



Health, Medicine and Biotechnology

Retinal Light Processing Using Carbon Nanotubes

Carbon Nanotubes As A Prototype Interface For
Retinal Cell Recording And Stimulation (Vision Chip)

NASA has patented a new technology called the Vision Chip, an implantable device that has the potential to restore or supplement visual function in a diseased or damaged retina. This technology could benefit millions of people in the US and globally who suffer from degenerative diseases of the eye's retina such as Age-related Macular Degeneration (AMD), Retinitis Pigmentosa (RP), and, in some cases, diabetic retinopathy. AMD is the leading cause of irreversible vision loss in the U.S., affecting >25% of people over age 74 [ref 1 at end]. Severe vision loss or blindness from many retinal disorders is increasing as the population ages. The Vision Chip is targeted to treat AMD, and other degenerative diseases of the retina by replacing a compromised retinal photoreceptor system with an array of equivalent external photoreceptors and carbon nanotube (CNT) "towers" (bundles of CNTs) that provide a pathway to transmit signals from the external photoreceptors to an active layer of retina.

BENEFITS

- Targeted treatment of age-related macular degeneration or other degenerative diseases
- Eye research applications
- Durability, mechanical strength
- Less tissue damage from flexible CNTs
- Biocompatibility less immune response, inflammation, etc.
- Ease of engineering and manufacture
- Low cost
- Readily integrated into silicon microcircuitry

technology solution



NASA Technology Transfer Program

Bringing NASA Technology Down to Earth

THE TECHNOLOGY

The Vision Chip provides an alternative, pixel-sized, wavelength-sensitive light path around diseased, injured, or deficient areas to functioning retina. The implantable Vision Chip is based on CNTs or CNT bundles, used as photodetectors, electrodes, transducers, or physical guides to transmit opto-electrical signals in response to light. Each array of CNT towers connects to a pixel at one end, and penetrates the active retina at the other end. The chip's array of electrically conducting or semi-conducting CNT towers project orthogonally from the surface of a silicon chip or similar solid support. The separate electrical connections allow for towers to be electrically stimulated independently for high resolution and flexibility. An insulating layer covers the electrical circuitry, thereby electrically isolating the eye tissue. A key design feature is sufficient mechanical stability of the towers to permit insertion into retinal tissue, either from the anterior or the posterior aspect of the retina, without breaking or dislodging the CNT towers. A ground electrode, or counter-electrode, is incorporated onto the Vision Chip, to optimize electrical stimulation and electrical sensing from eye tissue. Benefits can include partial or full restoration of vision for those with certain retina disorders, injuries, and diseases like AMD or RP. In addition, light sensitivities of the system can be 'tuned' to respond to certain frequencies or amplified nonlinearly, so certain forms of color blindness and night blindness may benefit from this technology. The Vision Chip can also be used as an electrical sensor for the retina in fundamental vision science research to understand the eye's processing and integration of light signals.

Ref 1: Bressler et al. Potential public health impact of Age-Related Eye Disease Study results: AREDS report no. 11. Arch Ophthalmol. Nov 2003;121(11):1621-4. [Medline]



Doctor performs eye exam on a senior

APPLICATIONS

The technology has several potential applications:

- Nanobiotechnology
- Nanomedicine
- Neuromorphic engineering
- Molecular nanotechnology
- Biomolecular computing
- Medical devices

PUBLICATIONS

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