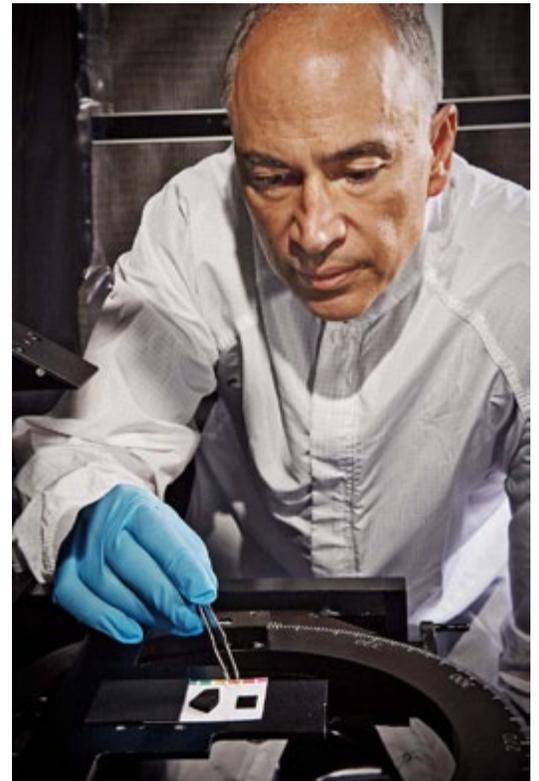


**technology opportunity**

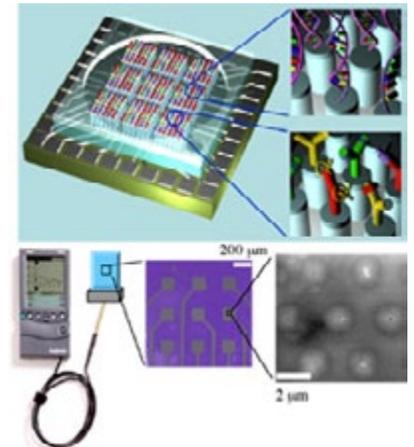
# Biochemical Sensors Using Carbon Nanotube Arrays

## Ultrasensitive Label-Free Electronic Biochips Based on Carbon Nanotube Nanoelectrode Arrays

The reduction of cost and time is the major concern in clinical diagnostics based on molecular analysis. Low-cost microchips are particularly desired for health monitoring and biomarker detection in NASA's space exploration, due to the fact that it is not possible to take the supporting facilities used in today's clinical lab into outer space missions. Miniaturization technologies have been recognized as the only promising solution for quick in-situ biomarker detection, astronaut health monitoring, and environmental monitoring in future human flights. Electronics technology is of particular interest due to the ease of integration with computers as a fully automated system. However, current electronics technology can not provide the desired detection sensitivity, which limits the realization of their advantages. Nanotechnology can be employed to solve this problem. We have successfully demonstrated a miniaturized electronics technology with extremely high sensitivity and simplified sample preparation for in-vitro detecting a specific biomarker signature, which is based on incorporating embedded vertically aligned carbon nanotubes as nanoelectrode arrays in diagnostics devices. The electroactive components inherent in the target molecules can be directly measured with electrocatalytic methods. Labor intensive and costly labeling and amplification processes can be skipped or minimized. This technology fuses micro- and nanotechnologies with biology, which dramatically improves the detection sensitivity so it has a great potential for development of low-cost disposable chips for rapid molecular analysis, that can be carried out with simple handheld devices, ideally for applications in space explorations.



Carbon nanotube is used by NASA to coat the internal components of cameras and telescopes in space.



Magnified carbon nanotube nanoelectrode array.

## Benefits

- Simple, low cost accurate methods for rapid gene analysis
- Electronic detection platform can be integrated with microfluidics and microelectronics as highly automated disposable chips for human flights
- No need for labor intensive and costly labeling and amplification processes
- Carbon nanotubes have a wide potential window, well-defined surface functional groups, and good biocompatibility, which are all highly demanded properties for biosensors

## Technology Details

### Overview

Vertically aligned multiwalled carbon nanotubes (MWCNTs) are fabricated by wafer-scale plasma enhanced chemical vapor deposition (PECVD) on prefabricated microelectrode pads and encapsulated in SiO<sub>2</sub> dielectrics with only the very end exposed at the surface to form an inlaid nanodisk electrode array.

### Why the Size Matters?

As the size of an electrode is reduced, one can obtain: (1) higher sensitivity, i.e. the signal-to-noise ratio, which is inversely proportional to the radius ( $r$ ) of the electrode, (2) lower detection limit, (3) higher temporal resolution (proportional to  $1/r$ ), and (4) miniaturization. Therefore, nanoelectrodes have great properties for electroanalysis.

### Why Carbon Nanotubes?

CNTs, particularly MWCNTs can be fabricated at wafer scale, as high-aspect-ratio metallic wires, down to a few nanometers in diameter on metal microcontact pads to form well-defined nanoelectrode arrays. In addition, MWCNTs have a wide potential window, well-defined surface functional groups, and good biocompatibility, which are all highly demanded properties for biosensors.

### What has been achieved?

MWCNT arrays have been successfully fabricated on micropatterns. The electrical and electrochemical properties of the embedded MWCNT nanoelectrode arrays have been thoroughly characterized to show well-defined nanoelectrode behavior. Selective covalent functionalization of probe oligonucleotides has been achieved through the formation of amide bonds at the exposed end of MWCNTs. Direct electrochemical detection of the oxidation signal of inherent guanine bases in the target nucleic acids has been demonstrated with both oligonucleotide and PCR amplicon targets.

## Licensing and Partnering Opportunities

NASA Ames is currently seeking U.S. companies interested in further development and commercialization of this technology. This technology has been patented (U.S. Patent 7,939,734) and opportunities for licensing and development partnerships exist.

## For More Information

If you would like more information about this technology, please contact:

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