Studies On Thermal Characteristics of Micro-Titanium and CNT Reinforced Copper Based MMC

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Abstract - **Copper based composites play a vital role in the field of marine, aerospace, automobile and power sector for making of components like electrical sliding contacts, gears, bearings, bushes, brakes and clutches etc. Even though promising reinforcements are available for the composites, always researchers search for the new combination of matrix and reinforcement for tailored properties and cost effectiveness. CNT is one of the effective reinforcements used in the metal matrix composites by various researches because of its excellent properties. The present work is focused on the preparation of copper/CNTs/Micro-Titanium composite through stir casting technique performance studies of the composite are made on the thermal properties. The composite prepared with reinforcement such as CNTs and Micro-Titanium of 0.5, 1, 1.5 % and 1, 3 & 5wt. % were studied. The thermal conductivity of the developed copper metal matrix composites found to be increased with increasing in CNTs and Micro Titanium. The Coefficient of thermal expansion obtained for developed copper metal matrix composite is less than pure Copper. Overall, the in-plane thermal conductivities of the composites with 0.5 Wt%–1.5 wt% CNTs can reach to 392–636 W(mK)-1, which is much higher than that of traditional packaging materials. Due to the properties of high thermal conductivity, low CTE, and good machinability, the obtained composites are the suitable candidates as electronic packaging materials. Although anisotropy could be an issue for some applications, it could also be a benefit, allowing designers the ability to make heat preferentially flow in one direction.**

Index Terms - **Component; Micro Titanium, CNT, Thermal Conductivity, CTE.**

I.INTRODUCTION

A typical composite material is a system of materials composing of two or more materials (mixed and bonded) on a macroscopic scale.

Composite materials are heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can also be considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

Generally, a composite material is composed of reinforcement (fibers, particles, flakes, and/or fillers) embedded in a matrix (polymers, metals, or ceramics). The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material.

1.1 Characteristics of composites

Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents, or the constituents may interact in a synergistic way resulting in improved or better properties.

Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The concentration distribution and orientation of the reinforcement also affect the properties. The shape of the discontinuous phase (which may by spherical, cylindrical, or rectangular cross sectioned prisms or platelets), the size and size distribution (which controls the texture of the material, and volume fraction determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforcement and the matrix.

1.2 Constituents of composites

In its most basic form, a composite material is one, which is composed of at least two elements working together to produce material properties that are different to the properties of those elements on their own. In practice, most composites consist of a bulk material (the "matrix"), and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix shown in figure 1.1.

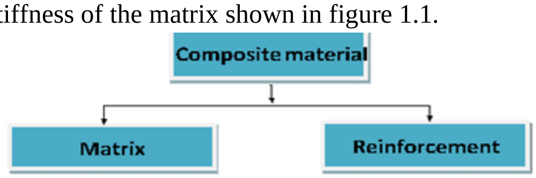

Figure 1.1 constituents of composites

1.2.1 Matrix

Many materials when they are in a fibrous form exhibit very good strength but to achieve these properties the reinforcement should be bonded by a suitable matrix. The matrix isolates the reinforcement from one another in order to prevent abrasion and formation of new surface flaws and acts as a bridge to hold the reinforcement in place. A good matrix should possess ability to deform easily under applied load, transfer the load onto the fibers and evenly distributive stress concentration.

Properties of a Matrix

- The desired properties of the matrix which are important for a composite structure are as Follows:
- Reduced moisture absorption. Low shrinkage.
- Low coefficient of thermal expansion.
- Good flow characteristics and eliminates voids during the compacting curing process.
- Reasonable strength, modulus and elongation (elongation should be greater than fiber).
- Must be elastic to transfer load to reinforcement.
- Strength at elevated temperature (depending on application). Low temperature capability (depending on application).
- Excellent chemical resistance (depending on application). Should be easily processable into the final composite shape. Dimensional stability (maintains its shape).

1.2.2 Reinforcement

Reinforcement is the minor constituent in the composite material which is actually responsible for improving the properties of the matrix material. This is strong and stiffer than the matrix material.

Properties of reinforcement

- Low density and Economic efficiency.
- Mechanical compatibility (a thermal expansion coefficient which is low but adapted To the matrix).
- Chemical compatibility. Thermal stability.
- High young's modulus.
- High compression and tensile strength. Good process ability.

