# 1. INTRODUCTION

The "Nokia Morph" is a theoretical future device based on nanotechnology that might enable future communication devices. It is intended to demonstrate the flexibility of future mobile devices, in regards to their shape and form allowing the users to transform them according to their preference. It demonstrates the ultimate functionality that nanotechnology might be capable of delivering i.e. flexible materials, transparent electronics and self-cleaning surfaces. It also features nanosensors that can interact with the environment to provide key information for anything from temperature changes to pollution.

Nanotechnology enables materials and components that are flexible, stretchable, transparent and remarkably strong. Fibril proteins are woven into a three dimensional mesh that reinforces thin elastic structures. The nanoscale mesh of fibers controls the stretching when the device is folded. The surface of morph is super hydrophobic which makes it extremely dirt repellent. Nanoscale grass harvests solar energy which could be used for recharging batteries.

Since the **KAIST**, developed a transparent resistive random access memory (TRRAM), the idea of morph technology seems to be growing. By integrating TRRAM device with other transparent electronic components, we can create a total see-through embedded electronic system which became the major platform for Nokia morph technology.

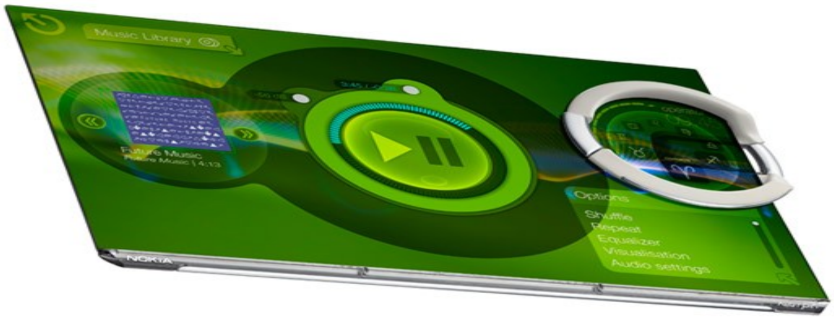


**FIG 1:-***MORPH IN OPEN MODE*


**FIG 2:-***MORPH IN FOLDED MODE*

**FIG 3:-***MORPH IN WRIST MODE*

# 2. HISTORY

The concept of NOKIA MORPH has been introduced to the global world at the Museum of Modern Art (MoMA) in New York City from February 24 to May 12 of 2008 as part of the "Design and the Elastic Mind" exhibition. The concept emerged through collaboration between Nokia Research Center and Cambridge University Nanoscience Center in the UK. Since the KAIST, developed a transparent resistive random access memory (TRRAM), the idea of morph technology seems to be growing and Nokia Research Center collaborated with Cambridge University Nanoscience Center and initiated to develop this fairytale concept a reality and researches are still undergoing. Nokia also added a concept video regarding morph on YouTube which received 2.3 million viewers on its initial week. This technology enabled phones are expected to reach the global markets around 2020.

# 3. MOBILE GATEWAY

The mobile device works at the center of our everyday life, interconnecting local intelligence-temperature changes, air pollution, our heart rate-with needed information and services. Mobile devices together with the intelligence that will be embedded in human environments – home, office, public places – will create a new platform that enables ubiquitous sensing, computing, and communication. Core requirements for this kind of ubiquitous ambient intelligence are that the devices are autonomous and robust. They can be deployed easily, and they survive without explicit management or care. As shown in FIG 4, mobile devices will be the gateways to personally access ambient intelligence and needed information.

