Electrikus...

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As the chiefs say

From an initiative 3 years back to a tradition now, The e-newsletter has explored all limits of knowledge. I extend my heartfelt greetings to all participants, authors, faculty staff and students associated in this endeavor.

Er. DC Jain
Chairman
(Gyan Ganga Group)

It is a matter of great happiness to me to know that the students have continued the e-newsletter for such a long time with great efficiency. Each edition comes out better than the previous and I have similar hopes from this one.

Mr. Rajneet Jain
Secretary
(Gyan Ganga Group)

I am very pleased to know that our college team is coming out with another issue of the e-newsletter. I heartily congratulate the editorial team. We expect to put a lot of technical knowledge to the readers from this e-newsletter.

Mr. Pankaj Goyal
Executive Director
(Gyan Ganga Group)

This effort of the students will be surely appreciated by one and all. Along with academics, the different activities in college are the keys that will unlock the hidden talents and thoughts in students.

Mr. Apurva Singhai
Executive Director
(Gyan Ganga Group)

It is joyous to know that the students are continuing the legacy of the e-newsletter as it shall help in spreading the activities being conducted by the institute to the public. I wish the team good luck.

Dr. Maneesh Choubey
Group Director
(Gyan Ganga Group)

It gives me immense pleasure to know that another edition of Electrikus is coming out. I wish all the success to the team of the EC branch involved and hope that this edition will also benefit the students in a great manner.

Dr. Vinod kapse
Principal
GGITS, Jabalpur

This new edition of Electrikus has lots of exiting updates. Technology and time never stop and the updates here keep account og the latest developments. My warm wishes to the Gyan Ganga Group for the publication of this e-newsletter.

Dr. Preeti Rai
H.O.D. EC Dept.
GGITS, Jabalpur

so many incredible issues previously. I congratulate the editors on handling the pressure well and coming out with yet another brilliant edition of Electrikus. We truly are "Commited for Excellence".

Prof. Pankaj Sahu
Faculty in-charge
Electrikus

Editors of this issue

- **DEBTANU MUKHERJEE**
- **KAMINI PANDEY**
- **MIHIR DATTANI**
- **TULIKA BHATTACHARYA**

Gyan Ganga Participation in Plantation Program by Government of M.P.

VISION

"To be centre of excellence in teaching-learning and employability in various fields of Electronics and Communication Engineering to produce globally competent, innovative and socially responsible citizen."

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1. To offer high quality graduate and post graduate programs in Electronics and Communication with strong fundamental knowledge and to prepare students for professional career or higher studies.
2. To foster spirit of innovation and creativity among students, faculty and staff, promote environment of growth, participation in conferences, technical and community services and lifelong learning for all.
3. To discover and disseminate knowledge through learning, teaching, sharing, training, research, engagement and creative expression.

NANOTUBE ELECTRONICS

A flexible approach to mobility

An innovative and scalable strategy for making high-density arrays of aligned nanotubes could lead to the mass-production of high-performance, high-power flexible electronics

Seunghun Hong* and Sung Myung are at the School of Physics and Nano-Systems Institute, Seoul National University, Seoul 151-747, Korea.

Rapid progress in flexible technology allows us to imagine a large number of innovative products such as

electronic paper, wearable displays, smart gloves and so on. Single-walled carbon nanotubes

have great promise for applications in flexible electronics, but it has been very diffi cult, if not impossible,

to prepare flexible high-performance integrated circuits based on them. On page 230 of this issue, John Rogers and co-workers report an innovative solution to this problem, which involves growing dense

arrays of aligned nanotubes on a crystalline quartz substrate, and then transferring the arrays onto plastic materials to make flexible, high-performance, high-power electronic devices.

