Nano Whiskers
..A "BIG" discussion on "SMALL" things..

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Abstract:

Technologyis shrinking fast. Computing technology that would have filled awarehouse 30 years ago can now be squeezed onto a chip a fraction ofthe size of your thumbnail. The very smallest scale of engineering is called nanotechnology. Ananometer is a billionth of a meter, about the width of ten atoms. Nanotechnology may, one day, be capable nanorobotics, nanorobots ornanobots. Working at an almost atomic level, nanobots could buildcomplex items cheaply and repair clothes, equipment and even peoplewithout being noticed. They could also be used to rid the atmosphere ofpollution and to repair holes in the ozone layer.

What is nanotechnology?

Nanotechnology aims at the design and creation of functional materials, structures, devices and systems through direct control of matter on the nanometer length scale and exploitation of novel phenomena and properties on this length scale. The length scale is usually

defined as being smaller than 100 nm, depending on the physical and chemical characteristics of the particular system that undergoes quantitative and qualitative changes when the length scale boundary is crossed.

Nanotechnology research and development includes manipulation under control of the nanoscale structures and their integration into larger material components, systems and architectures. Within these larger scale assemblies, the control and construction of their structures and components remains at the nanometer scale. Essential in nanotechnology is to have a direct control of matter either between two nano-objects, or between a micro (or macro) object and a nano-object.

Nanotechnology is the materials science involving the manipulation and manufacture of materials and devices on the scale of nanometers (billionths of a meter). Although usable devices this small may be decades away, techniques for working at the nanoscale have become essential to electronic engineering, and some nanoengineered materials have appeared in consumer products. For example, billions of microscopic "nanowhiskers," each about 10 nanometers in length, have been hooked onto natural and synthetic fibers to impart stain resistance to clothing and other fabrics*; zinc oxide nanocrystals have been used to create invisible sunscreens that block ultraviolet light; and silver nanocrystals have been embedded in bandages in order to kill bacteria and prevent infection.*

What is a nanowhisker?

A nanoscale structure that consists of brushes attached along a common spine.

Silicon nanowhiskers are a major research area at GNS Science. Since the discovery of these little but fascinating structures in 1994, research has focused on understanding why they appear (they don't appear by vacuum oven annealing, only under the bombardment of the electron beam under high vacuum conditions) and what we can use them for. The overview talk will give a short summary of the discovery and will then outline what we are currently using them for and what we may be also doing with them in the near future.

Examples will be given on

(1) how to produce them,

(2) why they grow,

(3) how we can control their height and spacing,

(4) fabrication,

(5) super water phobic fibers

(6)electronic fibers and contribution to textiles,

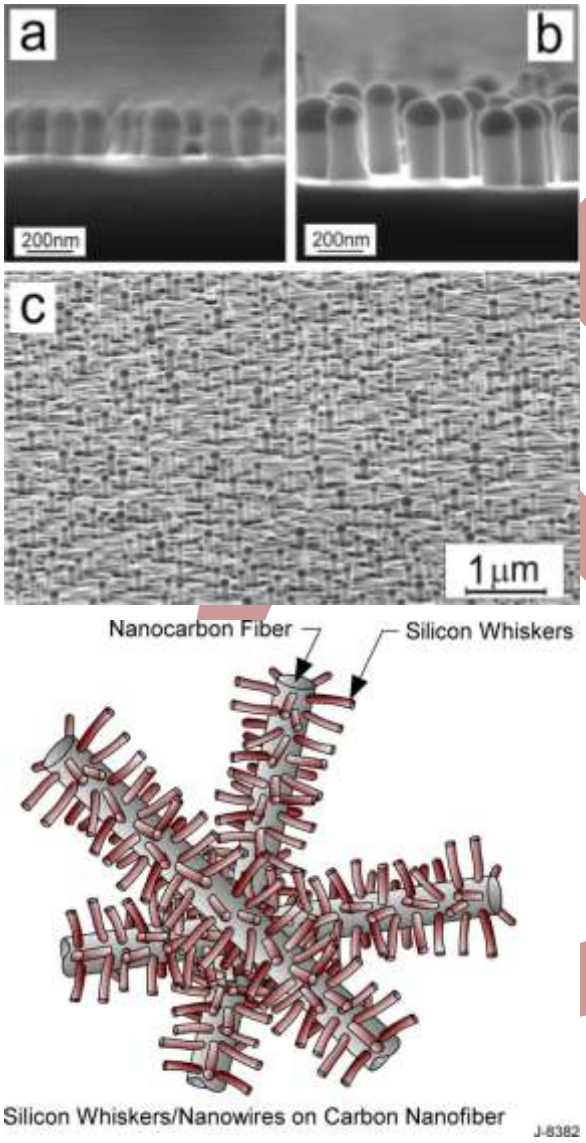
(7) bioceramics and gas sensors.