1.4 Classification of composites

Classification of composite is done based on both geometry of reinforcing material and the type of matrix material. Classification scheme for the composite is as illustrated in figure 1.2 shown below.

1.4.1 Classification of composites based on Matrix Materials.

a. Polymer Matrix Materials
b. Carbon Matrices
c. Metal Matrix Materials
d. Ceramic Matrix Materials

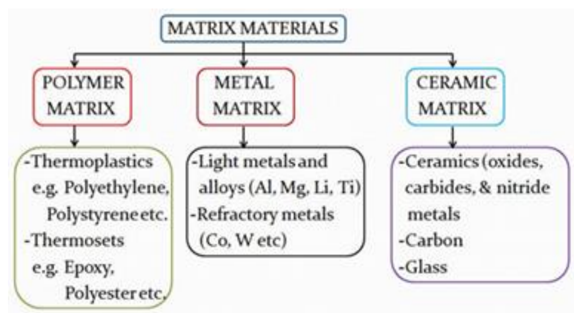

Figure 1.2 Classification of composites based on matrix

1.4.2 Classification of composites based on Reinforcement.

a. Fiber Reinforcement
b. Particulate Reinforced Composites
c. Structural Composites (Laminar Composites)

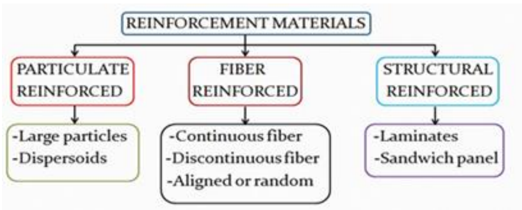

Figure 1.3 Classification of composites based on reinforcements

1.3 METAL MATRIX COMPOSITES

Metal matrix composite (MMC's) is engineered combination of the metal (matrix) and hard particle or ceramic (reinforcement) to get the tailored properties. Metal composite materials have found application in many areas of daily life for quite some time. Often it is not realized that the application makes use of composite materials. These materials are produced in situ from the conventional production and processing of metals. Here, the Dalmatian sword with its meander structure, which results from welding two types of steel by repeated forging, can be mentioned. Materials like cast iron with graphite or steel with high carbide content, as well as tungsten carbides, consisting of carbides and metallic binders, also belong to this group of composite materials. For many researchers the term metal matrix composites are often equated with the term light metal matrix composites (MMCs).

Substantial progress in the development of light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications. In traffic engineering, especially in the automotive industry, MMCs have been used commercially in fiber reinforced pistons and copper crank cases with strengthened cylinder surfaces as well as particle-strengthened brake disks.

These innovative materials open up unlimited possibilities for modem material science and development; the characteristics of MMCs can be designed into the material, custom-made. Dependent on the application. From this potential, metal matrix composites fulfil all the desired conceptions of the designer. This material group becomes interesting for use as constructional and functional materials, if the property profile of conventional materials either does not reach the increased standards of specific demands or is the solution of the problem. However, the technology of MMCs is in competition with other modern material technologies, for example powder metallurgy.

MMC's are used for the space shuttle, commercial airliners, electronic substrates, bicycles automobiles, golf clubs and a variety of other applications. Like all composites, copper matrix composites are not a single material but a family of material whose stiffness, strength, density, thermal and electrical properties can be tailored. The matrix alloy, reinforcement material, volume and shape of the reinforcement, location of the reinforcement and fabrication method can be varied to achieve desired properties. The aim involved in designing MMC's is to combine the desirable attributes of metals and ceramic materials. Metals have useful combination of properties such as medium strength, ductility and high temperature resistance but sometimes have low stiffness, whereas ceramic material is stiff and strong. Though brittle, the addition of high strength, a high modulus refractory particle to a ductile metal matrix produces a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement.

Particulate reinforced metal matrix composites can be fabricated by solid state as well as liquid state processing methods. Among liquid state fabrication process, stir casting is generally accepted as a particularly promising route, currently practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. This liquid metallurgy technique is the most economical of all the available routes for the metal matrix production and also allows very large sized components to be fabricated. The solidification synthesis of metal matrix composite involves producing a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt. obtaining a suitable dispersion.

