Carbon Nanotube based Nanotechnology for NASA Mission Needs and Societal Applications

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Carbon nanotubes (CNT) exhibit extraordinary mechanical properties and unique electronic properties and therefore, have received much attention for more than a decade now for a variety of applications ranging from nanoelectronics, composites to meeting needs in energy, environmental and other sectors. In this talk, we focus on some near term potential of CNT applications for both NASA and other Agency/societal needs.

The most promising and successful application to date is a nano chem sensor at TRL 6 that uses a 16-256 sensor array in the construction of an electronic nose. Pristine, doped, functionalized and metal-loaded SWCNTs are used as conducting materials to provide chemical variation across the individual elements of the sensor array. This miniaturized sensor has been incorporated in an iPhone for homeland security applications. Gases and vapors relevant to leak detection in crew vehicles, biomedical, mining, chemical threats, industrial spills and others have been demonstrated. SWCNTs also respond to radiation exposure via a change in conductivity and therefore, a similar strategy is being pursued to construct a radiation nose to identify radiation sources (gamma, protons, neutrons, X-ray, etc.) with their energy levels.

Carbon nanofibers (CNFs) grown using plasma enhanced CVD typically are vertical, individual, freestanding structures and therefore, are ideal for construction of nanoelectrodes. A nanoelectrode array (NEA) can be the basis for an affinity-based biosensor to meet the needs in applications such as lab-on-a-chip, environmental monitoring, cancer diagnostics, biothreat monitoring, water and food safety and others. A couple of demonstrations including detection of e-coli and ricin will be discussed. The NEA is also useful for implantation in the brain for deep brain stimulation and neuroengineering applications.

Miniaturization of payload such as science instrumentation and power sources is critical to reduce launch costs. High current density (> 100 mA/cm^2) field emission capabilities of CNTs can be exploited for construction of electron gun for electron microscopy and X-ray tubes for spectrometers and baggage screening. A CNT pillar array configuration has been demonstrated, not only meeting the high current density needs but more importantly providing long term emitter stability. Finally, supercapacitors hold the promise to combine the high energy density of a battery with the high power density of capacitors. Traditional graphite electrodes have not delivered this promise yet. A novel design and processing approach using MWCNTs has shown a record 550 F/g capacitance along with significant device endurance. This supercapacitor is suitable for railgun launch application for NASA, powering rovers and robots, consumer electronics and future hybrid vehicles.