# Potential Micro and Nano Reinforcements for Composites

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**Abstract**

The application of unconventional or composite materials has significantly enhanced and these materials now a days constitute more than 25% of the various components used in airline industries like Airbus A380 (25%) and also in Boeing 787 aircrafts (50%), Composite materials show a great potential in not only structural applications but also some engine parts. The rising use of composite materials in the aerospace industry is mainly due to their higher specific strength and better corrosion and fatigue resistance than most metals. The present article discusses on the development of ceramic, metal, and polymer matrix composite materials and also reviewed.

**Keywords:** Graphene, Polymer, CNT.

### *1 Introduction*

In today's world, the three main reasons on which we look first are- One is striving ultimately to profit. It is performance which makes a material more attractive or economic to use. The second is legislative, govern by environmental protection regulations. World's most environmentally friendly aircraft, the Boeing Dreamliner, uses 32 tons of composite material in its construction. Its design was the result of environmental legislation trends and increasing fuel prices. The third reason is, simply, because there is no alternative - the epic Apollo mission could not have got to the moon without composites used in the suits the astronauts used.

### *2.1 Ceramic Matrix Materials (CMC)*

Ceramic matrix materials are mostly widely researched Matrix materials in the recent years because of its ability to withstand high temperatures. CMC find its potential applications in aerospace industries where the components are subjected to high temperature like breaks of an airplane and exhaust nozzle. However low fracture toughness limits its application in several components of airplanes.

The most widely studied ceramic matrix materials are silicon carbide, zirconia, aluminum titanate and aluminum nitride (AlN) are widely studied matrix material in recent years because of its high temperature stability. However as discussed above low fracture toughness is a concern and Carbon nano tubes are found to possesses attractive properties which can improve toughness of ceramic composites. Iftikhar Ahmad et al reviewed the

potential reinforcements which improve fracture toughness and found out Graphene as potential reinforcement for improving toughness properties of ceramic matrix material over Carbon Nano Tubes. Multi walled carbon Nano tube with $Al_2O_3$ 10% showed a hardness of 22.9 GPa whereas grapheme with 1.5% volume with silicon nitride (Si3N4) improved toughness by 235% improvement in toughness and also improved flexural properties of the ceramic composites [16].

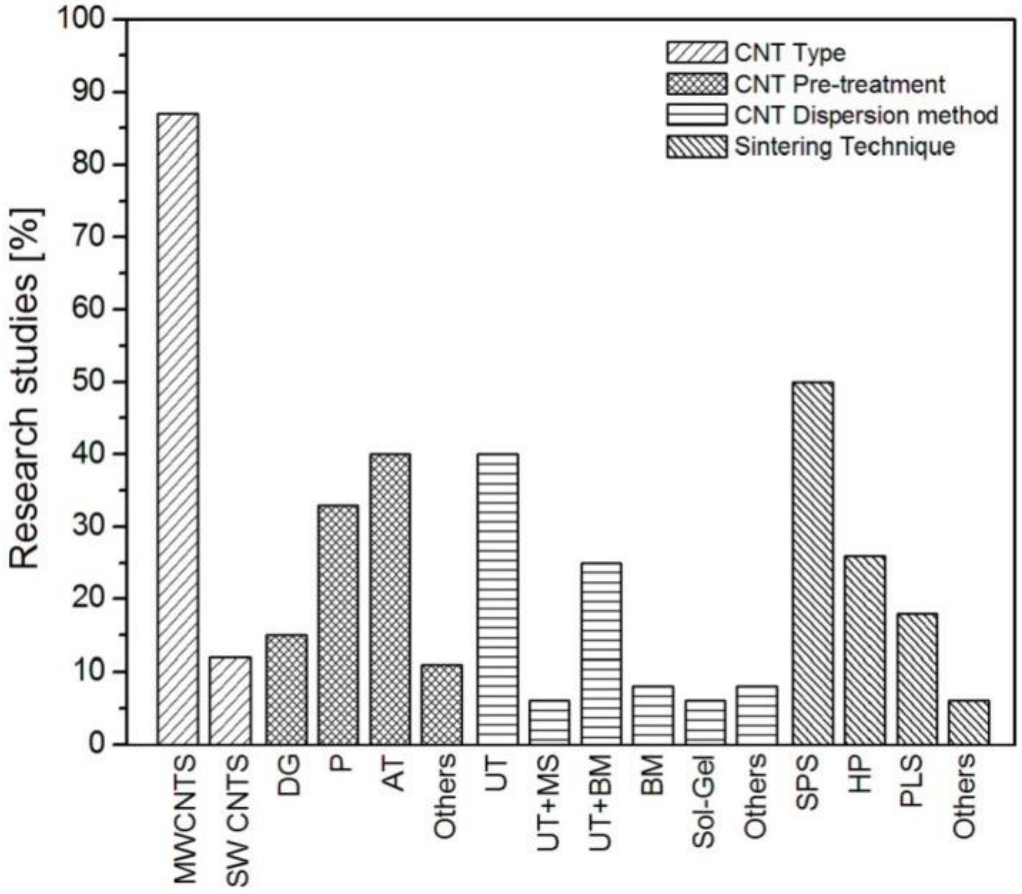


Figure 1: Contribution to the field of Nano Reinforcements. [16]

