DEVELOPMENT AND CHARACTERIZATION OF COPPER METAL MATRIX COMPOSITE BY POWDER METALLURGY TECHNIQUE

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ABSTRACT

Composite materials are combination of two or more materials with required properties. Two or more materials are combined to get desired properties like strength, stiffness and low weight. These composite materials have better properties than parent material. Thus present trend is to develop new materials to get desire properties. From literature study it has found that graphene is a good reinforcement material which increases strength. Copper is very regularly used in electrical applications. Thus area of interest of this paper is to develop copper graphene metal matrix composite by using powder metallurgy technique and study the basic characteristics of it.

Keywords: *Composite material, copper, graphene, powder metallurgy.*

1. INTRODUCTION

Copper is a malleable, ductile, good conductor of electricity and heat. It appears in reddish brown. Its yield strength is 70Mpa and Ultimate strength is 220Mpa. Its melting point is 1085°C. Copper used as an industrial and functional metal since so many years. The major application of copper is electric wire, industrial machinery. Copper paint is used on boat hulls to control growth of plants and shellfish. Graphene is the allotropic form of carbon in the form of 2-D. due to its low weight, thermal, electrical and mechanical properties has been attracted towards worldwide. Graphene is about 100 times stronger than strongest steel. It is the stiffness material. There are number of motives to develop graphene metal composites. The strengthening mechanism of graphene reinforcement is thought to be related to the excellent mechanical and structural characteristics of graphene and has good bonding characteristics.

Powder metallurgy process is the one of the famous fabrication methods for the metal matrix composites. It is widely used because of less material wastage, high dimensional accuracy and need for the secondary operation finishing operations is reduced to get a great extent. Initially base powder and alloying element is weighed according to the requirement. These powders are blended by using ball milling to acquire uniform circulation of powder as for as molecular size, thickness and shape. Blended powder is than compacted to the required shape by using die and punch. Powder is poured into the die cavity and it is compacted by applying load to the punch. Finally compacted product

taken out from the die. Heat treatment for the compacted specimen has to be done to impart strength and integrity. The temperature of the sintering has to be below the melting of major constituent of the powders.

1.1 LITERATURE REVIEW

Prashantha Kumar et.al.., [1] investigated that graphene has remarkable properties and it is a good reinforcement in the metal composites. It also has exclusive optical and thermal properties. In this paper metal matrix composites compared with conventional metal matrix composites and has an immense potential to fabricate composite reinforce with graphene having important properties and have high level of stiffness and strength.

I.A.Oval [2] focused on both fabrication and mechanical properties of metal matrix Nano composites containing graphene inclusions. A particular attention is devoted to experimental data giving evidence for enhancement of strength, hardness and Young modulus.In this paper conclusion was to create a metal matrix composite with high strength and hardness is to implant graphene platelets and few layer sheets in metallic matrices in particular, metal graphene composites with low weight fraction of graphene inclusions exhibits dramatically enhanced strength and hardness.

D.Hary Madhava Swamy [3] investigated that composite materials are combination of different constituent materials which can lead to the desire combination of low weight, high strength and stiffness. In this paper metal matrix composites were successfully fabricated by powder metallurgy technique. Material characterisation was carried out successfully.

2.MATERIALS AND METHOD

The present study consists of development of copper graphene metal matrix composite.

2.1 MATERIALS

Graphene reinforced copper metal matrix composite were manufactured by powder metallurgy technique. Copper as a matrix and Graphene as reinforcement.

Table 2.1 Copper specifications

Minimum assay	Min 99.5%
Particle size	Min 95.0%
Nitric acid	0.05%
Antimony	0.005%
Arsenic	0.0002%
Lead	0.05%
Iron	0.01%

Fig. 2.1 Copper powder

Table 2.2 Graphene specifications

Material	Thermal conductivity	Tensile modulus	Tensile strength	Electrical conductivity
Graphene	3000 watt/m-k To 6 watt/m-k	>1000GPa	>5GPa	107 specimen/m 102 specimen/m

Fig 2.2 Graphene powder

2.3 Methods

Graphene powder of 0,1%,2%,3%,4%,5% weight percentage was mixed with copper powder using ball milling. The process of mixing is continued for duration of 10 min at 220rpm in order to get uniform mixing. The mixing of weigh percentage of graphene and copper compacted in the die assembly using 40 ton capacity UTM and 100 KN was applied gradually. In the present work the addition of graphene was limited to 5% of weight. The compacted solid billets were sintered at sintering furnace at 700°C.