In fabrication of MMC's by stir casting routs, there are several factors that need considerable attention, including the difficulty of achieving a uniform distribution of the reinforcement material, wettability between the two main substance, porosity in the cast and chemical reactions between the reinforcement and matrix material. In order to achieve the optimum properties of the metal matrix composite, the distribution of the reinforcement material in the matrix must be uniform and the wettability or bonding between these substances should be promised. The literature reveals that the major problem was to get homogenous dispersion of ceramic particle by using low-cost conventional equipment for commercial applications. Among various matrix material available, copper and its alloy are widely used in fabrication of MMC's and has reached industrial production stage. The emphasis has been given on developing affordable Cu-based MMC's with various hard ceramic reinforcements such as Al2O), SiC, TiB), B, C etc because of the likely possibilities of these combination in forming highly desirable composites. Micro titanium is an attractive reinforcement for copper and its alloys showing many of the mechanical and physical properties required of an effective reinforcement, in particular high stiffness and hardness. Copper micro titanium particulate MMC's produced by stir casting represents a class of inexpensive tailor-made materials for variety of engineering application such as cylinder blocks, piston and piston insert rings, brakes disk/drum. Their uses are being explored in the view of their superior technological properties such as low co-efficient of friction and low wear rate. This has led to increase in research interest on evaluating the effect of type and weight fraction of reinforcement and procedure used to produce MMC's.

For other application different development objectives are given, which differ from those mentioned before. For example, in medical technology, mechanical properties, like extreme corrosion resistance and low degradation as well as biocompatibility are expected. Metal matrix composites (MMC's), like all composites, consisting of at least two chemically and physically distinct phases, suitably distributed to provide properties not obtainable with either of the individual phase. Generally, there are two phases, e.g., a fibrous or particulate phase, distributed in a metallic matrix. Examples include continuous Al, fiber reinforced AI matrix composites used in power transmission line Nb-Ti filaments in a copper matrix for superconducting magnets Tungsten Carbide particulate reinforced Al matrix composites used in industrial processes like rotating paddles or impellers, aerospace, automotive, marine industries and thermal management applications.

1.4 Processing of Metal Matrix Composites

Metal-matrix composites can be processed by several techniques. Some of these important techniques are described below.

- Solid state processing
- Liquid metal processing
- In situ processing
- Vapor state processing
- Plasma/spray deposition

1.8.1 Liquid state processing (Stir casting)

Many times it is better to have the matrix in liquid form so as to facilitate the flow of filling the interstices and to cover completely the fibers, whatever form they may be. That's the reason because the foundry is one of the techniques more used and less expensive to produce metal matrix composites. In such a situation, using a molten bath, production can be increased considerably, it is not coincidence that it is widely used by industry to produce semi-finished products and for this there are several solutions.

Generally, in this case technologies are divided between those that provide for the incorporation of ceramic reinforcement into the liquid metal, and that where the cast is infiltrated into pre-forms of the same reinforcement.

The most common method is explained below.

Both the terms compo-casting and melt stirring are used for stirring particles into a light alloy melt. The particles often tend to form agglomerates, which can be only dissolved by intense stimming. However, here gas access into the melt must be absolutely avoided since this could lead to unwanted porosities or reactions.

Careful attention must be paid to the dispersion of the reinforcement components, so that the reactivity of the components used is coordinated with the temperature of the melt and the duration of stirring, since reactions with the melt can lead to the dissolution of the reinforcement components. Because of the lower surface to volume ratio of spherical particles, reactivity is usually less critical with stirred particle reinforcement than with copper.

