Nanowires

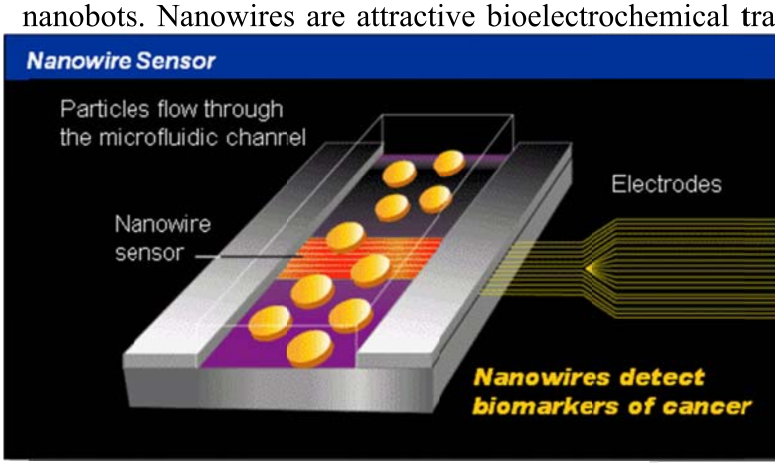
Nanowires:

A nanowire is an extremely thin wire with thickness or diameter of about 10^{-9} m or less. They have aspect ratios (length-to-width ratio) of or greater than 1000 and are often referred to as one-dimensional (1-D) materials as well. Their physical properties differ significantly from the bulk 3-D materials because of confinement and surface effects and thus enter into the domain of quantum mechanics, and are also referred as called-"quantum wires". Depending on its size and material, a nanowire can have the properties similar to an insulator, a semiconductor or a metal e.g. nano clusters of aluminum atoms are magnetic, though aluminum is not. They are grouped into - metallic (e.g., Ni, Pt, Au), semiconducting (e.g., Si, inp, gan, etc.), insulating (e.g., sio_2, tio_2) and molecular nanowires (molecular units of organic (e.g. DNA) or inorganic (e.g. $Mo_6S_{9-x}i_x$) repeats). Nanowires possess high electric conductivity without heat loss and are usually very flexible.

Nanowires can be synthesized by top-down or bottom-up approaches, but currently, we don't have a suitable method for mass production. In laboratories most commonly used techniques are suspension, electrochemical deposition, vapor deposition, and vapor-liquid-solid method (VLS) growth. Nanowires are also made by heating up a rod of sapphire and wrapping the cable around the rod and then pulling the cable to stretch it thin to fall in the nano range width. DNA based template is also used. DNA template is used to fabricate nanowires as its diameter is around 2 nm and its length and sequence can also be precisely controlled.

Applications

Nanowires are promising materials for development of microprocessors, prototype sensors and nanobots. Nanowires are attractive bioelectrochemical transducers as their diameters match the size of biochemical analytes and since their conduction is sensitive to surface perturbations. Thus nanowires have been incorporated into devices for bio sensing purposes. Nanowire based devices are ultrasensitive and can be used for direct electrical detection of a wide range of biological and chemical species, from DNA to drug molecules and viruses; ph; and in markers of various types. They will be made out of materials that react with harmful agents, and thus alerting to the presence of harmful agents.



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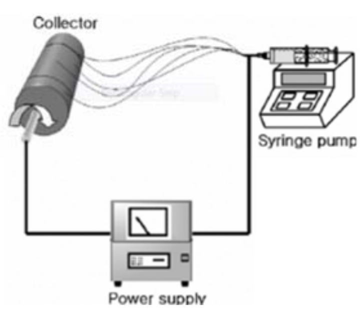
In a nanowire sensor, multiple nano sized sensing wires(characteristically very selective and specific) are postioned across a microfluidic channel. When an analyte particle flows through the microfluidic channel, the nanowire sensors pick up the molecular signatures of these particles and can immediately signal this information via a connection of electrodes to the scientist. They are capable to detect the presence of altered genes associated with cancer and can even determine the exact location of the mutation.

Nanofiber

A variety of polymers like nylon, polystyrene, polyacrylonitrile, polycarbonate, peo, pet and water-soluble polymers are commonly used to produce nanofibers. The material used to make them significantly effects its properties. They can be produced in a number of ways, such as electrospinning, melt spinning, solution spinning, electroblowing, self-assembly, template synthesis, force spinning, drawing and phase separation. Carbon nanofibers are produced by catalytic synthesis of graphite. Electrospinning method is a widely used process at industrial level. This process makes use of electrostatic and mechanical force to spin fibers from the tip of a fine orifice or spinneret which is maintained at positive or negative charge by a DC power supply. At critical voltage, the electrostatic repelling force overcomes the surface tension force of the polymer solution in the syringe pump, the liquid spills out of the spinneret and forms an extremely fine continuous filament. These filaments are collected onto a rotating or stationary collector with an electrode beneath of the opposite charge to that of the spinneret where they accumulate and bond together to form nanofiber fabric. Nanofibres in the range of 10 to 1000 nm diameter can be produced by appropriately choosing among the parameters such as viscosity, applied voltage, concentration, distance between the two electrodes, and nozzle tip (needle) diameters.

Nano-dimension brings them with some unique properties like low density, large surface area to mass, high pore volume, small pore size, superior mechanical properties and possibility to incorporate different additives. Functionalization can significantly improve and add to their properties, for example creating super-hydrophobic (water repellent) or super-hydrophilic (highly water absorbent) materials. Nanofibers are generally not used as a single fiber. They are layered as a sheet or mat. Nanofiber is so small and light that just over one gram would be enough to circle the world round the equator.



Due to their unique properties, nanofibers offer numerous astonishing opportunities in the field of nanotechnology, textile industry, energy production and biomedical engineering. Peptide nanofibers associates to form nanofiber scaffold with well-ordered nanopores averaging 5-200nm. These pores contain extremely high water quantity (95.5% w/v) and are used for the preparation of three dimensional (3-D) cell culture. These scaffolds closely resemble the porosity and gross structure of extracellular matrices. They allow cell to reside, grow and replicate in a 3-D environment. They also allow molecules like growth factors and nutrients, to diffuse in and out very slowly. Thus these peptide scaffolds are ideal materials for 3-D cell culture of artificial organs or tissue, controlled cell differentiation, regenerative medicine, wound healing and slow drug delivery applications. Nanofibers are also used to make sensors to detect chemical agents; filters for air, water, beverage, oil and fuel purification; lightweight clothing; better efficiency batteries and food packaging.

Conclusions

The integration of nanotechnology and biology presents numerous avenues of untouched possibilities. The field of study is still nascent. Most applications are towards sensing responses to certain biochemical processes and in assays. Applications in the field towards the development of drug delivery systems and in therapy are one of the most promising areas of development. The major challenges faced are towards the mass production of most of the bionanomaterials, which are neither technically nor economically feasible. In-vivo applications are still not completely feasible. Still, nanotechnology lights up the hope of mankind to get the insight and understanding of the nature's beautiful creations.

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