Metal-carbon nanotubes (CNTs) composites are the promising advanced materials that are being developed to take the advantage of the exceptional properties of CNTs. Because of the intrinsically strong in-plane atomic SP2 bonding CNTs offer high young's modulus (1.0-1.8 TPa), high tensile strength (30-200 GPa) and high elongation at break (10-30%). The thermal conductivity of individual single-walled carbon nanotube (SWCNT) and multi-walled carbon nanotube (MWCNT) are about 6000 W/m-K and 3000 W/m-K, respectively. Therefore it is expected that by incorporation of CNTs in metal matrices multi-functional composites can be used ideally as thermal interface materials, light-weight high-strength structural materials, electric components, optical devices, electromagnetic absorption materials etc. However, so far results are far from satisfied for CNT composites, mainly due to the fact that there are two main key issues remained without good solutions for CNT composites: the poor uniformity in CNT dispersion and the weak interfacial bonding between CNTs and the matrices.

In this study, MWCNTs were functionalized and coated with metals like Cu and Ni by electroless deposition methods prior to their application. Metal coatings result in strong interfacial bonding at CNT-metal interfaces and uniform dispersion. During metal coating processes CNTs are physically separated in electrolyte and after coating they get physically retain the separation by the coated metal layer that they are not allowed to aggregate to form bundles. Moreover, after metal coating, the resultant density of Ni-coated MWCNTs is close to that of molten metal matrix. This prevent separation of CNTs due to buoyancy effects and results in uniform dispersion. Metal coating on CNTs surfaces also allows to form strong interfacial bonding with the metal matrices.

SnBi alloy has been identified as novel lead-free thermal interface material (TIM) for electronics packaging. However the thermal conductivity and the mechanical strength of pure SnBi alloy are not sufficient to withstand harsh environment imposed by powder electronics. Therefor how to increase the thermal conductivity and the mechanical strength of SnBi solder becomes important. In this study, MWCNTs have been added into SnBi alloy to form SnBi/CNT composite solders by different material processing methods. First, in sandwich method Cu-coated CNTs were added to the 70Sn-30Bi alloy and mixed mechanically. UTS was increased by 47.6% for 3 wt. % Cu/CNTs addition. Second, Ni-coated CNTs were added by sonication assisted melting method in fabricating 70Sn-30Bi solder. For 3 wt. % Ni-coated MWCNTs, equivalent to 0.6 wt. % pure MWCNTs, UTS and YS were increased by 88.8 % and 112.3% respectively. In addition the thermal conductivity was also increased by more than 70%.

Ni-coated CNTs were also added to pure Al by powder metallurgy method. For 7 wt. % Ni/CNTs having diameter 30-50 nm, UTS and YS were increased by 92.7% and 101.6% respectively. For CNTs having diameter 8-15 nm, UTS and YS were increased by 108.9% and 128.2% respectively for 3 wt. % addition. All these results are first time obtained that are much greater than published data on CNT/metal composites. Results discussion and mechanism in reinforcement were also presented.

Major: Materials Science and Engineering

Educational Career:
Bachelor's of Materials and Metallurgical Engineering, BS, 2009, Bangladesh University of Engineering and Technology
Master's of Materials and Metallurgical Engineering, MS, 2012, Bangladesh University of Engineering and Technology

Committee in Charge:
Dr. Quanfang Chen, Chair, Materials and Metallurgical Engineering
Linan An, Materials and Metallurgical Engineering
Yuanli Bai, Materials and Metallurgical Engineering