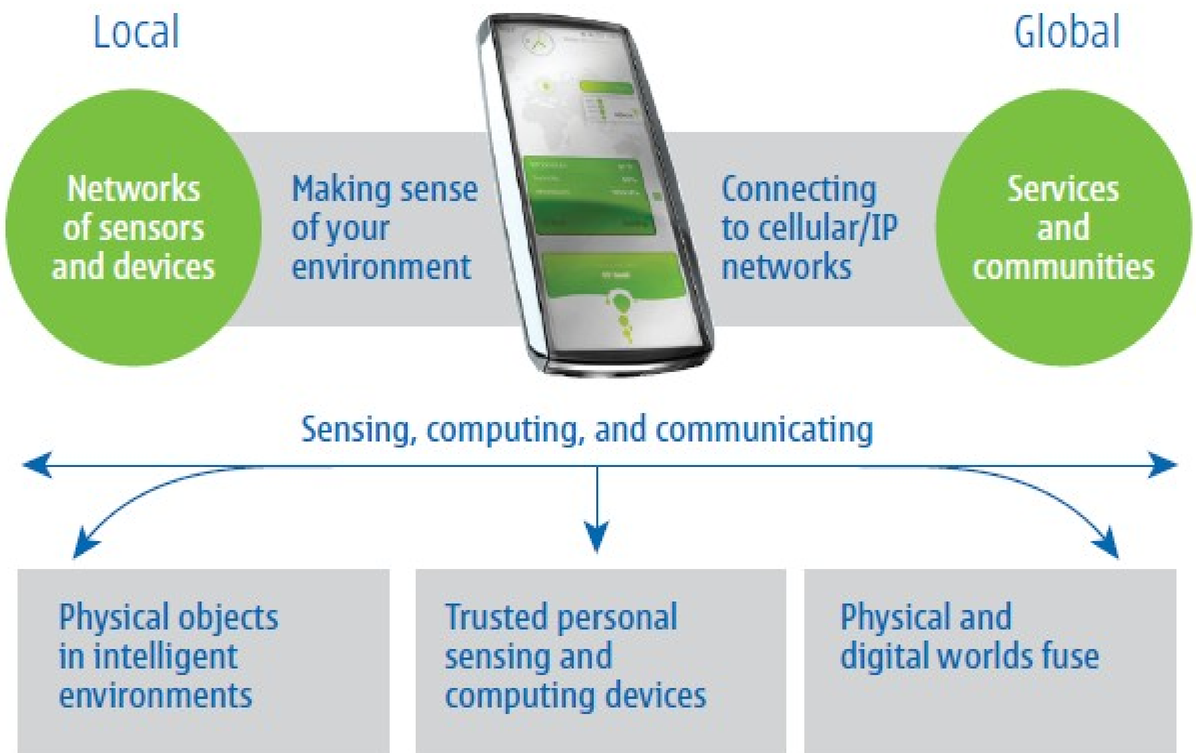


**FIG 4:-** *Mobile devices become gateways to ambient intelligence and needed information.*

Mobility also implies limited size and restrictions on the power consumption. Intelligence, sensing, context awareness, and increased data rates require more memory and computing power, which together with the size limitations leads to severe challenges in thermal management. Nanotechnology could provide solutions for sensing, actuation, radio, embedding intelligence into the environment, power efficient computing, memory, energy sources, human–machine interaction, materials, mechanics, manufacturing, and environmental issues.

Think morph is a snapshot of a new kind of mobility, made possible by a personal device that intelligently bridges local and global information. By sensing ambient elements, physical objects, and your individual context, the device adapts its form factor and functionality accordingly. It connects automatically to global services and communities, transmitting local data and returning context-relevant information in real time.

The vision of Nokia Research Center is to become the global leader of open innovation for human mobility systems of the fused physical and digital world, giving birth to the growth of business for Nokia. In this paper we will give an overview of how nanotechnology can help to realize this vision, and in particular what is the impact for wireless communication technologies.

# 4. NANOTECHNOLOGY

Nanotechnology means “The science, engineering and technology related to the understanding and control of matter at the length scale of approximately 1 to 100 nanometers”. Nanotechnology was first introduced in 1959 by Richard Feynman. Nanotechnology is an umbrella term that encompasses all fields of science that operate on the nanoscale. Nanotechnology is an extremely diverse and multidisciplinary field, ranging from novel extensions of conventional device physics, to completely new approaches based upon molecular self-assembly, to developing new materials with dimensions on the nanoscale. Nanotechnology allows control of physical properties of nanostructures and devices with single molecule precision. Development of nanotechnologies creates a new basis for solutions and systems in sensing & actuation, memory, information, signal processing and communication. It creates miniaturized, power efficient technologies for the future mobile, multimedia and computers and also enables intelligent systems that can be embedded into human environments. Nanotechnologies also provide a new generation of added value products and services with superior performances across a range of applications.

Two main approaches are used in nanotechnology. In the "bottom-up" approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition. In the "top-down" approach, nano-objects are constructed from larger entities without atomic-level control.

Consider 10000 transistors being fitted on a single fly hair, the nanostructure of Nokia morph is similar to this. Nanograss, Nanosensors, Nanoflowers, Nanoscale mesh, Nanotube etc are the nanotechnologies used inside Nokia morph**.**

# 5. SENSING

Nokia Morph can interact with the surrounding environment and is capable of providing key information for anything from temperature changes to pollution i.e. Morph can sense its surrounding. Nanosensors are used for this purpose and it empowers users to examine the environment around them in completely new ways, from analyzing air pollution, to gaining insight into bio-chemical traces and processes. New capabilities might be as complex as it may help us monitor evolving conditions in the quality of our surroundings, or as simple as knowing if the fruit we are about to enjoy should be washed before we eat it. Our ability to tune into our environment in these ways can help us make key decisions that guide our daily actions and ultimately can enhance our health. Nanostructures can also enable robust chemical and bio-chemical sensing, especially in scenarios where nanoscale values are being measured. And since nanoscale is the scale of the fundamental processes of life, nanoscale chemical sensors can leverage principles and materials common to biological systems. Nanosensors construct a complete awareness of the user context–both personal and environmental enabling an appropriate and intelligent response.