*Shangwu Fan et al (2015)* discusses the progress of ceramic matrix material for the application of brakes in aircraft by reinforcing carbon fiber with Silicon carbide as matrix material. Reinforcement of carbon fiber reduced the weight by 300kgs when compared to steel design. The author reviews various manufacturing process of C/SiC brakes are introduced first, followed by focus on manufacturing process, properties and wear mechanisms of C/SiC aircraft brake materials. C/SiC exhibited superior frictional properties and a higher brake efficiency [17].

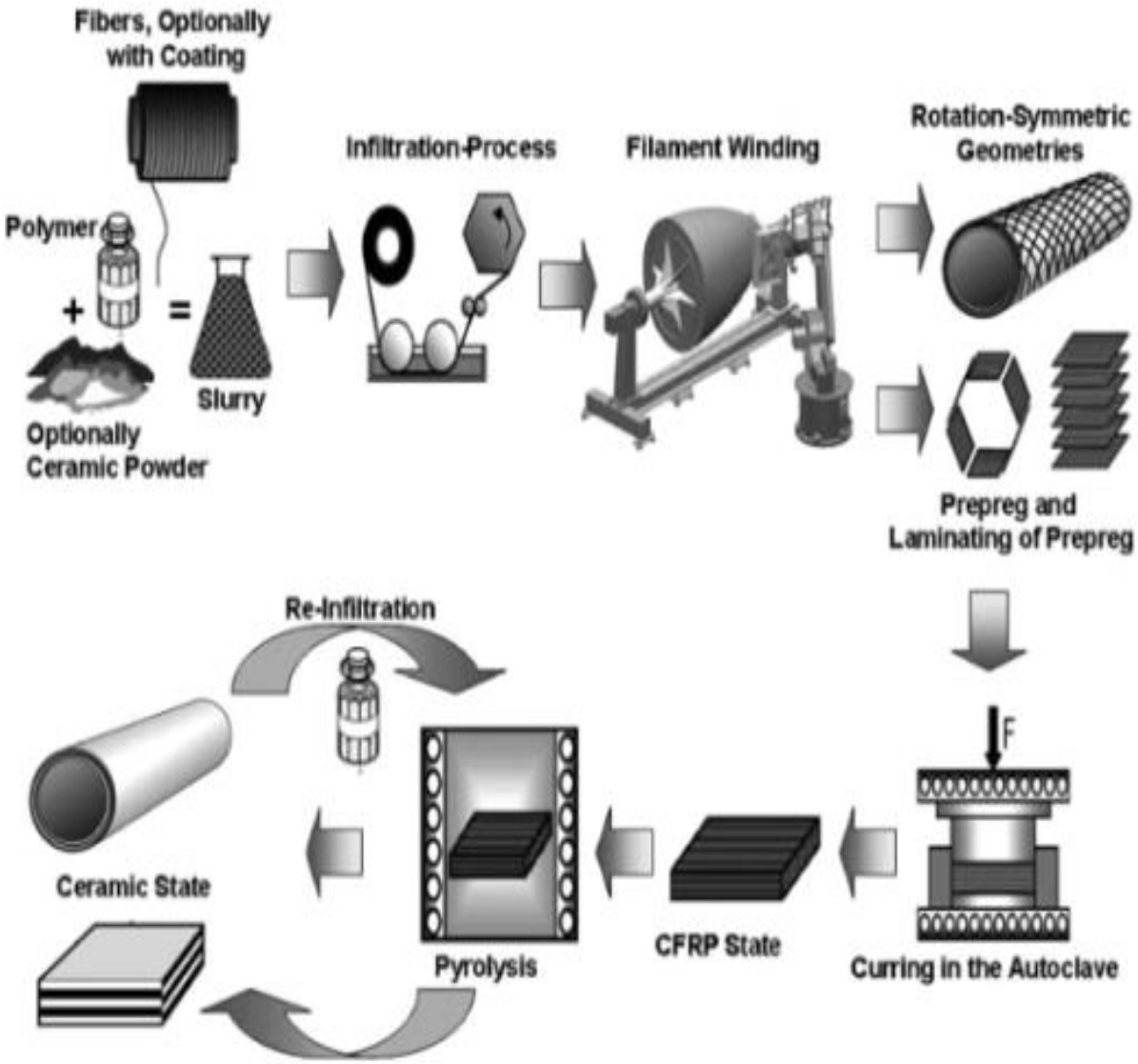


Figure 2: Flowchart for PIP Process.