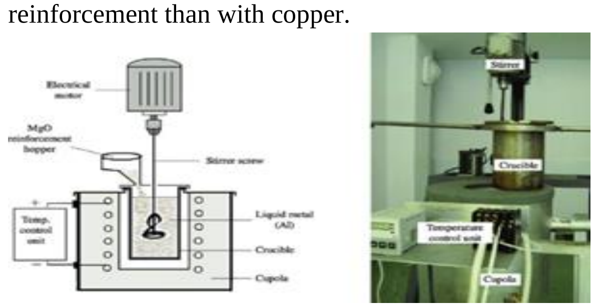

Figure 1.4 melt stirring

1.9 APPLICATIONS OF METAL MATRIX COMPOSITES

Here dimensional stability is of prime concern over a temperature range of -160* 93C. The demand on materials of construction is that the coefficient of linear thermal expansion must be of the order of 1.8 x 10 mom's. Monolithic materials like steels cannot be used which have linear thermal expansion as high as 1.2 x 10 mom's. Composites provide the answer.

a. Aircraft Bodies
b. Abrasive grinding and cutting wheels
c. Cast copper Particulate Composite
d. Automotive
e. Electronics Applications

II.METHODS AND MATERIAL

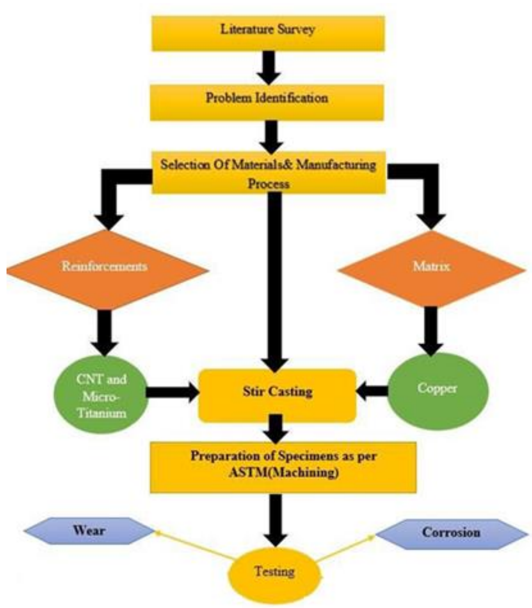

Figure:2.1 Experimental methodology

2.1 Material Selection:

In selection of matrix material such as metals or alloys the matrix should be chosen only after giving careful consideration to its chemical compatibility with the reinforcement, its ability to wet the reinforcement and to its own characteristics properties and processing behaviour. One of the very crucial issues to be considered in selection of the matrix alloy composition involves the natural dichotomy between wettability of the reinforcement and excessive reactivity with it. Good load transfer from the matrix to the reinforcement depends on the existence of a strongly adherent interface. In turn, a strong wetting and aggressive reactivity are both favored by strong chemical bonding between the matrix and reinforcement. Adjusting the chemical compositions to execute this is difficult as many substitutes are involved.

As a rule of alloying element addition, the added element should not form inter metallic compounds with the matrix elements and should not form highly stable compounds with the reinforcing metals. The good properties can be obtained in a composite material when the reinforcement particulates and matrix are as physically and chemically compatible as possible.

Reinforcements: CNT and Micro-Titanium

Matrix: Copper

2.1.1 Copper (Cu)

The word copper comes from the Latin word 'cuprum', which means 'ore of Cyprus'. This is why the chemical symbol for copper is Cu. Copper and copper alloys are widely used in a variety of products that enable and enhance our everyday lives. They have excellent electrical and thermal conductivities, exhibit good strength and formability, have outstanding resistance to corrosion and fatigue, and are generally nonmagnetic. They can be readily soldered and brazed, and many can be welded by various gas, arc and resistance methods. They can be polished and buffed to almost any desired texture and luster. Pure copper is used extensively for electrical wire and cable, electrical contacts and various other parts that are required to pass electrical current. Coppers and certain brasses, bronzes and copper nickels are used extensively for automotive radiators, heat exchangers, home heating systems, solar collectors, and various other applications requiring rapid conduction of heat across or along a metal section. Because of their outstanding ability to withstand corrosion, coppers, brasses, bronzes and copper nickels are also used for pipes, valves and fittings in systems carrying potable water, process water or other aqueous fluids, and industrial gases. Copper alloys are also ideally suited where it is important to minimize bacterial* levels on touch surfaces. Because of their inherent ability to kill 99.9% of bacteria* within two hours, more than 280 copper alloys have been granted public health registration by the U.S. Environmental Protection Agency (EPA). This unprecedented registration recognizes copper's inherent ability to continually kill bacteria* between regular cleanings, and aids in reducing infection causing bacteria* on touch surfaces in hospitals, schools, offices and other public establishments.