In order to improve sensor and signal processing characteristics Nokia introduced Nanowire Lithography (NWL) process that fabricates a large area and self aligned 3D architectures.

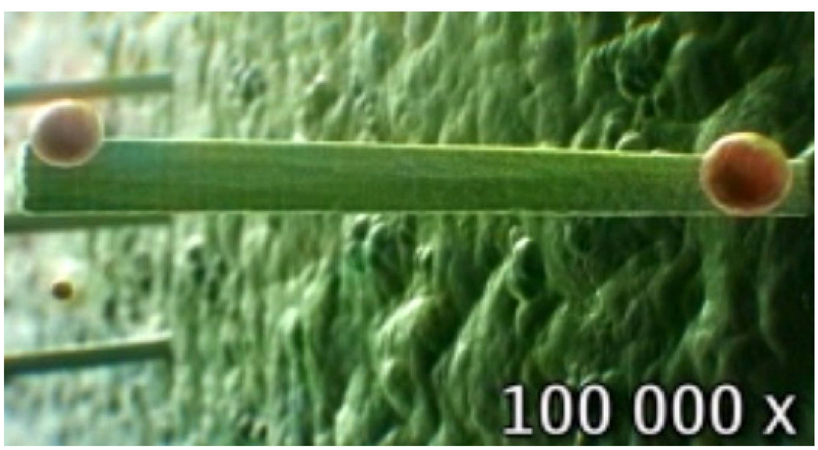


**FIG 5:-** *Nanosensor inside Nokia Morph.*

## 5.1 ECOSENSOR CONCEPT

As an initial step for sensing ability of Morph, Nokia Research Center supported by Nokia designers conceived the Nokia Eco Sensor Concept. This visionary design concept is a mobile phone along with a compatible sensing device that will help us to stay connected to our friends and loved ones, as well as helps us to monitor our health and local environment. We can also share the environmental data that our sensing device collected and view other users shared data, thereby increasing our global environmental awareness.

The concept consists of two parts – a wearable sensor unit which can sense and analyze our environment, health, and local weather conditions, and a dedicated mobile phone. The sensor unit will be worn on a wrist or neck strap made from solar cells that provide power to the sensors. NFC (Near Field Communication) technology will relay information by touch from the sensors to the phone.

**FIG 6:-***Nokia Eco sensor Concept Phone.*

## 5.2 HAPTIC SURFACE

Touch sensitive and responsive (HAPTIC) surface of Nokia Morph is provided by large area sensing surfaces using piezoelectric nanowire arrays. ZnO nanowires are used to produce the piezoelectric nanowire arrays. Buttons on the device surface are in real 3D forms.

