Carbon Nanotubes in Neuro-nanotechnology

Neuro-nanotechnology [2] is an approach that integrates nanoparticles [3] (or nanostructures) into the field of neuroscience in order to both study the structures and functions of the brain and to treat neurological diseases. These technologies include nanoparticles [3] to deliver drugs across the blood-brain barrier, to monitor electrical signals in the brain, and to induce neural signaling in damaged brain tissue. One advance in this field is the development of artificial synapses [4], which offers a way to stimulate damaged neurons and may to restore brain function. The artificial synapses [4] double as a platform for modeling artificial neural networks in supercomputers [1].

The neural architecture of the brain is disrupted, impacting body functionality and cognition after tissue damage due to stroke, injury, or neoplasm (abnormal growth usually attributed to cancer [5]). Artificial synapses [4] can aid in reconstructing nerve networks, in studying neuronal differentiation, and facilitate nerve tissue repair by increasing the movement electrical signals between neurons. The increase in electrical signals creates the chemical signals needed for the peripheral and central nervous systems to function properly [3]. Artificial synapses [4] are composed of multiple transistors that use carbon nanotubes [6] (CNTs [7]) as the electrical channeling material. CNT's are both highly conductive and non-toxic [5]. Currently, artificial synapses [4] use a special type of CNT [8] known as the optically gated carbon nanotube field-effect transistors [9] (OG-CNTFET), which are coated with a polymer to make them light sensitive. This sensitively to light is extremely important, as the circuitry is programmed to respond to positive or negative light pulses. Using OG-CNTFETs also helps to reduce density variability and minimize defects within the nanotube structures. Outside of the human brain, computing power increases exponentially with each artificial synapse added to the network. In a study conducted using OG-CNTFETs, the first four synapses were capable of performing 104 linearly separable logic functions, but with the addition of two more synapses the total computing power increased to over 90,000 functions. Computing power could be increased without increasing the size of the transistors by using artificial synapses [4] as a biological model for computer circuitry [2].

Left: optical microscope image of eight nanotube-based programmable resistances forming three
synapses Right: scanning electron microscope image of patterned network of carbon nanotubes [8]

(Source: Gacem et. al, 2013)

References


Author:

Abigail Howel [12]
Elliot Navarro [13]

Development Stage:

- Scientific [14]

Key Words:

- Neuro-nanotechnology [2]
- Artificial synapses [4]
- Optically gated carbon nanotube field-effect transistors [9]

Mechanism:

- Active Nanostructure [15]

Material:
**Benefit Summary:**

*Artificial synapses* [4] cannot only be used in brain tissue repair and augmentation, but also function as a model for designing computer circuitry. Due to the high volume of *CNT* [8] transistors on a single chip (thousands of *CNTs* [7]), slight variability in *CNT* [8] density and orientation does not negatively impact the ability of the computer to learn a programmable logic function. Additionally, using OG-CNTFETs in the synapses allows the transistor [17] conductivity to be adjusted, is nonvolatile, and can be easily programmed using light pulses.

**Benefit:**

- **Health** [18]

**Risk Summary:**

Although *CNTs* [7] are at such a small scale that they can be assumed to be inert, they do pose the same risks that are created when ultra-fine and *nanoparticles* [3] enter the body. For example, *CNTs* [7] are structurally similar to asbestos (long fibers that are chemically untreated), which are a carcinogenic risk if they embed themselves in lung tissues. Implantation of *artificial synapses* [4] or any *neuro-nanotechnology* [2] has similar risks associated with brain surgery such as infections, bleeding, seizure, stroke, coma, brain damage, brain swelling [4].

**Risk Characterization:**

- **Uncertain** [19]

**Risk Assessment:**

- **Health Risks** [20]

**Facility:**

- **Medicine/Healthcare** [21]
CNS-ASU research, education, and outreach activities are supported by the National Science Foundation under cooperative agreement #0937591.

Terms and Conditions

Source URL: https://nice.asu.edu/nano/carbon-nanotubes-neuro-nanotechnology

Links:
[1] https://nice.asu.edu/nano/carbon-nanotubes-neuro-nanotechnology
[2] https://nice.asu.edu/keywords/neuro-nanotechnology
[3] https://nice.asu.edu/keywords/nanoparticles
[5] https://nice.asu.edu/keywords/cancer
[6] https://nice.asu.edu/keywords/carbon-nanotubes
[7] https://nice.asu.edu/keywords/nts
[8] https://nice.asu.edu/keywords/cnt
[10] https://nice.asu.edu/keywords/carbon-nanotube
[12] https://nice.asu.edu/users/abigail-howel
[14] https://nice.asu.edu/development-stage/scientific
[15] https://nice.asu.edu/mechanism/active-nanostructure
[16] https://nice.asu.edu/material/carbon
[17] https://nice.asu.edu/keywords/transistor
[18] https://nice.asu.edu/benefit/health
[21] https://nice.asu.edu/facility/medicinehealthcare