Figure 2.2. Copper

2.1.2 Carbon Nanotubes (CNT)

Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. Nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1, significantly larger than for any other material. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of materials science and technology. In particular, owing to their extraordinary thermal conductivity and mechanical and electrical properties, carbon nanotubes find applications as additives to various structural materials. For instance, nanotubes form a tiny portion of the material(s) in some (primarily carbon fiber) baseball bats, golf clubs, car parts or Damascus steel.

Nanotubes are members of the fullerene structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene. These sheets are rolled at specific and discrete ("chiral") angles, and the combination of the rolling angle and radius decides the nanotube properties; for example, whether the individual nanotube shell is a metal or semiconductor. Nanotubes are categorized as single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTS).

Types of carbon nanotubes and related structures

There is no consensus on some terms describing carbon nanotubes in scientific Literature: both "-wall" and "-walled" are being used in combination with "single", "double", “triple" or "multi", and the letter C is often omitted in the abbreviation; for example, Multiwalled carbon nanotube (MWNT)

- Single-walled carbon nanotubes (SWNTS)
- Multi-walled nanotubes (MWNTS)
- Double-walled carbon nanotubes (DWNTS)

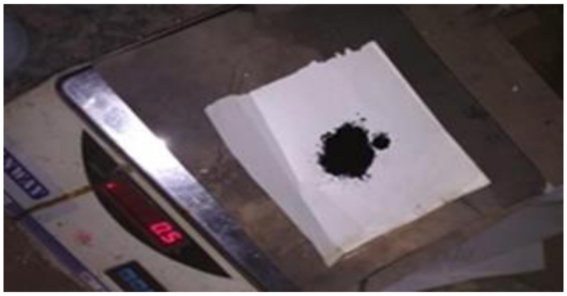

Figure 2.3 CNT

2.1.3 Micro-Titanium (µ-Ti):

Titanium is a chemical element with symbol Ti and atomic number 22. It is a lustrous transition metal with a silver color, low density, and high strength. Titanium is resistant to corrosion in sea water, aqua regia, and chlorine.Titanium was discovered in Cornwall, Great Britain, by William Gregor in 1791, and was named by Martin Heinrich Klaproth after the Titans of Greek mythology. The element occurs within a number of mineral deposits, principally rutile and ilmenite, which are widely distributed in the Earth's crust and lithosphere, and it is found in almost all living things, water bodies, rocks, and soils. The metal is extracted from its principal mineral ores by the Kroll and Hunter processes. The most common compound, titanium dioxide, is a popular photo catalyst and is used in the manufacture of white pigments. Other compounds include titanium tetrachloride ($TiCl_4$), a component of smoke screens and catalysts; and titanium trichloride ($TiCl_3$), which is used as a catalyst in the production of polypropylene.

Titanium can be alloyed with iron, copper, aluminum, vanadium, and molybdenum, among other elements, to produce strong, lightweight alloys for aerospace (jet engines, missiles, and spacecraft), military, industrial processes (chemicals and petrochemicals, desalination plants, pulp, and paper), automotive, agri-food, medical prostheses, orthopedic implants, dental and endodontic instruments and files, dental implants, sporting goods, jewelry, mobile phones, and other applications. The two most useful properties of the metal are corrosion resistance and strength-to-density ratio, the highest of any metallic element. In its unalloyed condition, titanium is as strong as some steels, but less dense. There are two allotropic forms and five naturally occurring isotopes of this element, 46Ti through 50Ti, with 48Ti being the most abundant (73.8%). Although they have the same number of valence electrons and are in the same group in the periodic table, titanium and zirconium differ in many chemical and physical properties.

