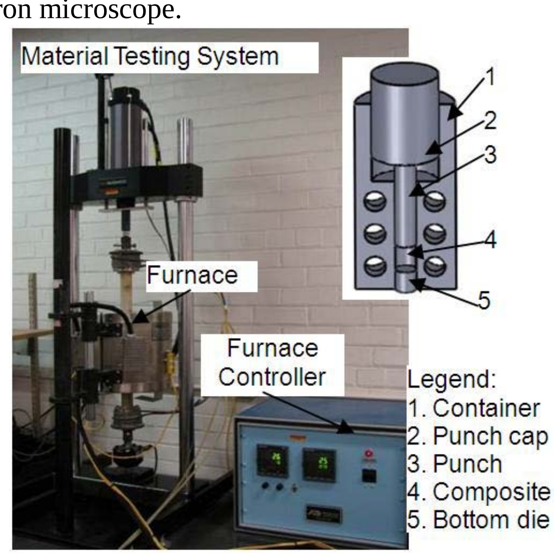

Fig. 1 Experimental setup for consolidation of composites.

3. Results and Discussion

Due to the mask, the distribution of particles on the substrate sheets, which is presented in Fig. 2(a) and (b), were well organized on the Al1100 sheets. A magnet was used to keep the contact between the substrate and mask, spray droplets were observed in the masked areas as shown in Fig. 2(b). And microstructure images of a single pattern in planar and cross sectional views are shown in Fig. 2(c) and (d), respectively. A very thin layer containing only several particles is observed. A complete circular planar view was difficult to obtain due to challenges in aligning the layers with the polisher.

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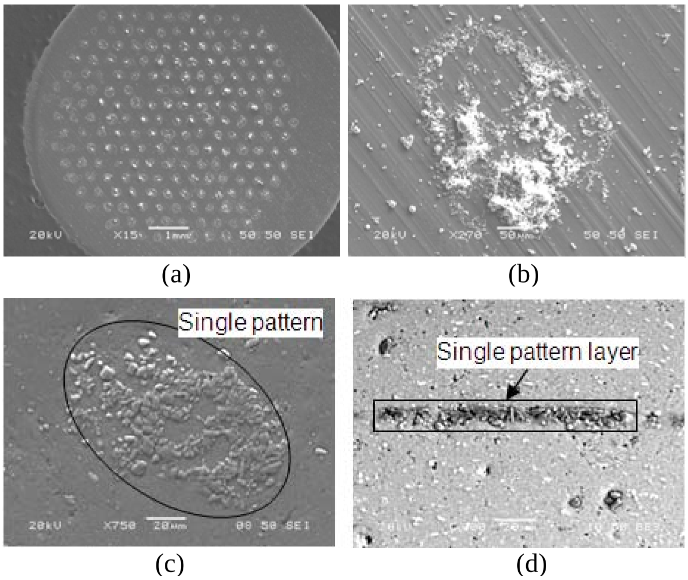

Fig. 2 SEM images of spray deposition with pattern structures and consolidated composites.

The stress-strain curves of the samples obtained from the bend test are shown in Fig. 3. Two patterned bend samples and two powder mixing bend samples were tested and their flexural stress and strain were analyzed. The equations used for the calculation of flexural stress and strain are:

$$\sigma_f = 3PL / bd^2 \quad (1)$$

$$\varepsilon_f = 6Dd / L^2 f \quad (2)$$

where σ_f and ε_f is the flexural stress and flexural strain, P is the load applied, L is the span of the supporting pin, b is the width of bend sample tested, d is the depth of bend sample tested, and D is the maximum deflection at the center of the bend sample.

Table 1: Volume percentage and flexural strength of bend samples

	Deposited powder in overall composite (vol.%)	SiC in overall composite (vol.%)	Experimental Flexural Strength (MPa)
Al-(Al6061+SiC) with pattern 1	0.89	0.35	158
Al-(Al6061+SiC) with pattern 2	2.1	0.84	171
Al-(Al6061+SiC) powder mixing 1	0.89	0.35	153
Al-(Al6061+SiC) powder mixing 2	2.1	0.84	60

The flexural stress of the Al-(Al6061+SiC) with pattern 1 composite is 158MPa, about 4 MPa more than the Al-(Al6061+SiC) powder mixing composite 1 of the same

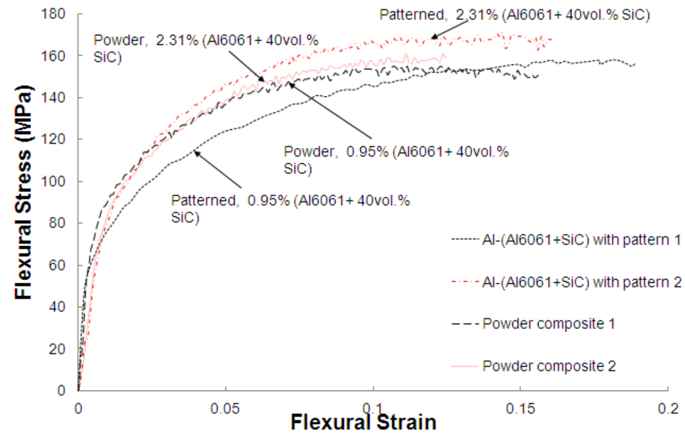

Fig. 3 Flexural stress-strain curves of Al and composites.

composition. Though the increase in flexural stress is not significant, there is a 21% increase of the flexural strain when compared with the Al-(Al6061+SiC) powder mixing composite. For the Al-(Al6061+SiC) with pattern 2 and the Al-(Al6061+SiC) powder mixing composite 2, the flexural stress and strain conditions are similar, about a 30% increase was obtained with pattern composite 2 to powder mixing composite 2. Thus, obvious increase can be observed in the bend test results of flexural strain of bend samples with the patterned microstructures, while the increase of flexural strength can be ignored.

4. Conclusions

A novel method of spray patterning combined with semi-solid processing was fabricated by semi-solid forming-joining process successfully. From the bend tests results, the flexural strain had an obvious increase while the flexural strength gained a small increase. Further analysis and testing are needed to fully explain the strengthening effect. Compositional analysis within and at the interfaces of layers are needed. Moreover, percolation threshold of reinforcing phase need to be studied. Finally, accurate loading of particles on the substrate material is required to precisely control the patterned microstructure.

5. Acknowledgements

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References

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