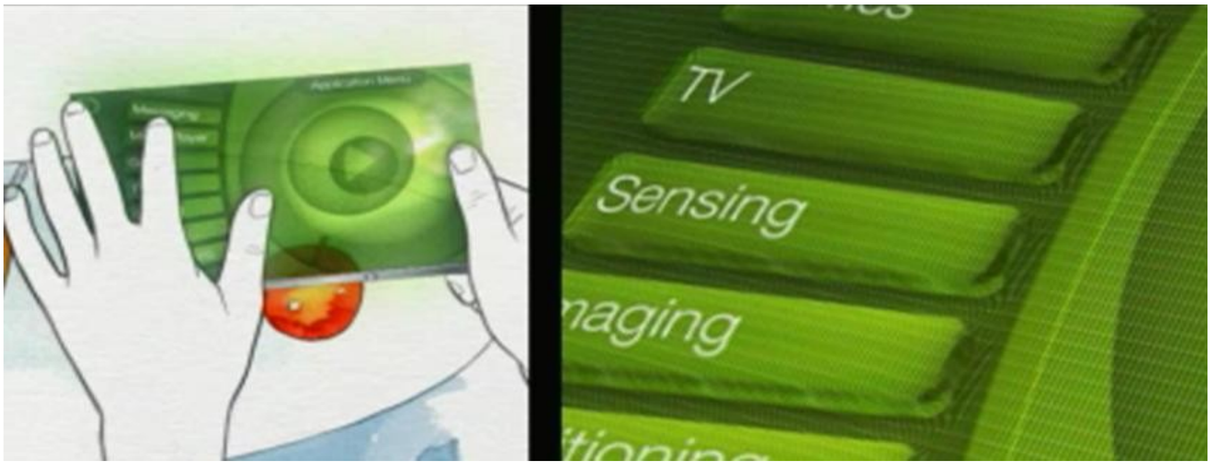


**FIG 7:-** *Haptic surface of Nokia Morph*.

ZnO exhibits an unusual combination of properties, including uniaxial piezoelectric response and n-type semiconductor characteristics. Nokia is exploiting these qualities to achieve strain-based electromechanical transducers—ideal for touch-sensitive (even direction-sensitive) surfaces.

Arrays of ZnO nanowires can be fabricated at low temperatures (70−100˚C), providing compatibility with polymer substrates, such as polyethylene terephtalate (PET). By coating a substrate (silicon, glass, or PET) with an array of these ZnO nanowires, the electrical signals on the surface can be activated by mechanical force. Since ZnO nanowires and nanoparticles are nearly transparent, this technique can be used to develop compliant, touch-sensitive, active matrix arrays that sit on top of displays or other structural elements.

# 6. STRETCHABLE AND FLEXIBLE ELECTRONICS

Nokia are developing thin-film electronic circuits and architectures supported on elastomeric substrates which are robust enough to allow multi-directional stretching. Nanotechnology enables materials and components that are flexible, stretchable, transparent and remarkably strong. Fibril proteins are woven into a three dimensional mesh that reinforces thin elastic structures. This elasticity enables the device to literally change shapes and configure itself to adapt to the task at hand. Thus nanoscale structure of the electronics enables stretching .

A folded design would fit easily in a pocket and could lend itself ergonomically to being used as a traditional handset. An unfolded larger design could display more detailed information, and incorporate input devices such as keyboards and touch pads.

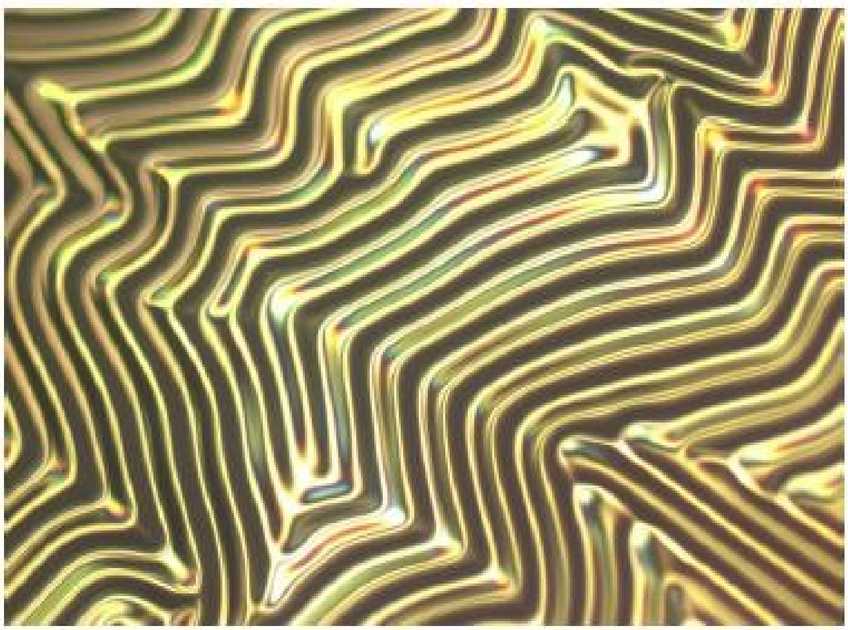

**FIG 8:**-*Stechable electronics of Morph*

A nanoscale mesh of fibers similar to spider silk controls the stretching when device is folded. ZnO nanowires act as flexible tactile arrays that enable the flexible ability of Nokia Morph. Arrays of aligned zinc oxide nanowires grown hydrothermally from zinc salt precursor on the surface of substrates (at roughly 70 – 100 °C) are used here.

