PREPARATION AND CHARACTERISATION OF CNT- METAL COMPOSITES

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The development of nano-particle reinforced composites is currently one of the key areas of research in materials science and engineering. Carbon nanotubes (CNT) and other nano-particles are being intensely investigated as potential candidates for reinforcement of metallic and non-metallic matrix materials[1]. To date, CNT have been used as reinforcements in polymers, ceramics and monolithic metals to form composites[2]. Single walled nanotubes (SWNT) and multi-walled nanotubes (MWNT) posses excellent mechanical properties and chemical stability, which result from their cylindrical graphitic structure. Experimental measurements indicate that the Young's Modulus for CNT is as high as 1 TPa and it's tensile strength in the order of 20 – 100 GPa [3-4].

A SWNT is typically 1-3 nm in diameter and > 1μm in length, while MWNT range from 10 - 40 nm in diameter and about the same length as SWNT. These dimensions show that CNT have high aspect ratios typically in the order of 1000:1. The size and aspect ratio allows for much finer distribution of the tubes within a matrix.

This work focuses on the incorporation of MWNT as reinforcements of ferrous metal surfaces by means of laser alloying. The alloying powder was prepared using a commercial 316 stainless steel powder with average particle size between 30-45 μm and commercial MWNT with a diameter from 30-50 nm and the length of approximately 50 μm. The commercial CNT were characterized using Raman Spectroscopy for determining the type of the tubes, while a Scanning Electron Microscope (SEM) was used to verify the physical dimensions of the CNT.

A major challenge in taking full advantage of the unique properties of the CNT is controlling the degree of dispersion of the nanotubes in the matrix. It can be seen from fig. 1 that the tubes tend to organize themselves into long intertwined ropes, thus making it difficult to disperse as individual tubes in a metal powder matrix.

The stainless steel powder was mixed with 1 mass % of CNT in cellulose binder to make a slurry. The mixture was ground and sonicated for 2 hours. The mixture was dried in air and mechanically fractured for further (SEM) investigations. A SEM micrograph of the blended CNT-stainless is shown in fig. 2. The tubes remain embedded in the binder bonded to the steel particles. Some degree of separation of the tubes is noticeable in the micrograph. However, the majority of the tubes remained in bundles because of the van der Waals forces between that makes it difficult to disperse in the prepared mixture.

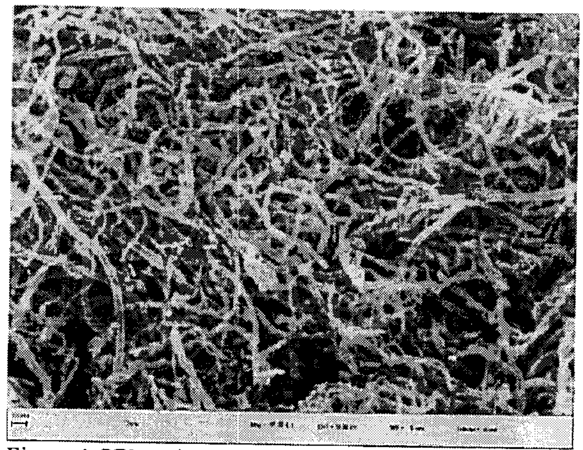

Figure 1 SEM micrograph of MWNT, showing network and bundles of CNT.

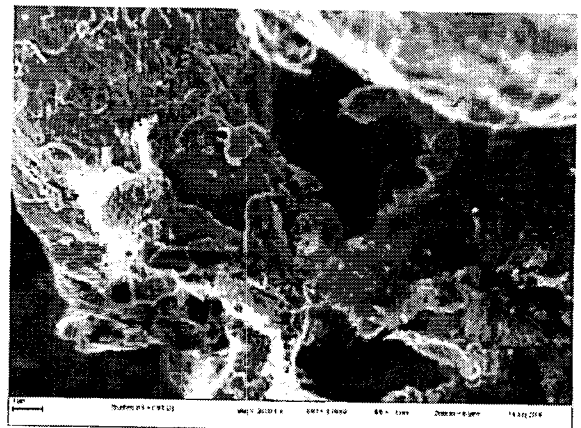

Figure 2 SEM micrograph of the surface of the stainless steel powder coated with CNT.

The success in keeping the CNT bonded to the stainless steel by use of a binder provides a possible method for the preparation of CNT-metal composites. Alternative methods for the preparation of CNT-metal composites include hot pressing, sintering etc. In this work laser surface alloying will be used, the advantage of this is that critical pre-selected areas on the surface of a high value component can be specifically targeted for reinforcement. The alloying of the CNT will be carried out with a laser beam in an inert gas environment. The role of CNT in the reinforcement of metal components will be characterized for mechanical and chemical properties.

References

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