A Microstructure and Dispersion study of MWCNT reinforced Aluminum alloy 5083 Metal Matrix Composites

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***Abstract*— In Multiwall carbon nanotube (MWCNT) reinforced Aluminum Nano metal matrix composites (ANMMCs), the homogeneous dispersion of MWCNTs in the matrix material as well as manufacturing problems are the major challenges. A well dispersed MWCNTs aluminum nano metal matrix composites was fabricated by using compo-casting method. In this study, compo-casting was used to disperse up to 0.7 wt% of MWCNT in an aluminum alloy AA5083 matrix. AA5083 – MWCNT sample micro-structures were studied using Field-Emission Scanning Electron Microscope (FESEM). The chemical composition of the cast materials was investigated through EDAX spectrum and the expected dispersion of the MWCNT was achieved using this method.**

Index Terms: Compo-casting, SEM, EDAX, ANMMC, AA5083.

I. INTRODUCTION

Light metals such as Al and magnesium (Mg) have been studied with much attention for being used as Aerospace, Aeronautical, Automobile, Marine and structural materials, though they lack in strength and rigidity compared with Steel. CNTs are attractive reinforcement materials for metal matrix composites not only due to their high strength and elastic modulus, but also due to their exceptionally small diameters [1]. This is because; the size of CNTs is smaller in diameter and, when the CNTs are uniformly dispersed in the composites, the respective matrix domains enclosed by the CNTs become extremely small. It is expected that this condition might produce a strong effect on the matrix metal and cause a totally new reinforcement system [2]. The primary aim was to spread MWCNTs in the matrix material. In this work Aluminum Alloy 5083 is selected as matrix material and MWCNTs as reinforcement [3]. The tensile strength of the composite material was good, when a small amount of CNT's were added (0.5 wt %). An appropriate and economical fabricating technique for MWCNT/ Al MMCs is a challenge for researches [4]. Stir casting is one of the low cost process out of available manufacturing techniques for AMCs, with advantage of low cost [9]; it also offers a wide range of material and processing conditions and can manufacture composites with up to 30% volume fraction of reinforcement with better bonding of metal matrix with reinforcement particles because of stirring action [5–13]. Due to all these advantages compo-casting process is employed in the present study for the manufacturing of ANMMCs. Therefore, this study focuses only on low cost fabrication with homogeneous dispersed MWCNT.

II. MANUFACTURING PROCESS:

The fabrication of the composites (AA 5083 and MWCNT) is executed using the stir casting apparatus Fig 1. This method is preferred for fabrication as a result of various factors such as simplicity, flexibility, mass production and the low cost of production. In this direction, the properties such as uniform distribution, porosity, wettability and chemical reaction between the matrix and the reinforcement should be analyzed efficaciously. The uniform distribution of the matrix and the reinforcement in this pursuit is conceivable due to the density facet. It is established that the density of the aluminum AA5083 is 2.66 g/cm^3 and that of the MWCNT is 2.1 g/cm^3, as both are different (Table 1 and 2 shows the chemical composition of matrix material and properties of reinforcement), so the qualified distribution is manifest. Promptly, the property of 'wettability' can be elucidated as the comfortable spreading of the liquid on the solid surface and this property should be immense in our study. In addition to that, the porosity be up to absolutely less or should not be present this much that our specimen is capably strong, durable and rigid and care should be taken to bypass porosity. Finally, the chemical reaction must not ensue between the matrix material and the reinforcement such that preservation of each of the properties is possible. In this study, the motive is to

TABLE:1 CHEMICAL COMPOSITION OF BASE METAL AA5083

Constituent	Content %
Al	Balance
Mg	4.0-4.9
Si	0.4
Fe	0.4
Cu	0.1

Mn	0.4-1.0
Zn	0.25
Ti	0.15
Cr	0.05-0.25

TABLE:2 PROPERTIES OF MWCNT

Reinforcement particles	Mean Diameter, D (nm)	Average Length, l	Density (g/cm3)
MWCNT	30 - 50	10-20 µm	2.1

Fabricate four specimens; the first specimen piece is AA 5083. The other exemplar being composites are structured with 500g of AA 5083 as the matrix and Multiwall carbon nanotube (MWCNT) in the varying compositions (0%, 1%, 1.25%, 1.5% and 1.75%) as the reinforcement.