Composites were prepared for various composition and the samples were investigated for microstructure, scanning electron microscope (SEM), X-RAY diffraction(XRD) and density.

2.4 Die Preparation

Die and punch are used for the compaction of copper and graphene powders. Material used for the die and punch is EN8. Facing, turning, annealing and cylindrical grinding are steps followed for the die preparation.

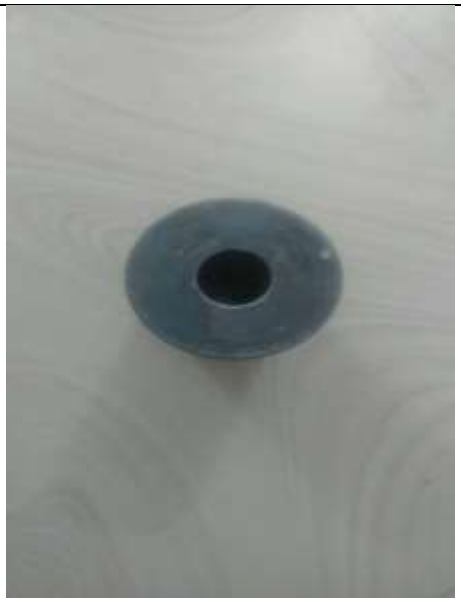
Specification of die:

Inner diameter	22.1mm
Outer diameter	46mm
Length	120mm

Specification of punch:

Diameter	22mm
Length	140mm

Front view of die



Top view of die

Front view of punch

Fig 2.3 Die and punch

2.3 Powder metallurgy technique

Initially copper and graphene are weighed to the required different mass fractions. Copper, copper with 1% of graphene, 2%, 3%, 4% and 5% is weighed in a digital weighing machine.

Blending, compaction and sintering are the steps in the powder metallurgy. copper and graphene two powders are mixed [blended] by ball milling for uniform distribution of graphene in the copper powder in molecular level. Mixed powder is then compacted using die and punch to get the compacted specimen. UTM machine is used to apply the load of about 90KN is applied on punch for the compaction. Compacted specimen is sintered at 700°C to impart the strength and integrity in sinteredfurnace .

Fig 2.4 Compacted and Sintered specimen

3 RESULT AND DISCUSSION

3.1Microstructure

Microstructure is defined as the structure of a specimen surface prepared about 25 x magnifications. Microstructure of the copper graphene metal matrix composites are shown in the following fig 3.1(a)-(e)

The above fig 3.1(a)-(e) shows the microstructure under unetched condition reveals reasonable uniform distribution of graphene particles in the copper powder matrix.