For example, cuprotitanium (rutile with copper added is reduced), Ferrocarbon titanium (ilmenite reduced with coke in an electric furnace), and manganotitanium (rutile with manganese or manganese oxides) are reduced. 2

$FeTiO_3 + 7\ Cl_2 + 6\ C \rightarrow 2\ TiCl_4 + 2\ FeCl_3 + 6\ CO$ (900 °C)

$TiCl_4 + 2\ Mg \rightarrow 2\ MgCl_2 + Ti$ (1,100 °C)

Figure: 2.4. Micro-Titanium

Applications

Titanium is used in steel as an alloying element (ferro-titanium) to reduce grain size and as a deoxidizer, and in stainless steel to reduce carbon content Titanium is often alloyed with aluminum (to refine grain size), vanadium, copper (harden), iron, manganese, molybdenum, and other metals. Titanium mill products (sheet, plate, bar, wire, forgings, castings) find application in industrial, aerospace, recreational, and emerging markets. Powdered titanium is used in pyrotechnics as a source of bright-burning particles.

2.2 Manufacturing Process.

One of the most important issues to prepare CNT metal matrix composite is the CNTs dispersion in composites, the main purpose of many research and experiments is to improve it. Another issue needs to be considered is the reinforcement of CNTs, which depend on the interfacial wettability between CNTs and metal matrix. Also, chemical reaction should be avoided during composites manufacture process.

2.2.1 Stir casting

Stir casting set-up mainly consists of a furnace and a stirring assembly as shown in Figure 4.6. In general, the solidification synthesis of metal matrix composites involves a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt, obtaining a suitable dispersion. The next step is the solidification of the melt containing suspended dispersoids under selected conditions to obtain the desired distribution of the dispersed phase in the cast matrix. In preparing metal matrix composites by the stir casting method, there are several factors that need considerable attention, including The difficulty in achieving a uniform distribution of the reinforcement material.

Wet ability between the two main substances.

Porosity in the cast metal matrix composites.

Chemical reactions between the reinforcement material and the matrix alloy.

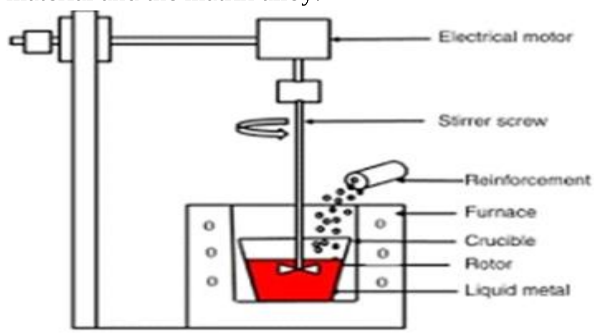

Figure 2.5:- Stir Casting

In order to achieve the optimum properties of the metal matrix composite, the distribution of the reinforcement material in the matrix alloy must be uniform, and the wettability or bonding between these substances should be optimized. The porosity levels need to be minimized.

Figure 2.6. Casting Set up

Stir Casting Procedure:

1. Required amount of Carbon nanotube, Micro-Titanium and pure copper weighed and Kept aside.
2. Carbon nanotube powder and Micro-Titanium is preheated to 300° C-350°C and maintained at that

Temperature for about 15 minutes to remove moisture content.

3. Then weighed quantity of copper was melted in a crucible at more than 1085°C.
4. Slag is removed using scum powder.
5. The molten metal is degassed at a temperature of 1000°C using solid dry hexachloroethane tablets.
6. Then the molten metal is stirred to create a vortex and the weighed quantity of pre heated carbon nanotubes, Micro-Titanium and Copper are slowly added to the molten metal maintained at a temperature >1000°C with continuous stirring at a speed of 350-500rpm to a time of 7-10 minutes.
7. Then the melt with the reinforced particles were poured into preheated moulds the poring temperature is maintained at 1000°C.
8. The castings are taken once the solidification of molten metal takes place.

III.EXPERIMENT

The Experiment was carried using Thermal Conductivity Meter.

2.1 Thermal Conductivity Meter [Hot Disk-Thermal Constants Analyzer TPS 2500S]

This equipment is measures the thermal conductivity (Tc), thermal diffusivity (Td) and specific heat capacity (Cp) of variety of materials (solids, liquids, powders, pastes and foams) and meets the standard ISO 22007-2. It is unique sensor (patented) allows to measure the Tc accurately in very short time span. Thermal Conductivity, Thermal Diffusivity and Specific heat capacity can be measured in the range 0.005- 1800 W/m/K, 0.1-1200mm2/s and 5 MJ/m3K respectively in the temperature range between -40° to 200°C.

