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# An Overview on Ceramic Matrix Composites with Nano Technology

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**ABSTRACT:** It is widely recognised that ceramic matrix composites (CMCs) are extremely valuable materials for applications with challenging mechanical and thermal requirements. Despite the fact that ceramic matrices often present brittle behaviour, CMCs have been developed to achieve quasi-ductile fracture behaviour and maintain all other advantages of monolithic ceramics at high temperatures. For instance, CMCs can be invented as strong as metals, but they are copious lighter and can withstand much higher temperatures. These advantages led to their application in automotive and aerospace engineering.

Ceramic matrix composites (CMCs) are auspicious materials for use in high temperature structural applications. This class of materials offers high strength to density ratios. Also, their higher temperature capability over conventional super alloys may allow for components that require little or no cooling. This benefit can lead to simpler component designs and weight savings. These materials can also contribute in growing the operating efficiency due to higher operating temperatures being achieved. Using carbon/carbon composites with the help of Nanotechnology is more beneficial in structural engineering and can decrease the production cost. They can withstand high stresses and temperatures than the traditional alumina, silicon carbide which fracture easily under mechanical loads. Fundamental work in processing, characterization and analysis is important before the structural properties of this new class of Nano composites can be optimized. The fabrication of such composites using Nano technology can make a revolution in the field of material science engineering and can make the composites able to be used in long long-lasting applications.

**KEYWORDS:** ceramic, composite, nano composite, CMC.

### I. INTRODUCTION

As we know that Composite materials are the type of materials that are shaped by combining two or more materials of different physical and chemical properties. The material formed has totally different characteristics from the separate materials. Ceramic materials in general have high strength and can withstand very high temperatures.

Also their chemical inertness and low density increases their application in many fields like in aerospace shuttle designing, material casting, etc. But they are prone to failure in case of thermal shock and are easily damaged during fabrication or service. Therefore, it is necessary now to make these composites overcome this problem.

Particles with different shapes such as spherical, uneven and faceted are commonly used during the processing of CMCs. The schematic of morphology of the different particulate reinforcements is shown in Figure 1.

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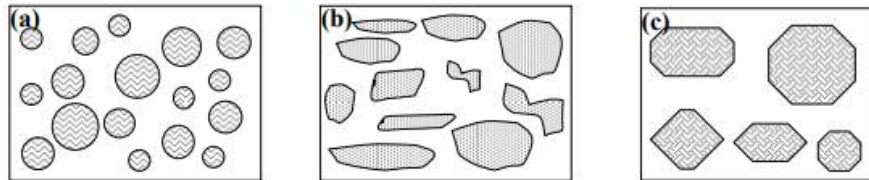


Figure 1 Particulate morphology (a) Spherical (b) Irregular (c) Faceted

Nano composites are the ceramics materials composed by the use of Nano technology. Our main focus is on this part of Ceramic matrix composite. Ceramic Matrix Composites are a subgroup of composite material. They consist of ceramic fibres embedded in a ceramic matrix forming Ceramic fibre reinforced ceramic. Nowadays CMC's are mainly used in the field that require reliability at high temperature (beyond the ability of metals) and resistance to corrosion. These include heat shield system of space vehicles, for manufacturing the components of high temperature gas turbines and components for burners and flame holders.

There are some basic differences in ceramic composites and other composites. In non- ceramic matrix composites the fibres bear a greater proportion of the applied load. This load partitioning depends on the ratio of fibre and matrix elastic moduli.