Fig 3.1(a) 1% of graphene

Fig 3.1(b) 2% of graphene

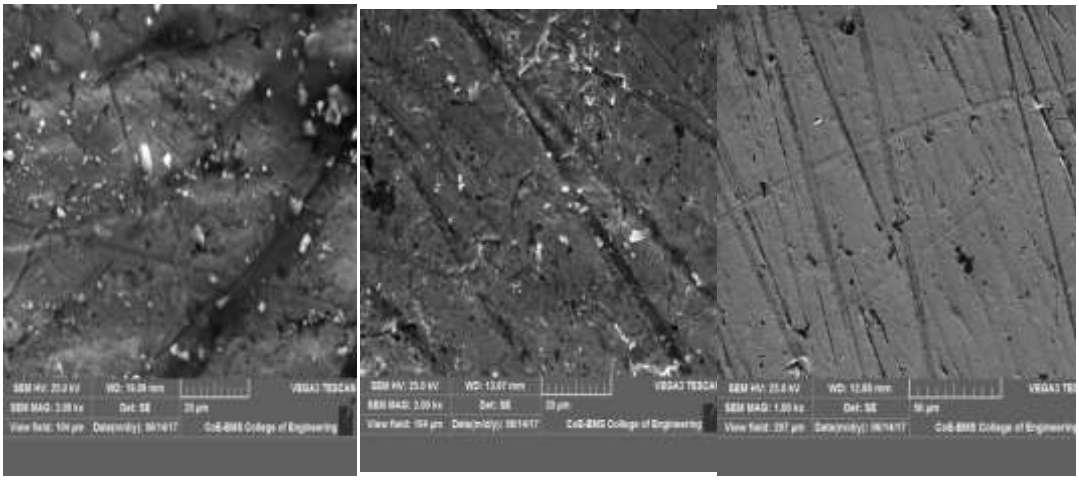
Fig 3.1(c) 3% of graphene

Fig 3.1(d) 4% of graphene

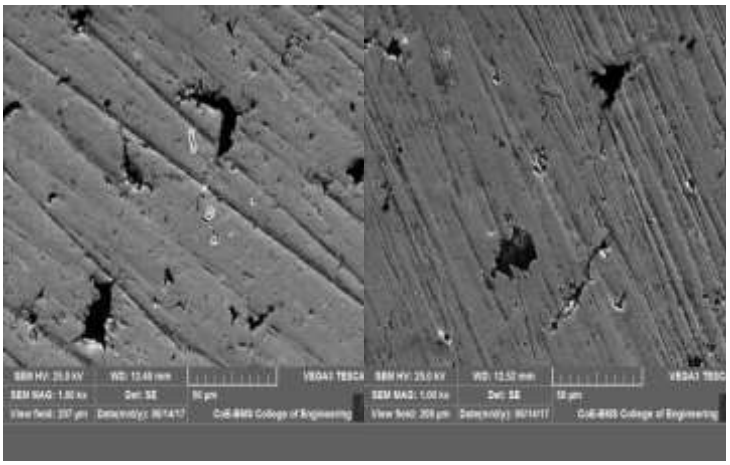
Fig 3.1(e) 5% of graphene

3.2 SEM Analysis

The scanning electron microscope uses highly focused beam of high energy electrons to generate a variety of signals at the surface of a specimen. The SEM gives the information about external morphology, chemical composition, crystalline structure and orientation of materials. Results are in the form of 2-D images.



1% of graphene 2% of graphene 3% of graphene



4% of graphene 5% of graphene

Fig 3.2(a)-(e) SEM of Copper Graphene composite of 2000x

Following fig 3.2(a)- 3.2(e) shows the SEM of copper graphene composite of 2000x

The micro sample of composite clearly reveals the morphology of dispersoid particles indicating uniform distribution of graphene in copper powder.

3.3 XRD ANALYSIS

X-ray diffraction (XRD) is a rapid analytical technique used for a phase identification of a crystalline material and can provide information about unit cell dimensions.Following figure shows the analysed material is finely grounded, homogenised and bulk composition is shown

Peak List: (Bookmark 3)

Pos. [°2θ]	Height [cts]	FWHM Left [°2θ]	d-spacing [Å]	Rel. Int. [%]
35.9268	114.06	1.5447	2.49765	2.13
42.9212	5361.47	0.3137	2.10544	100.00
49.9988	2164.56	0.3823	1.82273	40.37
73.7670	980.96	0.5113	1.28342	18.30
89.5402	903.92	0.5524	1.09376	16.86