Figure 2.1 Hot Disk-Thermal Constants Analyzer TPS 2500S

IV.RESULTS AND DISCUSSION

Thermal Properties

Table3.1 Thermal properties of CNTs/Ti/Cu metal matrix Composites

Specimen Designation	Reinforcement Composition CNTs/Micro-Ti	Thermal Conductivity W/mk	Thermal Diffusivity mm^2/s	Specific heat Jg/K	Coefficient of Thermal Expansion 10^{-6}/K
C1	0/0	337	106.75	0.384	14
C2	0.5/1	392	145.56	0.397	9.7
C3	0.5/3	426	159.91	0.432	9.08
C4	1/5	454	177.3	0.471	8.13
C5	1/1	512	209.16	0.562	7.92
C6	1/3	546	228.07	0.587	7.05
C7	1/5	561	242.35	0.613	6.48
C8	1.5/1	584	268.12	0.659	5.78
C9	1.5/3	618	289.47	0.682	5.49
C10	1.5/5	636	305.8	0.719	5.13

Table 3.1. summarizes all experimental values of density, specific heat, thermal diffusivity, CTE of the Cu/CNTs/Ti composites. It can be clearly seen that the thermal properties developed composites in X–Y direction are evidently superior to that of those in the Z direction. From the data, the thermal conductivities in X–Y direction are 1.5–2.5 times of that in Z direction, and the CTEs in X– Y direction are 30–60 % lower than that in Z direction, depending on the reinforcement content. Obviously, these anisotropic thermal properties arise from the planar orientation of the reinforcements and large difference between their radial and axial thermal properties. Also, it can be observed that the thermal conductivities of the composites in X–Y direction are all higher than that of as cast copper, and they are increased with the CNTs/Ti content increasing. The higher thermal conductivities obtained suggests that CNTs contribute to enhancing thermal conductivity of the composites. On the contrary, the thermal conductivities of the composites in Z direction are all lower than that of pure copper, and they are decreased with increase of the reinforcement content. This can be easily understood because the major contribution of thermal conductivity in Z direction comes from Cu matrix. In addition, unlike the changing trend of thermal conductivity with CNTs content, the CTEs of the composites in both X–Y and Z direction all decrease, while the fiber content increases; from that, it can be

explained that the axial and radial CTEs of the CNTs are all much lower than the CTE of copper. Moreover, the experimental results demonstrate that CNTs/ titanium has a positive effect on thermal properties of the prepared composites. The thermal conductivity of the Pure copper composite is only 337 W(mK)-1 even in X–Y direction, which is 229 W(mK)-1 lower than that of the C7 composite. The CTE values in X– Y and Z direction of the coated composite are lower than those of the uncoated composite, respectively. As the relative density difference of both is less than 1 %, it can be deduced that such remarkable thermal properties improvement mainly originated from the good metallurgical bonding between the micro-titanium and Cu matrix caused by the formation of TiC layer. Overall, the in-plane thermal conductivities of the composites with 0.5 Wt%–1.5 wt% CNTs can reach to 392–636 W(mK)-1, which is much higher than that of traditional packaging materials. Due to the properties of high thermal conductivity, low CTE, and good machinability, the obtained composites are the suitable candidates as electronic packaging materials. Although anisotropy could be an issue for some applications, it could also be a benefit, allowing designers the ability to make heat preferentially flow in one direction.

V.CONCLUSION

The research on composite materials where composites have a vital role in industrial application such as deference, aerospace, automobile, marine, etc, bring into the limelight various tailored properties that compete with monolithic materials. The Copper reinforced with CNT and Micro-Titanium is manufactured and their inherent properties are found out via different tests. The major contribution of the research work is concluded below.

- The Coefficient of thermal expansion obtained for developed copper metal matrix composite is less than pure Copper.
- Overall, the in-plane thermal conductivities of the composites with 0.5 Wt%–1.5 wt% CNTs can reach to 392–636 W/mk, which is much higher than that of traditional packaging materials. Due to the properties of high thermal conductivity, low CTE, and good machinability, the obtained composites are the suitable candidates as electronic packaging materials. Although anisotropy could be an issue for some applications, it could also be a benefit, allowing designers the ability to make heat preferentially flow in one direction.

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