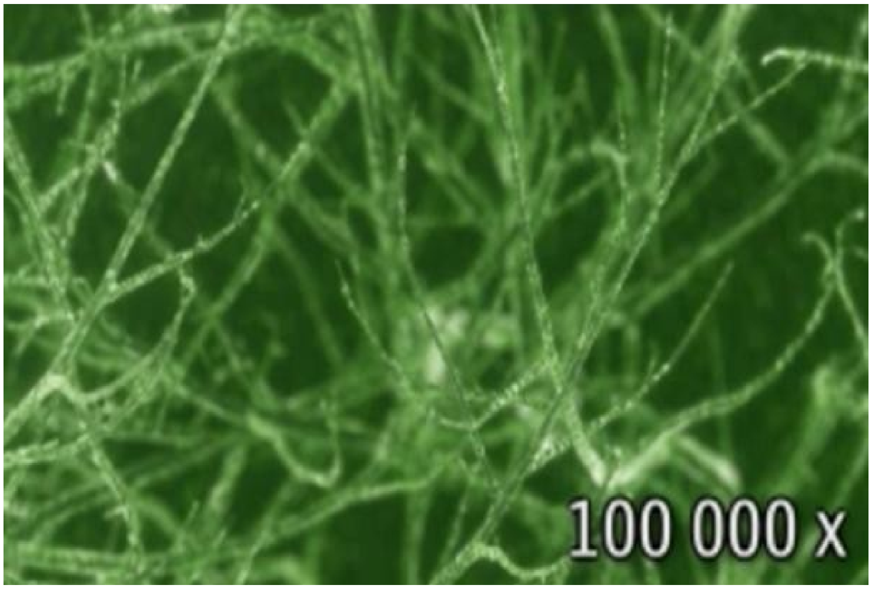


**FIG 9:-** *Nanoscale Fibers*

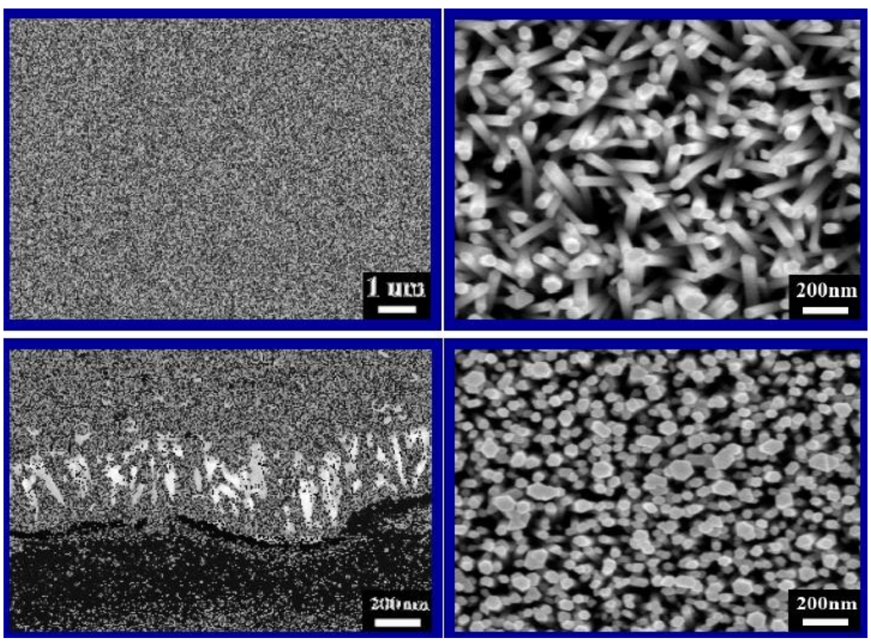


**FIG 10:-** *ZnO naowires.*

# 7. NANOWIRE LITHOGRAPHY on silicon

To improve sensor and signal processing characteristics, nanotechnology can yield innovative fabrication techniques that exploit the building-block nature of nanocomponents. Scientists at Nokia Research Center and the University of Cambridge have demonstrated versatile new nanowire lithography (NWL) process for fabricating a range of ultra small, large-area, and self-aligned 3D architectures. Nanowire lithography (NWL) uses nanowires (NWs) as etch masks to transfer their one-dimensional morphology to an underlying substrate. The method relies on electrochemical deposition and selective chemical etching.

By applying chemically grown silicon nanowires as etch masks, the research team stenciled nanowalls into thin films of silicon (Si), producing interesting electronic transport effects. This same lithographic method can be applied to create patterned nanostructures of other materials besides Si, such as metals or graphene.

The applications of NWL also extend into the third dimension. Under proper conditions, a periodic undercutting can be obtained during etching, producing an array of vertically stacked nanowires from a single nanowire mask. Together, these and other Nokia projects highlight the potential of this NWL process for next-generation nanoelectronics, sensing, and electromechanical systems.