Initially, the AA 5083 rod has to be chopped into tiny pieces and the fragments are weighed to device it to 500g. Thenceforth, the MWCNT is also measured to proposition of 1%, 1.25%, 1.5% and 1.75%from total weight of 500.

FIGURE: 1 COMPO-CASTING SETUP

In this process, the MWCNT is taken in the alumina crucible and is preheated at 773k. Later, the red hot liquid melt was degassed using nitrogen for about 3-4 minutes. The mechanism of degassing is of due significance such that it restricts the formation of oxides compounds while kneading it with the AA 5083. AA 5083 is heated to 1173K and formed to semi-solid state in the apparatus; Table 3 shows the process parameters of compo casting. Now, the preheated MWCNT is brewed with the semi-solid AA 5083 with the aid of the stirrer at 250-400 rpm.

TABLE:3 PROCESS PARAMETERS OF COMPO-CASTING (SEMI SOLID STATE)

S.No	Process Parameters	Value
1	Stirring Temperature	1173K
2	Stirring Speed	300 rpm
3	Stirring Time	2 min
4	Preheat temperature of reinforcement	773k
5	Preheat temperature of permanent mould	524k

Subsequently, the refined composition of igneous metal is poured into the molten cavity to obtain the desired composite material. Leaving the specimens in the mould, it is taken out with the assistance of the holding instrument and was cooled to the room temperature for few minutes. On that occasion, the required composite specimens of the dimension (100mm*100mm*10mm) is obtained. Thus the fabrication of the material is contrived by using compo-casting [9].

III. RESULTS AND DISCUSSION

The microstructure of cast AA 5083 (Fig.3 (b)) reveals the formation of α-aluminum network structure which is formed due to super-cooling of casting during solidification, with less impurities present [12]. The manufactured FESEM image of ANMMCs is shown in Fig 3 (b-e). The microstructure of ANMMCs shows the uniform distribution of MWCNTs along with clustering at some locations. The MWCNTs with low density compared to that of AA5083 was uniformly distributed due to compo-casting. Fig. 3 (d) shows the elemental maps of aluminum nano metal matrix reinforced with 1.5 wt% of MWCNTs. From the elemental maps of the composite it is proved that the main elements present in the ANMMCs are Al (largest amount) and C denotes the MWCNTs whereas Mg and Mn which are constituents of base metal AA5083 are also present in small amount. Table 4 shows the elements present in the AA5083 + 1.5 % MWCNTs reinforced composites with their percentage weight and atomic percentage in ANMMCs. Table 4 also shows the presence of basic elements of AA5083+ 1.5% MWCNTs reinforced nano composite in the compound form. The elemental map proves that the manufactured nano composite is reinforced with MWCNTs. Fig. 4 shows the EDAX results of manufactured nano composite.

TABLE:4 ELEMENTS PRESENT IN AA5083 + 1.5 WT% MWCNT REINFORCED COMPOSITES

Cast AA5083 + 1.5 wt% MWCNT reinforced composites			
Element	**Weight %**	**Atomic %**	**Compound (form)**
Al	80.68	70.56	Al_2O_3
Mg	1.41	1.37	MgO
Mn	0.35	0.15	Mn
O	13.43	19.80	$Si\ O_2$
C	4.13	2.59	$Ca\ Co_3$
Totals	100.00		