Fabrication:

A method of forming a nanostructure having the form of a tree, comprises a first stage and a second stage. The first stage includes providing one or more catalytic particles on a substrate surface, and growing a first nanowhisker via each catalytic particle. The second stage includes providing, on the periphery of each first nanowhisker, one or more second catalytic particles, and growing, from each second catalytic particle, a second nanowhisker extending transversely from the periphery of the respective first nanowhisker. Further stages may be included to grow one or more further nanowhiskers extending from the nanowhisker(s) of the preceding stage. Heterostructures may be created within the nanowhiskers. Such nanostructures may form the components of a solar cell array or a light emitting flat panel, where the nanowhiskers are formed of a photosensitive material. A neural network may be formed by positioning the first nanowhiskers close together so that adjacent trees contact one another through nanowhiskers grown in a subsequent stage, and heterojunctions within the nanowhiskers create tunnel barriers to current flow.

A nanoengineered structure comprising an array of more than about 1000 nanowhiskers on a substrate in a predetermined spatial configuration, for use for example as a photonic band gap array, wherein each nanowhisker is sited within a distance from a predetermined site not greater than about 20% of its distance from its nearest neighbour. To produce the array, an array of masses of a catalytic material are positioned on the

surface, heat is applied and materials in gaseous form are introduced such as to create a catalytic seed particle from each mass, and to grow, from the catalytic seed particle, epitaxially, a nanowhisker of a predetermined material, and wherein each mass upon melting, retains approximately the same interface with the substrate surface such that forces causing the mass to migrate across said surface are less than a holding force across a wetted interface on the substrate surface.



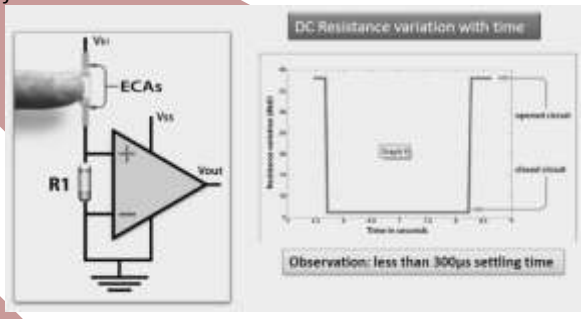
I. Applications:

- *Various kinds of field-effect transistor (FET) have been fabricated with C60 nanowhisker (NW) and also studied for nano-electronics application. Especially, pure and solvated C60 NWs have been synthesized in N2 environment so as to clarify the best device performance of C60 NW-FET. The FET works not only under vacuum but also in N2 environment when kept in the solvated condition. The solvated C60 NW-FET shows a clear improvement of their on/off ratio in the solvated condition, and the highest electron mobility after annealing. Although further study is needed, our results demonstrate the possibility, by appropriate choice of the solvent, of achieving good improvements in FET performance. Moreover, new kinds of C60 NW, such as derivative-based and nanotube-type one, have also been studied with regards to their fundamental FET characteristics.*
- *Bioceramics*

  The calcium phosphate Nanowhiskers produced by microwave assisted method can be used as Bioceramics to human bone
- *Gas sensor*

  SnO2 Nanowhiskers showed a high sensitivity of 23–50 ppm ethanol gas at 300◦C, which is much higher than that of regular SnO2 films.

  FE-SEM image of SnO2 Nanowhiskers synthesized by thermal evaporation
- *Nio2 Nanowhiskers having long life-cycle, High specific capacitance, high power, high stability, and low cost of the electrode materials are favorable factors for commercial applications. Thus prove great for electronic fibres.*



- *Anisotropic Etching of SiC Whiskers were used as building blocks in the fabrication of sensors, cellular probes, electronic, optoelectronic, electromechanical, and other devices*

How can nanotechnology improve fabric?

Making composite fabric with nano-sized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as might have been the case with previously-used techniques. For example incorporating nano-whiskers into fabric used to make pants produces a lightweight water and stain repellent material.

Fabric: Current Nanotechnology Applications

Nanowhiskers that cause water to bead up, making the fabric water and stain resistant.

Silver nanoparticles in fabric that kills bacteria making clothing odor- resistant.

- Nanopores providing superior insulation for shoe inserts in cold weather.
- Nanoparticles that provide a "lotus plant" effect for fabric used awnings and other material left out in the weather, causing dirt to rinse off in the rain.

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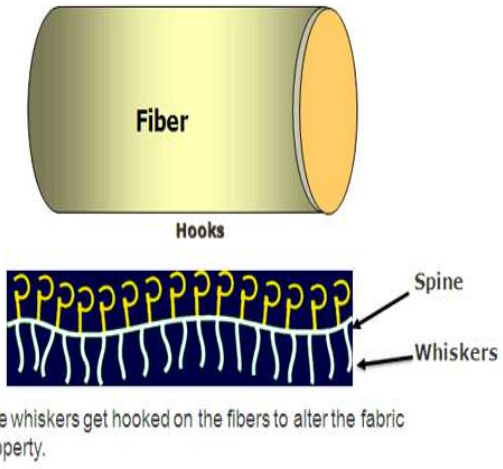
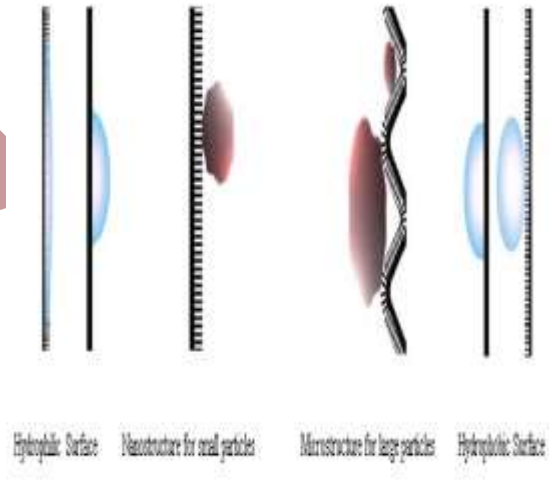
Properties of whiskers