**CONSTRUCTION OF NANOWIRE LITHOGRAPHY**

For the construction of NWL initially a planar field - effect transistors made of a single SOI-NW channel exhibit a contact resistance below 20 k Omega and scale with the channel width is used. Further the electrical response of NW networks obtained using a mask of SiO2 NWs ink-jetted from solution. The resulting conformal network etched into the underlying wafer is monolithic, with single-crystalline bulk junctions; thus no difference in conductivity is seen between a direct NW bridge and a percolating network. The potential of NWL into the third dimension is extended by using a periodic undercutting that produces an array of vertically stacked NWs from a single NW mask.

Figure below shows the construction procedure of Nanowire lithography.

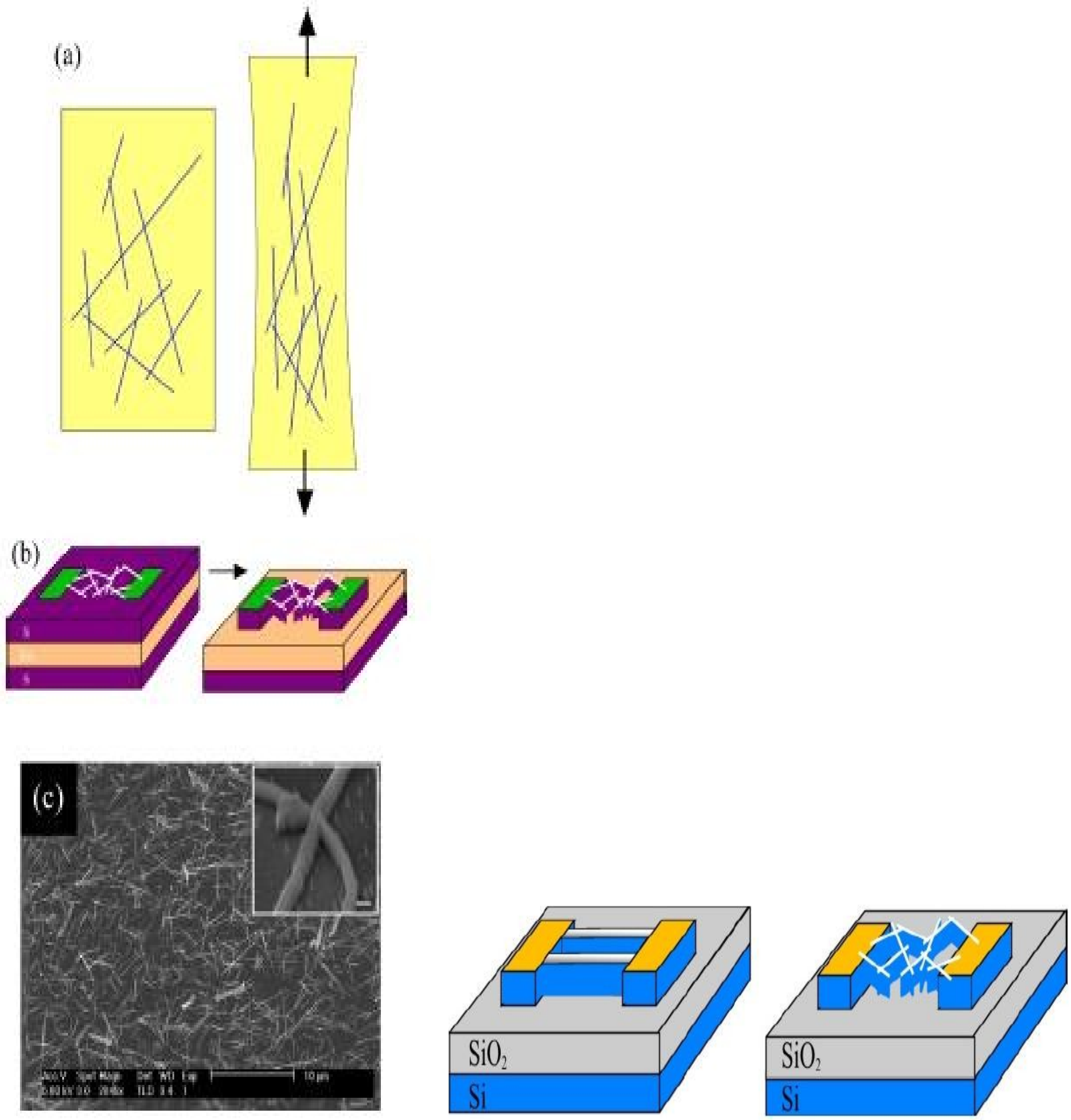


**FIG 11:-** *Construction of Nanowire Lithography*

# 8. TRANSPARENT ELECTRONICS

The whole electronic circuit inside Nokia Morph is entirely transparent. Nanoscale electronics becomes invisible to human eye. The major platform for transparent electronics came into existence with the introduction of transparent resistive random access memory (TRRAM) developed by KOREAN ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY (KAIST).