Figure 3: C/SiC brakes for Porsche 911 GT2. [17]

### *2.2 Metal Matrix Composite (MMC)*

Metal Matrix composites (MMC) are used in aeronautical applications because of its attractive properties like high yield strength, low thermal expansion, wear resistance and fracture toughness. aluminum, magnesium, titanium, copper, and nickel are the most studied Metal Matrix Composites [20]. *Afsaneh Dorri Moghadam (2015)* reviews the mechanical and tribological properties of self-lubricating MMC. The author reviews the self-lubricating MMC reinforced with CNT and Graphene. The author reviewed various manufacturing process like Powder metallurgy technique, cold compaction and sintering of Aluminum /Graphene, Copper /nanographite, Aluminum CNT, Aluminum/ MWCNT and concludes both Graphene and carbon Nano Tubes increase the mechanical properties and self-lubricating properties of MMC [20].

*Xiaoshu Zenga et al (2010)* developed a new technique for dispersion of carbon nanotube by ball milling process to get homogenous dispersion of MWCNT in AZ31 alloy. The ball milling process was performed in a horizontal rotary ball mill using stainless steel balls with the ball to powder volume ratio of 3:1, Maximum tensile strength was observed at 210.3MPa and an elongation rate of 8.56%, which represents an increase of 30.8% and 124.1 % compared with AZ31 alloy [23]. *Katsuyoshi Kondoh et al (2009)* investigated Characteristics of powder metallurgy pure titanium matrix composite reinforced with multi-wall carbon nanotubes. MWCNT are reinforced into Titanium matrix by Powder Metallurgy and subsequently by extrusion process. MWCNT are prepared by spark plasma sintering. Reinforcement of MWCNT 0.35 wt% CNTs with titanium matrix and increase of tensile strength and yield stress of the extruded TMC was 157 MPa and 169 MPa was observed [24].

### *2.3 Polymer Matrix Materials (PMC)*

Polymer materials are most preferred matrix material for aerospace applications as it offers specific strength properties with a weight saving of 20_40%, and its ability to meet stringent dimensional stability, lower thermal expansion properties, and excellent fatigue and fracture resistance over other materials like metals and ceramics makes it an ideal aerospace material. *Soraia Pimenta et al (2014)* discusses the recycling of carbon reinforced polymers A critical comparison between recycling processes proved each of them to have specific advantages and drawbacks, suggesting complementarity rather than competition. Most of recycling processes yield rCFs with high retention of mechanical properties [25].

*K.L. Pickering et al (2015)* the author reviews the potential applications of use of natural fibers composites and their mechanical performance. Natural fibers offer the potential advantage of recycling, low environmental impact and low cost. However, research is still being carried out to make it a suitable reinforcement in aeronautical applications. One of the challenges that natural fiber composites face apart from strength is its moisture absorption and weathering properties. However recent developments in Natural fiber reinforced

composites shows that the tensile strength, cost, stiffness of the composites are nearing Glass fiber reinforced composites. Some of the common natural fibers available are sisal, flax, hemp of which sisal possess better properties with tensile strength and flexural strength as 410MPa and 320MPa. [27]. *Tayyab Subhani et al (2015)* The author discusses a novel class of epoxy-based hybrid composites by taking Epoxy as matrix material and Multi-walled carbon nanotubes and nano diamonds reinforcements. The combined effect to MWCNT and NDs have been investigated and mechanical properties of epoxy hybrid nano composites has been investigated by increasing the contents of Nano reinforcements from 0.05 to 0.2%wt showed an increase in tensile strength of 70%, flexural 04% for 0.2 wt % of MWCNT and ND as compared to neat epoxy. The hardness is increased by 50% where as there is a significant increase in impact properties which is 161% [30].

**3 Conclusion**

After extensive literature review and discussion, it is crucial to put light on the usage of polymer composites in all sectors of the industry specifically in aircraft industry because of its merits of very high strength to weight ratio. Evaluation of mechanical, thermal and stealth properties of metal oxide reinforced polymer composites are emphasized to be important as stealth test and bending behavior are considered as real time tests applied in aircraft industries.

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