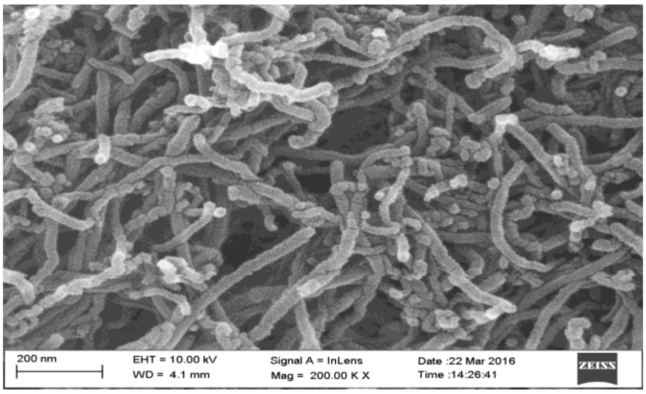

FIGURE: 2(A) FESEM IMAGE OF MWCNT

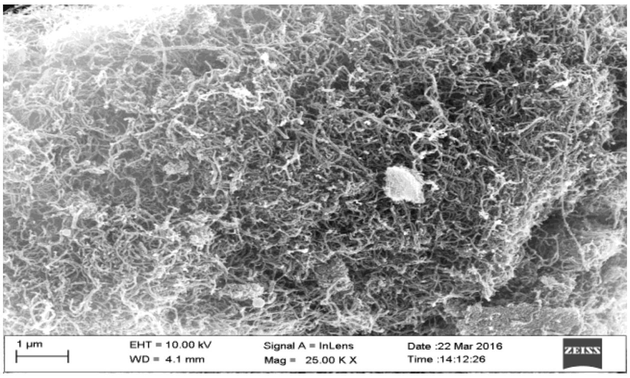

FIGURE: 2(B) FESEM IMAGE OF AGGLOMERATED MWCNT

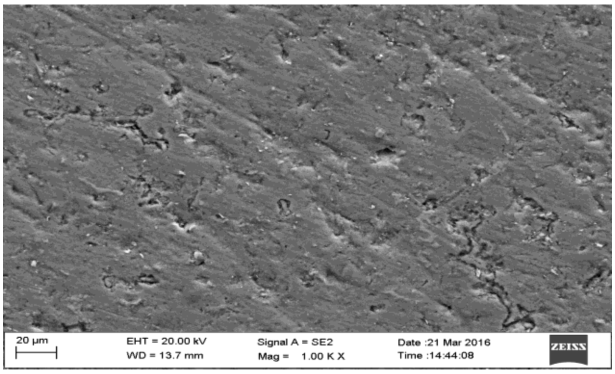

FIGURE: 3 (A) FESEM IMAGE OF CAST AA5083

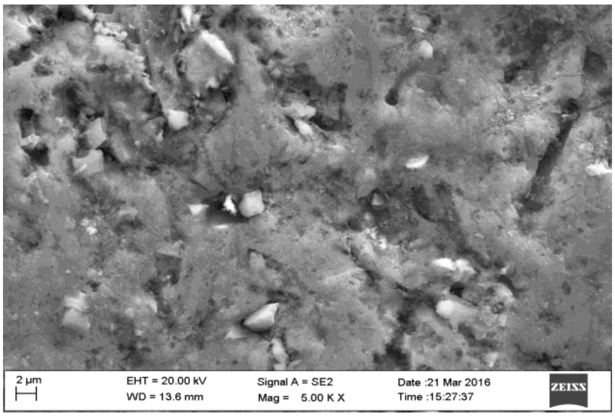

FIGURE: 3 (B) FESEM IMAGE OF CAST AA5083 + 1WT% MWCNT

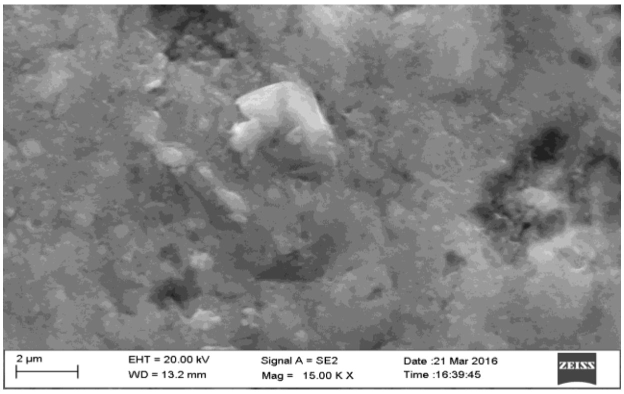

FIGURE: 3 (C) FESEM IMAGE OF CAST AA5083 + 1.25WT% MWCNT

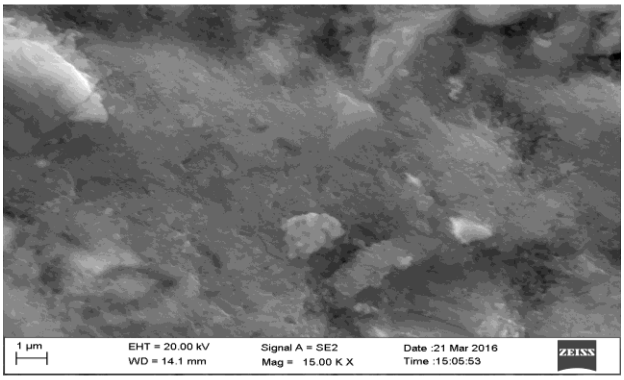

FIGURE: 3 (D) FESEM IMAGE OF CAST AA5083 + 1.5WT% MWCNT

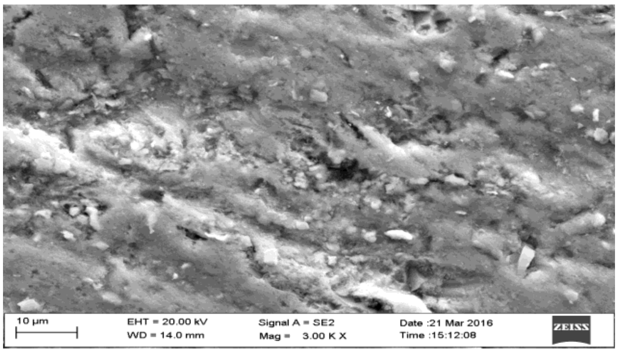

FIGURE: 3 (E) FESEM IMAGE OF CAST AA5083 + 1.75WT% MWCNT

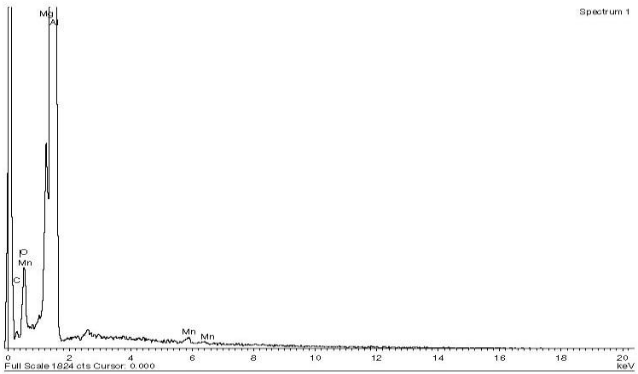

FIGURE: 4 EDAX IMAGE OF CAST AA5083 + 1.5WT% MWCNT

IV. CONCLUSION

From the present study the following concluding remarks were drawn:

1) The field emission scanning electron microscope revealed a uniform dispersion of MWCNTs in the matrix material.
2) Scanning electron microscope and EDAX elemental mapping confirmed the validation of manufactured nano composites.
3) Uniform dispersion of the MWCNTs was achieved using low cost manufacturing technique called compo-casting.

REFERENCES

[1] K.-T. Lau and D. Hui: Composites, Part B 33 (2002) 263–277.

[2] Toru Noguchi, Akira Magario, Carbon Nanotube/Aluminium Composites with Uniform Dispersion, Materials Transactions, Vol. 45, No. 2 (2004) pp. 602 to 604.

