www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 5 Issue 09 September 2016 Page No.18132-18134

Investigation on Microstructure and Mechanical Properties of Aluminum reinforced with MWCNT and Nano-SiC

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Abstract: ***Aluminum is most preferable structural material in the field of automotive and aerospace due to its properties such as strength, corrosion resistance and being light weight. So, to enhance mechanical properties of aluminum, attempts has been made to reinforce it with ceramic materials like Multi walled Carbon Nanotube (MWCNT), Silicon carbide (SiC), separately. This paper focuses on fabrication of Aluminum (Al) with dual reinforcement MWCNT- nanoSiC by powder metallurgy method and study of mechanical properties of composite as well as its microstructure.***

Keywords: dual reinforcement, MWCNT, nanoSiC, powder metallurgy, composite.

1. Introduction

Aluminum is used in many applications as structural material due its good mechanical properties. To improve properties it has been successfully reinforced with MWCNT and nano-SiC separately. But as MWCNT is very light weight so having disadvantage of agglomeration, and also cost of MWCNT is high. Whereas SiC having advantage of low cost and better dispersion in metal matrix. So, this research has used formula of dual reinforcement to overcome disadvantage of MWCNT by using advantage of SiC.

Aluminum is chosen as metal matrix. Mixture of dual reinforcement materials MWCNT and nano-SiCis prepared in the ratio of 1:1 respectively. Reinforcement mixture is added in metal matrix composite (Al) by weight fractions of 0.5 %, 1 % and 1.5%. Mixture of Al-MWCNT-SiC of mentioned weight fractions are ball milled for uniform distribution of reinforcement material into metal matrix composite. Them ball milled mixture is compacted into billet, followed by sintering. Thus sintered billets are hot extruded to prepare samples. Samples prepared are studied for microstructure and mechanical properties.

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2. Fabrication of Composite

Pure aluminum powder of 50 mesh is bought from market. Also MWCNT and SiC nano powder (50 nm) of desired properties are procured. Mixture of MWCNT and nanoSiC is prepared in the ratio of 1:1. This dual reinforcement

Mixture is then mixed into the aluminum matrix by weight fractions of 0.5,1, and 1.5 percentages.

2.1 Ball Milling

Figure 1 shows Planetary Ball Mill setup used for ball milling. Mixture prepared is put into the planetary ball milling machine. Tungsten balls are selected using ratio of ball weight to powder weight as 5:1. Mixture is ball milled for 2 hours at 250 rpm for uniform distribution of reinforcement material.

Figure 1: Planetary Ball Mill Setup

2.2 Powder Metallurgy

After ball milling, mixture is compacted using punch and die using 450 kN load to form billet. Time lag in between ball milling and compaction of is avoided so as to avoid oxidation. Billet is then sintered using 520^0 C temperatures. Figure 2 shows Billets prepared by compaction and then Sintered in Tubular Sintering Furnace

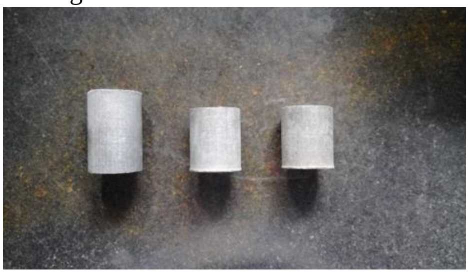

Figure 2: Billets after Sintering Process

Sintered billet is then hot extruded into rod. This rod is machined and samples are prepared. Thus samples prepared are used for measurement of Mechanical Properties. Figure 3 shows tensile testing specimens prepared for measurement of Tensile Strength, Yield Strength and Ductility of Composite.

Figure 3: Tensile Testing Specimens Of Composite

3. Micro structural Analysis

After Ball Milling of Aluminum and Reinforcement Mixture, some powder is taken out and is used for micro structural analysis. SEM images are taken to observe impregnation of MWCNT into Aluminum particles.

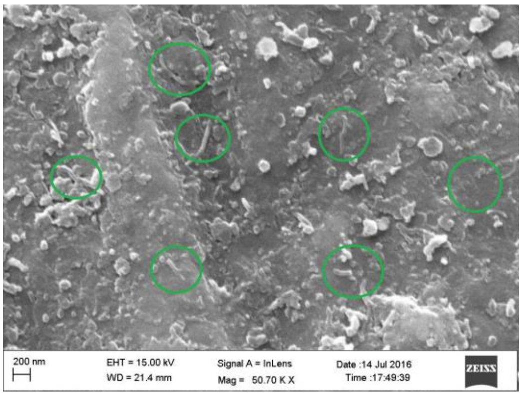

Figure 4: SEM Image of Ball milled powder of 1% reinforcement

Figure 4 shows SEM image of ball milled powder of 1 % reinforcement. It can be observed that encircled tubes like forms of MWCNT are impregnated into aluminum particle. So manufacturing of this Composite through powder metallurgy is quite effective.

4. Mechanical Properties

4.1 Experimental Density

Experimental density is calculated using Archimedes principle, and Table 1 Shows result of experimental density of composite from which it can be observed that with increase in weight percentage of reinforcement experimental density decreases. This is because of low density of CNT. And porosity problem of powder metallurgy approach.

Table 1: Experimental Density of Composite

Renforcement (%)	*Sample 1 gm/cc*	*Sample 2 gm/cc*	*Average Density gm/cc*
0	2.42	2.42	2.42
0.5	2.40	2.35	2.38
1	2.31	2.32	2.32
1.5	2.29	2.28	2.29

4.2 Hardness

Hardness is calculated using Brinell hardness tester and result in Table 2 shows with addition of CNT and SiC hardness of Composite gets increased. This increment in Hardness is due to addition of carbon in the form CNT and SiC. Maximum hardness obtained is 49 BHN with 1.5 % reinforcement.

Table 2: Hardness of Composite

Renforcement (%)	*Hardness BHN*
0	15
0.5	42
1	47
1.5	49

4.3 Tensile Strength

CNT has good tensile strength so increment in percentage of reinforcement increases the ultimate tensile strength. Extrusion aligns all CNT in metal matrix, thus improving tensile strength. Table shows Considerable increment in Tensile strength of Composite.

Table 3: Ultimate Tensile Strength of Composite

Renforcement (%)	*Ultimate Tensile Strength MPa*
0	95
0.5	219.88
1	232.50
1.5	246.41

4.4 Ductility

Result Table 4 shows ductility decreases with addition of reinforcement. This is because increase in content of SiC and CNT which increases Hardness of composite.

Table 4: Ductility of Composite

Renforcement (%)	*Ductility (%)*
0	60.01
0.5	20.96
1	20.04
1.5	19.36

5. Conclusion

Powder metallurgy process has been successfully applied to manufacture composite without considerable changes into original properties of base material as well reinforcement material. SiC is high density material so its property of good dispersion helped in uniform distribution of CNT as well as impregnation of it. Thus strength of aluminum particle is considerably improved. So study of mechanical properties shows hardness of aluminum is increased. Also Ultimate Tensile strength is increased retaining the extrusion property of material.So material finds application where good properties of material are required but weight is limiting factor.

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