**FIG 12:-** *Transparent electronics of Morph.*


**FIG 13:-** *TRRAM*

By integrating TRRAM device with other transparent electronic components a total see through embedded electronic system could be developed. TRRAM records data by changing the resistance of a metal oxide film known as resistive RAM.

# 9. SELF CLEANING

We all have seen a water droplet that beads up on a lotus leaf, it is due to the hydrophobic nanostructures and this principle is known as super hydrophobicity. The surface of Nokia Morph is similar to this. Nanotechnology can be leveraged to create self-cleaning surfaces on mobile devices, which ultimately reduces corrosion, wear and improving longevity. Nanostructured surfaces known as "Nanoflowers" provide the hydrophobicity to Morph that naturally repel water, dirt, and even fingerprints. Double roughening of a hydrophobic surface, on the submicron and nanometer scale, creates superhydrophobicity**.**

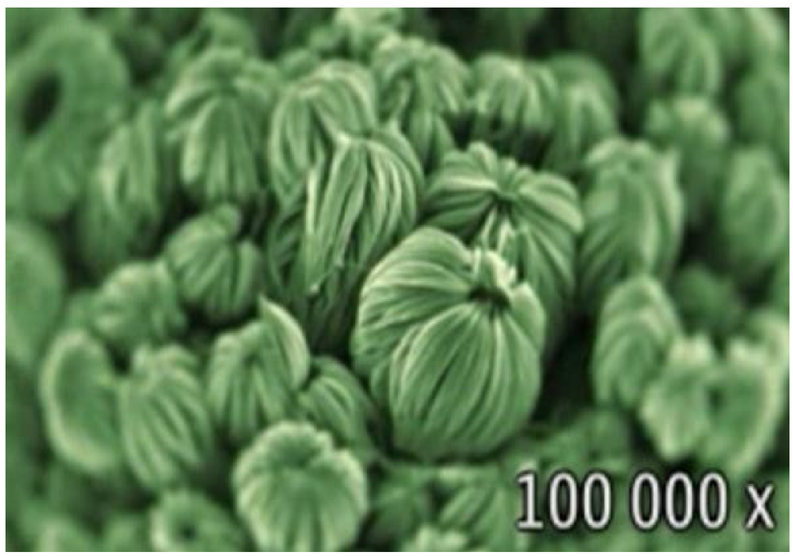


**FIG 14:-** *Nanoflower*

# 10. ADVANCED POWER SOURCES

Each and every mobile phone requires a power source. But in the case of morph it has got not one but many power sources. It has got an enhanced energy density battery that is quicker to recharge and is able to endure more charging cycles. Along with it polymer carbon nanotube composites with controlled conduction, nanotube enhanced super capacitors and nano composite solar cells also act as other power sources. Here nano enhanced dielectrics are used as separator and high power capacitors. Here energy is also harvested from RF using wideband antennas or by using nano electro mechanical (NEM) method. Microwatt level energy is harvested from waste energy in air.

Nanograss is used for harvesting solar power. Nokia developed a full solid state, flexible Dye Sensitized Solar Cell (DSSC) using ZnO nanostructure that act as photovoltaic's which harvests solar energy. Nanotechnology holds out the possibility that the surface of a device will become a natural source of energy via a covering of "Nanograss" structures that harvest solar power. At the same time new high energy density storage materials allow batteries to become smaller and thinner, while also quicker to recharge and able to endure more charging cycles.

ZnO nanostructures may also play an important role in low-cost photovoltaics. Researchers from Nokia and the University of Cambridge have demonstrated a new method for making a full solid-state, flexible dye-sensitized solar cell (DSSC). Although their efficiency needs improvement, these DSSCs may present a low-cost alternative to silicon-based photovoltaics. Because conventional DSSCs also pose challenges related to solvent leakage and evaporation, Nokia is working to develop a stable DSSC based on solid electrolytes.

Nokia's team has produced a promising photocurrent using a novel ionic liquid gel, organic dye, and a thin film of CNTs stamped on a flexible PET substrate. The CNTs serve both as the charge collector and as scaffolds for the growth of ZnO nano particles, where the black dye molecules are anchored. The flexible and lightweight qualities of this film open up the possibility of a continuous roll-to-roll process for low-cost mass production of DSSCs.