- **Shapes:** Whiskers may be straight, kinked, hooked or forked
- **Growth Rate:** Growth rates from 0.03 to 9 mm/yr
- **Whisker Diameter:** 10 um and rarely less than 100 nm
- **Temperature:** room temperatures (22°C to 25°C) ; whiskers grow faster
- **Moisture:** high humidity (85% RH)

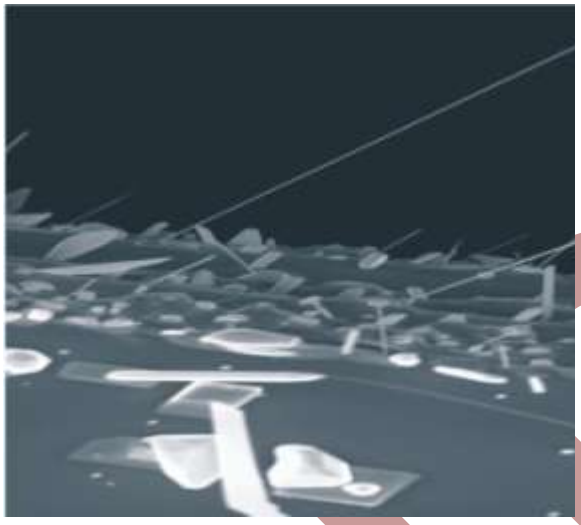


The whiskers get hooked on the fibers to alter the fabric property.



Nano Whiskers

- *The single crystalline metallic hair-like structure in the nanometer scale*
- *Also calledwires & nanorods.*



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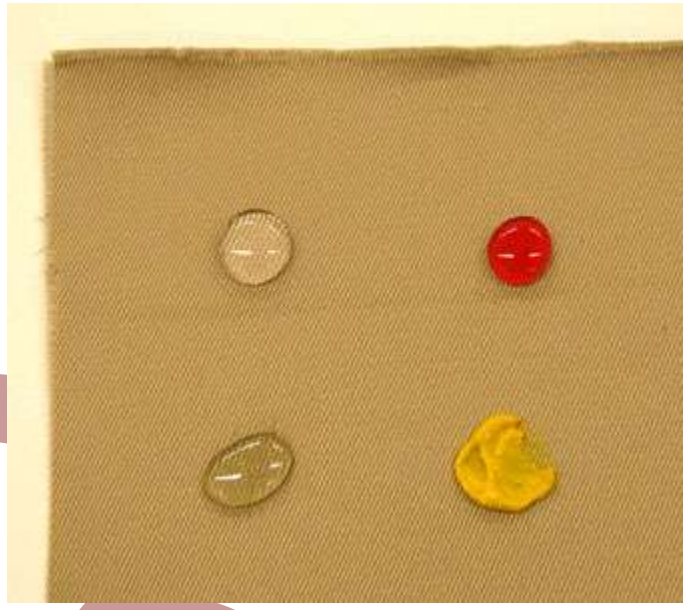
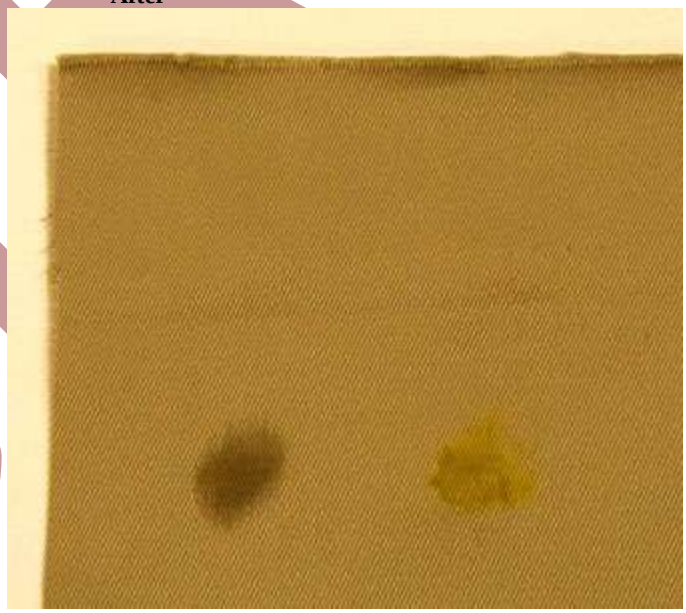
Before stain on cloth is



After



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