ABSTRACT

The discovery of carbon-nanotube (CNT) in the year 1991, is the recent most addition to ordered and stable form of carbon allotropes such as the diamond, graphene and carbon fullerence (also called buckminster-fullerene, C$_{60}$). The CNT structure is conceptualized by a rolled single sheet of graphene to form a cylindrical tube with end caps of hemispherical carbon fullerences. Nanotubes are composed of sp$^2$ bonds, similar to those observed in graphene, and this lends them to extraordinary properties as attributable to graphene. The graphene is well known to possess one of the highest modulus of the known materials as well as excellent electrical and thermal conductivity; the CNTs inherit such properties.

The CNTs as cylindrical carbon molecules possess outstanding and novel mechanical, electrical, thermal, and chemical properties; 100 times stronger than steel, can maintain current density of more than $10^9$ A/cm$^2$, are best field emission emitters, thermal conductivity comparable to that of diamond. Such excellent properties make them potentially useful in a wide variety of applications e.g., in composite materials, conductive polymers, in optics, nanoelectronics and the sensors, etc., to name the few. In the present (year 2005), two types of CNTs namely the Single-wall-CNT (SWCNT) and Multi-walled-CNT are being researched and commercially produced. The MWCNT, a less ordered form of CNT, is a relatively mature technology though their applications are mostly limited to exploiting the mechanical
strengths of CNTs through alloying and compositing with metals, ceramics and polymers. The SWCNT in highly crystalline form are being actively developed for possible applications to electronic transport based devices and optical devices. Techniques like carbon arc-discharge, laser ablation, high pressure carbon monoxide (HiPCO), and chemical vapor deposition (CVD) are being employed to synthesize CNTs of sizeable quantities. Of these, the CVD method has shown the most promise in terms of its price/unit ratio. CVD-grown CNTs possess inferior crystallinity, particularly the MWCNT. The growth control and structural integrity of CNT being dependent on several factors such as precursor material, a host of process parameters, catalyst and substrate used for deposition/condensation, become important issues for research. The defects in CNT, their dimensions both the diameter and length, extent of structural order besides the crystallinity are other critical issues for achieving potentially high theoretical strengths in MWCNT. These characteristics are equally important for electric and thermal properties of MWCNT. All extraordinary properties of CNTs are predicted for atomically-perfect CNTs. Because the probability of a critical flaw increases with volume, macroscale CNT of larger diameter and bundled CNTs can never achieve the strength of the constituent CNT. Improved knowledge is needed of how CNT chirality, diameter, length, and purity relate to precursors, catalyst composition and process conditions. Lack of quality control and assessment of CNTs synthesized by different groups by different methods does not allow us to
get correct product details. The motivation of this proposed research emerges from some of above needs.

The present research proposal will prepare iron catalyst CNT with process parameters available in literature and to measure mechanical properties of CVD grown MWCNT by the currently most preferred and advanced method namely the Atomic Force Microscopy (AFM). As part of the proposed investigations, the measured mechanical properties are proposed to be correlated to structural properties such as, the order of the grown CVD-MWCNT, crystallinity and defects that control the mechanical properties. The structural and topological features will be characterized by the Scanning Electron Microscopy (SEM) and the Raman Laser Microscopy. As a significant part of the proposal it will be an object to determine a possible relationship between the disorder/crystallinity of CVD-CNT with respect to their mechanical properties especially the modulus. It is expected that various CNT specimen prepared by differing process conditions yet may have a commonality, in the sense that the relationships of structural features and mechanical properties have a definite relationship. Knowledge of such relationships a-priori measured by routine instrumentation like Raman spectroscopy and SEM, can be predictors for mechanical properties and such an ability to predict mechanical properties by simpler instrumentation may be of significant utility since to measure mechanical properties otherwise is an extremely difficult task. The electrical properties, as a bulk property, will also be measured by the usual methods using the LCR bridge and the Ohm's law.