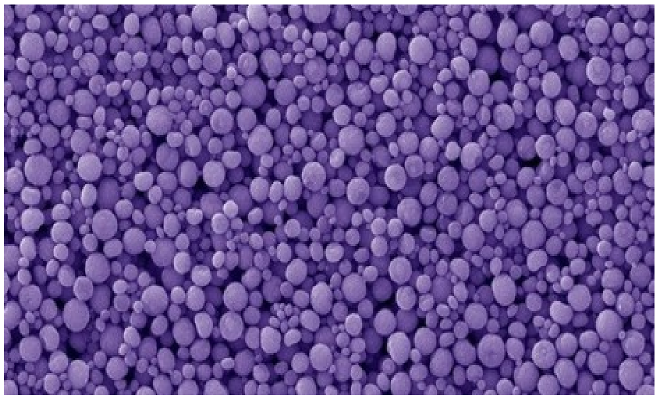

**FIG 15:-** *Dye-Sensitized Solar Cell*

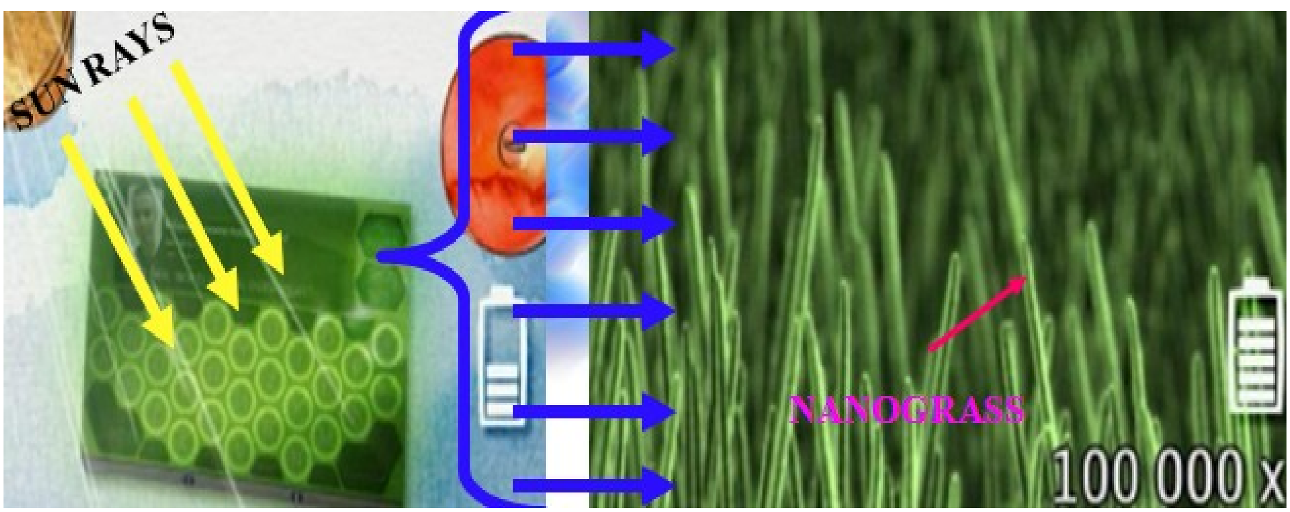


**FIG 16:-** *Nanograss*

**FIG 17:-** *Various Images of NOKIA MORPH*

# 11. ADVANTAGES

1. STRETCHABLE AND FLEXIBLE ELECTRONICS.
2. TRANSPARENT ELECTRONICS.
3. SELF-CLEANING SURFACES.
4. IT CAN SENSE IT'S SURROUNDING ENVIRONMENT.
5. IT DRAWS POWER FROM THE SUN FOR RECHARGING.

# 12. LIMITATIONS

1. THE INITIAL MANUFACTURING COST IS VERY HIGH.

2. THE EXPECTED MARKET PRICE IS AROUND RS 60000.

3. CONVENTIONAL DSSCS PROVIDES INSTABILITY RELATED TO SOLVENT LEAKAGE AND EVAPORATION.

4. STRETCHABLE BATTERIES HAVE NOT YET BEING DISCOVERED.

# 13. FUTURE SCOPE

1. THE SHAPES COULD BE MADE MUCH SIMPLER LIKE IN RING SHAPE.
2. MORPH IN OPEN MODE COULD ACT AS A KEYBOARD FOR PC'S.

# 14. CONCLUSION

Think Morph as a snapshot of a new kind of mobility made possible through nanotechnology and along with Nokia Research as their slogan says “Thinking, understanding and creating mobile innovations for cultures all over the world” and Cambridge University Nanoscience research centre the Morph has the potential of being both evolutionary and revolutionary when applied to the field of mobile technology and with more it always be bonded and is always be connected to a range of objects and services that have not yet being imagined. Thus NOKIA MORPH is just a beginning to the future mobiles.

# 15. REFERENCE

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