## II. RELATED WORK

Ceramic nanocomposites are newly developed ceramic composite materials in which the second-phase or third-phase nanoparticles are uniformly dispersed in micrometer- or nanometer-sized ceramic matrix to improve the microstructure and mechanical properties of ceramic materials [1–8]. Three key properties of ceramic nanocomposites are (i) powders that do not aggregate and exhibit good flowability; (ii) green bodies with high density and uniform distribution; and (iii) sintering with no obvious grain growth [3–8]. Hence, how to obtain high densification and simultaneously control grain growth is important for the sintering of ceramic nanocomposites. The densification and grain growth of ceramics depends on the sintering temperature, the nature of the original particles, the level of doping and the sintering methods used [4–8]. Consequently, selection of a suitable sintering method, lowering the sintering temperature and doping with secondary phase have proved to be effective approaches to realizing the sintering of ceramic nanocomposites. The aim of this work is to prepare nano-SiC-based composite by using b-SiC nanopowder as matrix phase, TiN nanopowder as toughening phase and Y<sub>3</sub>Al<sub>5</sub>O<sub>12</sub> (YAG) as sintering additive. In previous research [9,10], nano-SiC-based spray-dried granules with high packed density, low angle of repose and homogeneous compositions were prepared. In this paper, the sintering behavior, mechanical properties and microstructure of nano-SiC-based composites containing 5 wt.% nano-TiN were investigated.

## III. NANO COMPOSITES

A broad class of materials, with microstructures modulated in zero to three dimensions on length scales less than 100 nm. Materials with atoms arranged in Nano sized clusters, which become the constituent grains or building blocks of the material. Any material with at least one measurement in the 1-100 nm range. The area of Nano composite material has received a lot of attention from scientists and engineers in recent years. Nano composite is a multiphase solid material where one of the phases has one, two or three dimensions of less than 100 nanometres (nm), or structures having Nano-scale repeat distances between the different phases that make up the material.

The mechanical, electrical, thermal, optical, electrochemical, catalytic properties of the Nano composite will differ markedly from that of the component materials. Size limits for these effects have been proposed, <5 nm for catalytic activity, <20 nm for making a hard magnetic material soft, <50 nm for refractive index changes, and <100 nm for achieving super Para magnetism, mechanical strengthening or restricting matrix dislocation movement.

Nano composites are found in nature in biological form such as in plants and bones. These materials consist of an inorganic (host) solid containing an organic phase or vice versa. Or they can be consisting of two or more organic or inorganic phases in some combinatorial form with the constraint that at least one of the phases or features is in the nanometre size. Important examples of Nano composites can be porous media, colloids, gels and copolymers.

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The problems have been solved by incorporating second phase such as platelets, particulates, and fibres in the micro level at the matrix grain boundaries. But micro-sized fillers cannot solve these problems. High performance ceramics are being developed that can withstand high temperature, wear and chemical attack as required in applications like highly efficient gas turbines, automobiles and aerospace materials. Mostly ceramic materials face problems like low fracture toughness and strength, degradation of mechanical properties at high temperatures, fatigue and thermal shock. The most promising solution researched currently is the dispersion of Nano particles specially carbon Nano tubes in the ceramics matrix.

## IV. APPLICATIONS IN PAST

Boron carbide has found application in lightweight armour because of its high hardness and low density. Silicon carbide is also being reinforced with shape-modified SiC fibres for armour, as well as tungsten carbide with diamond. Research at the German Aerospace Centre has improved these discs by applying a coating based on Si-SiC. The discs are made by hot pressing half shell C/C preforms, pyrolysis at 900-1600°C, joining the two halves and then infiltrating them with liquid Si. In situ joining via reaction bonding during siliconizing also allows production of complex parts. The improved discs have almost no wear and are expected to last a lifetime or 300,000 km for a car and reduce costs by 75-80% compared to C/C disks. No distortion or corrosion has been observed.

## V. HOW NANO COMPOSITES WORK

Nanoparticles have an extremely high surface to volume ratio which dramatically changes their properties when compared with their bulk sized equivalents. It also changes the way in which the nanoparticles bond with the bulk material. The result is that the composite can be many times improved with respect to the component parts. Some Nano composite materials have been shown to be 1000 times tougher than the bulk component materials.

## VI. BACKGROUND

Nano composites are materials that incorporate Nano sized particles into a matrix of standard material. The result of the addition of nanoparticles is a drastic improvement in properties that can include mechanical strength, toughness and electrical or thermal conductivity. The effectiveness of the nanoparticles is such that the amount of material added is normally only between 0.5 and 5% by weight.

## VII. CURRENT OVERVIEW

Current performance limits are: a maximum temperature 1000°C, a resistivity of 10-15 W/m-K, and a strength of 100-200 MPa as irradiated. Creep limits are unknown and because lifetime depends on creep strain, these limits must be determined. Other issues include production cost, impurity control, joining, and chemical compatibility.

