Study of Dielectric properties on Metal Matrix Composite of LM25 alloy with Silicon carbide by Stir casting

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***Abstract**:*
In the present study, aimed to find out the dielectric property of LM25 alloy dispersed with SiC particles by Stir casting technique. Stir casting was carried out with a continuous stirring by melting LM25 alloy and subsequent adding of SiC. Following Stir casting, a detailed microstructural and phase analysis of the composite were carried out. The hardness of the composite was measured and dielectric property was evaluated in details. Rockwell hardness of the composite was significantly improved to as high as 85 (B-Scale) as compared to 35 (B-Scale) of the as received LM25 alloy. The dielectric property of the composite samples was negative as compared to the as-received specimen.

***Keywords: S**tir casting, metal matrix composite, Silicon carbide, Al alloy, dielectric constant*

1. Introduction

Metal matrix composites are a new class of materials that exhibit good wear and erosion resistance properties, higher stiffness and hardness at a lower density as compared to the matrix. Al and its alloys are used extensively in aerospace and automotive industries because of its low density and high strength to weight ratio. However, a poor resistance to wear and erosion is of serious concern for prolonged use. The dielectric properties of a composite material depend on the dielectric constants of the components, that is, matrix and reinforcement [1]. Therefore, the ceramic particles like SiC, Al_2O_3 etc and elevated values of dielectric permittivity are strongly required for application in modern electronics [2-3]. The objective of this study was to investigate the effect of process variables on the structure, morphology, and dielectric properties of composite produced by stir casting technique.

2. Experimental Procedure

In the present investigation, LM25 Al alloy is chosen as the matrix material and SiC particles (50-100 micron size) are taken as reinforcement. The samples are prepared by stir casting method where the LM25 alloy is melted above the melting point temperature [4-5]. After melting LM25 alloy, with the help of stirrer the molten liquid is stirred. The ceramic particles SiC are added in it. Then after mixing thoroughly, the samples are prepared in a cylindrical shape by down pouring the molten metal mix as shown in figure 1. The table 1 summarizes the weight proportions used for the formation of a defect free composite

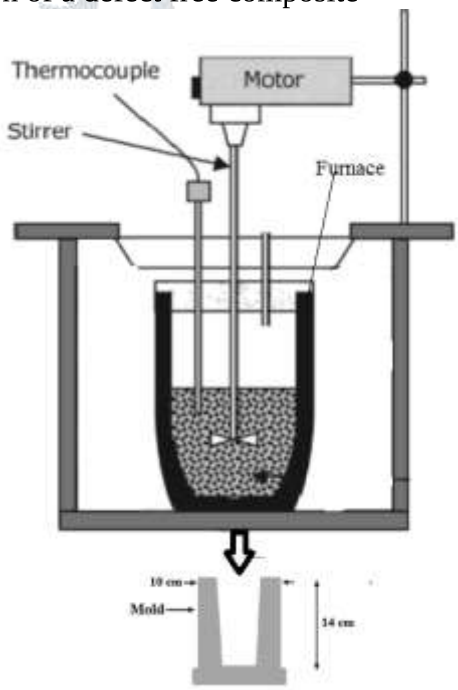


Figure 1: Schematic diagram of Stir Casting setup

Table 1: Description of sample composition

Sample	LM25 Alloy (g)	SiC (g)
1	1000	--
2	1000	20

Following composite preparation, the microstructure of the composite is characterized by optical microscopy. A detailed analysis of the phase and composition of the composite are carried out by X-ray diffraction and energy dispersive spectroscopy, respectively. The hardness of the composite is measured by a by Rockwell hardness tester in B-Scale. Finally, the dielectric properties of composite were measured with the help of LCR Meter.

3. Experimental results and discussions

In the present study, a detailed characterization of the microstructure, composition and phases of the composite LM25 with SiC is undertaken to observe the effect of SiC dispersion and rapid solidification on the characteristics of the composite In addition, the mechanical and dielectrical properties of the composite are evaluated and compared with as-received. The results of the characterization and mechanical/dielectrical properties of the composite are discussed in this section.

3.1Microstructural evolution

Fig. 2 shows the optical micrographs of the top surface of (a) as-received LM25 alloy and (b) stir casted LM25alloy with SiC. A close comparison between Fig. 1(a) and (b) shows that the microstructure is having uniform grain size for composite due to uniform heat dissipating from the alloy as compared to the as-received LM25. The grain refinement achieved is beneficial for improving the mechanical properties of the surface.