Just as circuit miniaturization revolutionized the electronics industry in the 1950s, and continues to do so, flexible electronics might also change the world in the future — if suitable materials can be found. Most high-performance electronic materials such as silicon are not flexible, whereas materials that are flexible, such as conducting polymers, have poor electric properties. The speed of an electronic device is essentially determined by the mobility of the charge carriers in the material used to make it. The mobility — which is measured in units of cm determines the speed at which charge carriers (that is, electrons and holes) can move in the material.For example, the mobility of electrons in silicon is ~1,000 cm, but the mobility of a charge carrier in a conducting polymer is usually less than ~1 cm. This means that polymer devices will perform at least one thousand times slower than silicon-based circuits. In other words, a computer that relied on chips made from the best conducting polymer would be slower than a silicon based machine from the 1970s. Flexible electronics might sound good, but nobody will buy such a slow computer.

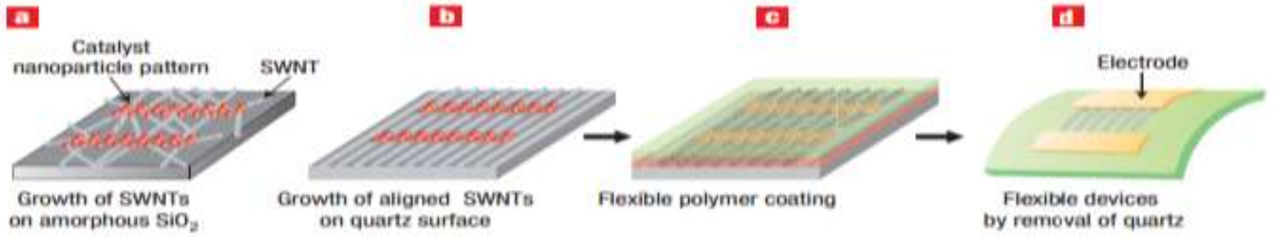

Figure 1 How to make a flexible electronic device. **a**, Growth of randomly orientated single-walled carbon nanotubes on an amorphous SiO_2 surface. **b**, Growth of dense aligned nanotubes on a quartz crystalline surface, followed by the direct transfer of the nanotubes onto flexible substrates (**c**,**d**) for flexible, high-performance, high-power electronic devices.

Single-walled nanotubes

Single-walled nanotubes (SWNTs) usually have diameters of 1–2 nm and lengths of a few micrometres or longer.They are generally produced by adding nanoparticles made of a transition metal to a carbon-based gas such as methane and heating it to 900 °C. Transition metals such as iron or nickel are known to catalyse the formation of carbon–carbon bonds, and each nanoparticle basically 'eats' carbon atoms from the surrounding gas and produces a single nanotube, just like a silkworm produces silk.

SWNTs have excellent electronic.properties: they have a carrier mobility of ~10,000 cm, which is better than that of silicon, and they can carry an electrical current density of ~4 × 109A cm–2, which is three orders of magnitude higher than a typical metal, such as copper or aluminium. Moreover,they are flexible owing to their small diameter. SWNTs are therefore an ideal candidate material for high-performance, high-power, flexible electronics. However, there is a catch.In fact, there are two problems. First, present production methods always produce a mixture of semiconducting and metallic nanotubes. This is a serious problem because high-purity semiconducting nanotubes are needed to build transistors. Fortunately, a number of promising methods for removing metallic nanotubes have been reported recently.The second problem concerns the fabrication of devices. Unlike conventional microelectronics, in which semiconducting wafers are 'carved' to make integrated circuits, SWNTs are first synthesized in a powder form. Th erefore, one has to 'pick-up and place' individual nanotubes onto specific locations on a wafer to build functional devices. As there are over 40 million transistors in a typical microprocessor, this is extremely time-consuming. Furthermore, most of the methods used to mass produce such devices result in a relatively poor mobility of ~10 cm because the SWNTs usually form randomly orientednetworks with contaminated contacts between nanotubes.One method for making highmobility devices is to pattern a surface with catalyst nanoparticles and then grow nanotubes on this pattern However, since nanotubes tend to grow in random directions, external forces (such as electric fields) must be applied to control the direction of growth. This method usually produces low-density arrays of nanotubes with relatively poor alignment. Moreover, the high temperatures needed for this An innovative and scalable strategy for making high-density arrays of aligned nanotubes could lead to the mass-production of high-performance, high-power flexible electronics.