



Manufacturing

# Functionalization Of Carbon Nanotubes

"Dry" chemical functionalization of CNTs

NASA has patented a method and system for dry chemical functionalization of a collection of carbon nanotubes (CNTs). For many applications of nanotubes in sensors, composites and other nano devices, chemical functionalization of the nanotubes is necessary. A common approach to functionalize nanotubes is to use a wet chemical procedure or electrochemical procedure. This NASA developed technology is a clean and efficient approach that uses a plasma or glow discharge to functionalize the nanotubes with atomic, or molecular chemical species. The method can use direct current, radio frequency, (inductive or capacitive) or microwave sources to strike a glow discharge and generate a large number of species needed for functionalization from appropriate source gases.

## BENEFITS

- CNT functionalization process is dry
- Produces little residue for clean-up
- Flexible can be used for large numbers of chemical functional groups
- Reasonably selective
- Is Scalable
- Does not require use of complex apparatus or complex processing

technology solution



### THE TECHNOLOGY

Carbon nanotubes (CNTs) have attracted much attention, due to their extraordinary mechanical and unique electronic properties. CNTs are being studied for applications in high strength/low weight composites and other applications. In order to alter the CNT properties for particular applications chemical functionalization may be necessary. For example, functionalization used in atomic force microscopy, of the side walls of the CNT with suitable molecules can provide chemical sensors that recognize certain target species and ignore all others. Development of multi-functional composite materials may require functionalization of a collection of CNTs to allow the tubes to be dispersed more easily in a host matrix. This technology provides a selective, scalable approach, not involving "wet" chemistry, for functionalization of a collection of CNTs with any of a large class of elements and compounds, including hydrogen, the alkali metals, selected hydrocarbons, selected organic species, and the halogens. A selected precursor gas is irradiated to provide a cold plasma of selected target particles in a first chamber. The target particles are directed toward an array of CNTs located in a second chamber. A CNT array is functionalized with the target particles, at or below room temperature, to a point of saturation, in an exposure time interval no longer than about 30 sec., making it an efficient method to dry functionalize CNTs.



Various applications of the technology

### APPLICATIONS

The technology has several potential applications:

- ➔ Multi-functional composite materials
- ➔ Body Armor and space suits
- ➔ Heat exchange systems
- ➔ Radiators
- ➔ Aerospace
- ➔ Chemical sensors, physical sensors
- ➔ Computers and data storage
- ➔ Electronics, nano-electro-mechanical systems

### PUBLICATIONS

Patent No: 7,276,266; 7,473,436

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