(a) As Received LM25 alloy at 450X

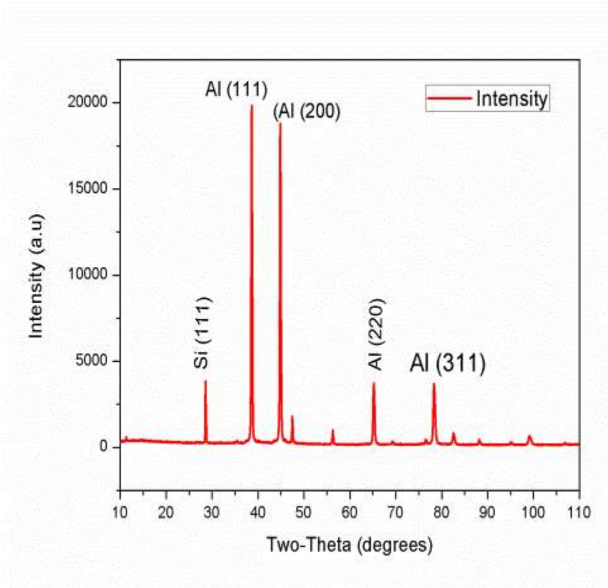
(b) Stir casted composite LM 25-SiC at 450X

Figure 2 Optical micrographs of (a) As received LM25 alloy at 450X (b) composite LM25 alloy with SiC at 450X

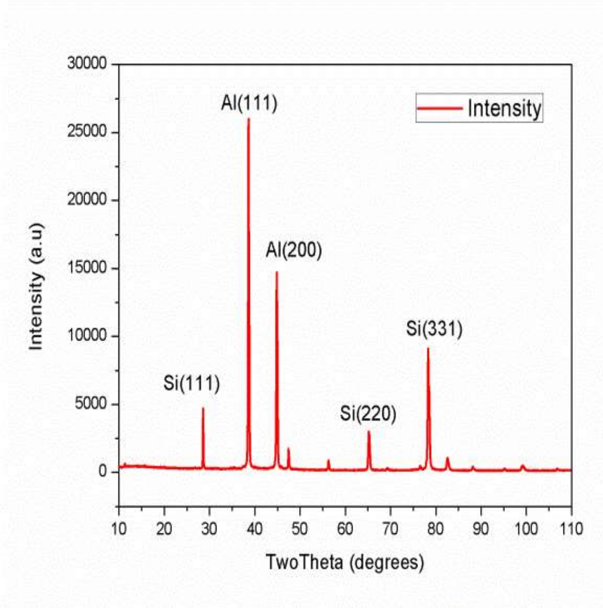
3.2 Phase analysis

A detailed phase analysis of the as received LM25 alloy and stir casted LM25 alloy reinforced with SiC was undertaken by X-ray diffraction to observe the influence of particle additions on the phase change. Fig. 3 shows the X-ray diffraction profiles of (a)

as-received LM 25 alloy and (b) stir casted LM25 alloy reinforced with SiC. A close comparisons between the X-ray diffraction profiles of as-received and stir casted LM25 alloy reinforced with SiC reveals the presence of a few Si peaks in as-received. On the other hand, stir casted LM25 alloy reinforced with SiC leads to dissociation of SiC and subsequent formation of Al_4C_3 and silicon in the matrix.



(a) X-ray diffraction profile of As received LM25 alloy



(b) X-ray diffraction profile of stir casted LM25 alloy reinforced with SiC

Figure 3: X-ray diffraction profiles of (a) as received LM 25 alloy and (b) stir casted LM25 alloy reinforced with SiC

3.3 Evaluation of mechanical properties

Figure 4 shows the hardness distribution of as received LM 25 alloy and composite. The hardness distributions measured from the hardness analysis are shown as data points. From the hardness analysis it is clear that the hardness of the as received sample is remains uniform throughout the sample. On the other hand, the hardness of the stir casted LM25 alloy reinforced with SiC also significantly improved as compared to as-received LM25. The improved average hardness in stir casted LM25 alloy reinforced with SiC is attributed to (a) grain refinement, (b) presence of Al–Si eutectic in the matrix and (c) dispersion of hard ceramic particle at the matrix.