[3] Julien Stein, Influence of the concentration and nature of carbon nanotubes on the mechanical properties of AA5083 aluminium alloy matrix composites, C A R B ON 77 (2 0 1 4) pp 44 – 52.

[4] Jinzhi Liao , Ming-Jen Tan., A simple approach to prepare Al/CNT composite: Spread–Dispersion (SD) method, Materials Letters 65 (2011) 2742–2744

[5] K.R. Ravi, V.M. Sreekumar, R.M. Pillai, M. Chandan, K.R. Amaranathan and K.R.Arul, Mater. Des., 28, 871–881 (2007).

[6] K.M. Shorowordi, T. Laoui, A.S.M.A. Haseeb, J.P. Celis and L. Froyen, J. Mater.Process. Technol., 142, 738–743 (2003).

[7] I. Kerti and F. Toptan, Mater. Lett., 62, 1215–1218 (2008).

[8] M.K. Surappa, J. Mater. Process. Technol., 63, 325–333 (1997).

[9] P.S.Samuel Ratna Kumar, Multiwall Carbon Nanotube Reinforced with AA5083 using stir caasting for Better Interface, IJIRT, 1, 1678 – 1680 (2015).

[10] A. Mortensen, Mechanical and Physical Behaviour of Metals and Ceramic Com-pounds, Riso National Laboratory, Roskilde, Denmark (1988), pp. 141.

[11] B.C. Pai, K.G. Satyanarayana and P. Robi, J. Mater. Sci. Lett., 11, 779–781 (1992).

[12] M. Kok, J. Mater. Process. Technol., 161, 381–387 (2005).

[13] Pardeep Sharma, A study on microstructure of aluminium matrix composites, Journal of Asian Ceramic Societies 3 (2015) 240–244.