## VIII. PROCESSING OF NANOCOMPOSITES

Polymer Nano composites are a class of materials that use fillers possessing dimensions on a nanometre scale reinforced into the polymer matrix. These materials blend a nanofiller with a polymer to produce a composite with equal or better physical and mechanical properties than their conventionally filled counterparts but with lower loadings of fillers.

Due to the higher surface area available with nanofillers, polymer nano composites offer the potential for enhanced mechanical properties, barrier properties, thermal properties and flame retardant properties when compared to conventionally filled materials.

Currently practiced processes for forming nanocomposites generally include individual steps for polymerizing each of the various monomers followed by palletisation of each of the various polymers thus formed separately. After the individual polymers are pelletized, the formed pellets may be mixed with a nanofiller material in an extruder to form

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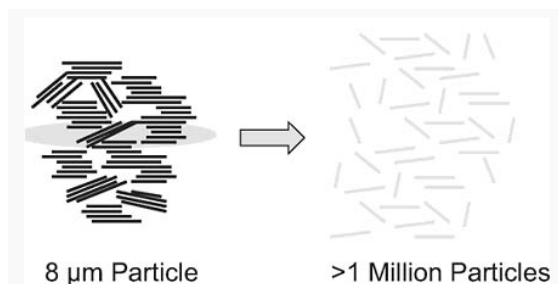
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the nanocomposite material. While this process may be efficient for forming nanocomposites, at some instances they appear to be relatively expensive.

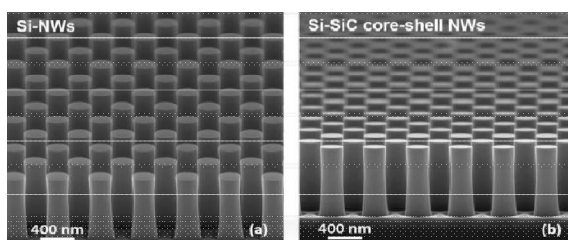
Three dimensional metal matrix composites, two dimensional lamellar composites and one dimensional nanowires and zero-dimensional core-shells all represent the various nano-mixed and layered materials. These methods of construction combine the best properties of each of the components or give rise to new and unique properties for many advanced applications.

Nano composite could also be produced by dispersion of multi-layered silicate material into a thermoplastic polymer at a temperature greater than the melting or softening point of the thermoplastic polymer. The thermoplastic polymer is selected from the group consisting of a thermoplastic urethane, a thermoplastic epoxy, polyester, nylon, polycarbonate and their blends.



## IX. FUTURE ASPECT

Silicon Carbide is a material now a days used in high temperature or high voltage applications. Now we can synthesize SiC at Nano level, in form of a coating. At Nano level, Silicon Carbide becomes stronger and its tensile strength increases. The heat bearing strength also increases at this level. Silicon Carbide of 12 micrometre size is converted into Nano powder by using high energy ball milling technology. As we increase the time of ball milling the surface area increases, size decreases, makes it more strong and rough. It can be used in the spacecraft sheets which require bearing heat radiated by the Sun. We can also use it in the creation of satellites which are continuously in the space and require such materials with such properties. It can also be used in construction up of space stations. The heat shield system based on ceramic matrix composite have advantages like reduced weight, reusability, better steering during re-entry into the earth's atmosphere. Figure below depicts the crystal structure of Silicon Carbide at 400 nm. The silicon carbide roughness increases on decreasing the size but it becomes stronger and stronger if we heat it for a more time.



## X. CONCLUSION

Production of ceramic matrix composite using Nano technology can be made more powerful, cost effective and high ending in the service conditions. Its future is very massive and can be used in various applications such as paints in

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households, automobile paints, metal paints or coatings to prevent corrosion, aircraft and space shuttle sheets. The roughness of silicon carbide can be used in abrasive metal coatings where the soft metals are corroded by wind action. It can be a cost effective and long lasting matrix in future. The relationship between the Nano composite structure, the properties, and the active toughening mechanisms remains to be recognized.

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