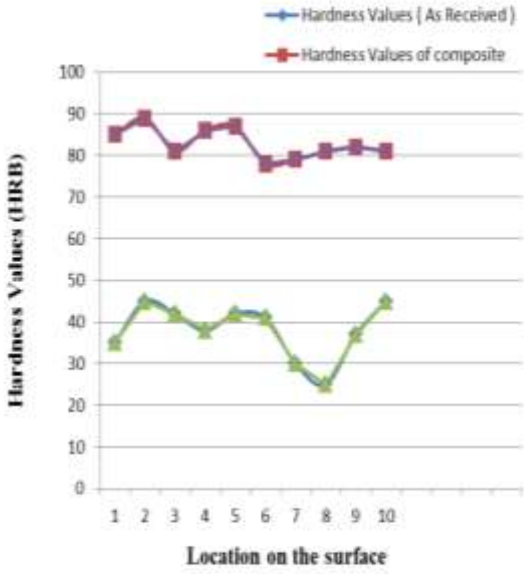
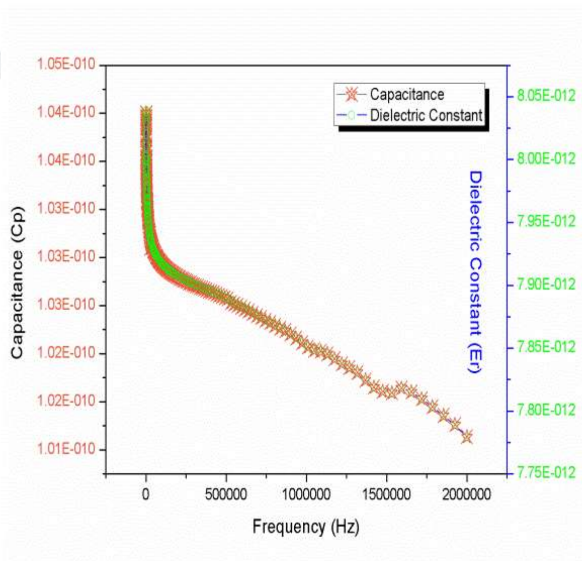


Figure 4: Average hardness distribution of as received LM 25 alloy and stir casted LM25 alloy reinforced with SiC.

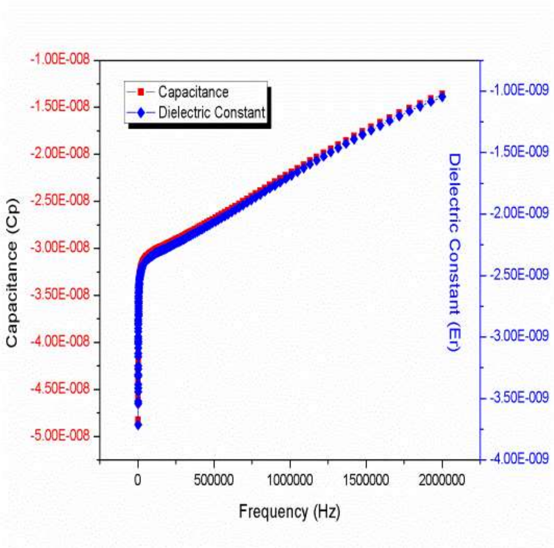
The improved hardness in the matrix is beneficial for enhancing the wear resistance property.

3.4 Evaluation of electrical properties

Figure 5 show the Frequency dependence of the dielectric constant and Capacitance for as received LM 25 alloy and stir casted LM25 alloy reinforced with SiC. The as received LM 25 alloys shows higher capacitance and Di electric constant when compared to stir casted LM25 alloy reinforced with SiC. For stir casted LM25 alloy reinforced with SiC there was a the capacitance and Dielectric constant is totally negative, which is a sign strong inductive contribution to impedance.



(a) Frequency dependence of the dielectric constant and Capacitance for as received LM alloy



(b) Frequency dependence of the dielectric constant and Capacitance for stir casted LM25 alloy reinforced with SiC.

Figure 4: Frequency dependence of the dielectric constant and Capacitance for (a) as received LM 25 alloy and (b) stir casted LM25 alloy reinforced with SiC.

4. Summary and conclusions

In the present investigation stir casted LM25 alloy reinforced with SiC have been undertaken by melting of an LM 25 alloy and mixed in the matrix with SiC. From the detailed analysis, the following conclusions may be drawn:

1. Stir casted LM25 alloy reinforced with SiC leads to formation of uniformly dispersed ceramic particles in a grain refined matrix. Presence of Al–Si eutectic lamellae was found to be present in the matrix.

2. A detailed X-ray diffraction study confirmed the presence of SiC along Si peaks.

3. The hardness is improved significantly Stir casted LM25 alloy reinforced with SiC (up to 80-90 HRB) as compared to as received LM25 alloy (40HRB).

4. For stir casted LM25 alloy reinforced with SiC there was totally negative in capacitance and Di electric constant as compared to as received LM25 alloy.

5. References

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