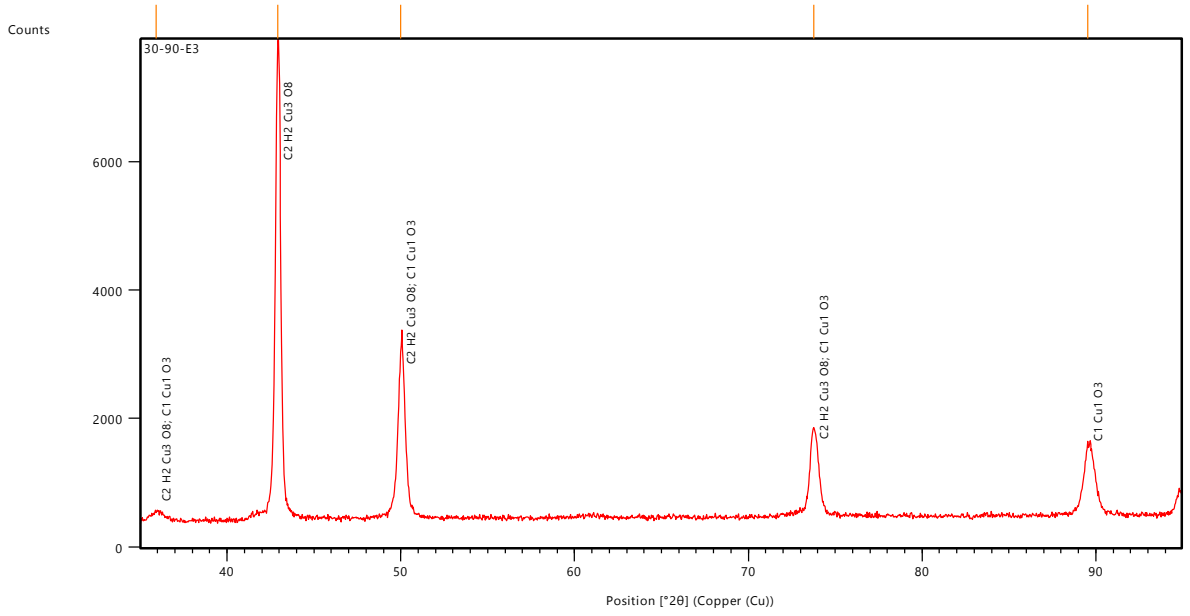


Fig 3.3 XRD of 5% graphene

Fig 3.3 shows the XRD of combined Copper Graphene metal matrix composite intensity vs. angle 2 [theta]. Here the XRD patterns of 5% of graphene composition are compared and high picks were identified of copper. The picks were graphene were not dictatable in the XRD particles.

3.4 DENSITY

Density of the composition is showed in the following fig 3.4

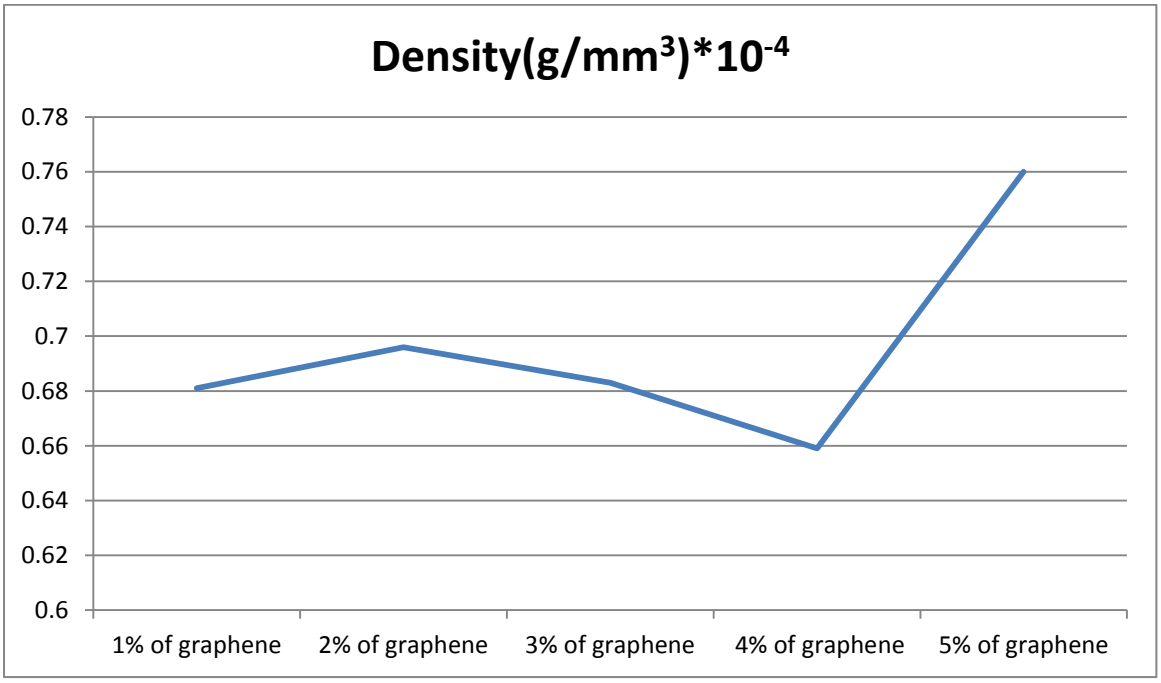


Fig 3.4 Density test

Fig 3.4 Density testshows that at 4% of graphene composite has less density compared to other composites

4 CONCLUSION

Copper /Graphene Metal Matrix Composite fabricated successfully by powder metallurgy technique. Microstructure shows that uniform distribution of graphene in copper powder. SEM and XRD show that there is an excellent bond between copper and graphene. Measure of density shows with 4% of graphene has less density.

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