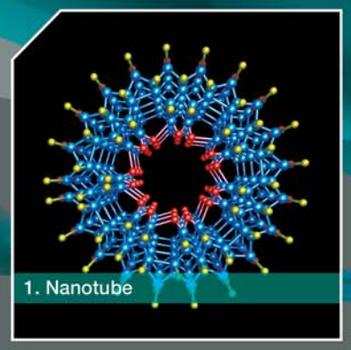
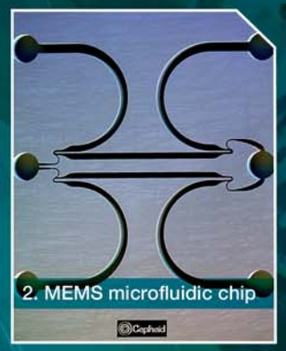
Peapod Nanotubes

One area of growing research is developing potential material for quantum computing storage media and processors. In collaboration with the National Physical Laboratory's (NPL) measurement expertise, Professor Andrew Briggs and his group at the University of Oxford are working on creating these novel materials. This team is examining the possibilities of using so-called 'Peapod Nanotubes' as a possible material.


1. Nanotube

Nanotubes are sheets of carbon wrapped up to form a tube, and are a very inspiring class of materials. One form of carbon, known as 'Buckminster Fullerene' or 'BuckyBalls', is a collection of 60 carbon atoms that join up to form a ball-like structure. Professor Briggs' group is able to take the buckyballs, remove an atom of carbon and replace it with a magnetic atom such as ytterbium or iron, and then actually place it *inside* the nanotube! If you put a number of these inside a particular nanotube, then you have what is known as a 'peapod' structure. The result is the buckyballs have restrictive movement, causing the magnetic atom attached to store and read-out data. However, the reading-out of the data is not a simple task. The quantum computer would be relying on some mechanism for measuring the size and direction of the spin of a single electron associated with the magnetic atom, and this is the problem that NPL is trying to solve. NPL scientists are working on producing Superconducting Quantum Interference Devices (SQUIDS) that are small enough to measure these properties.

Medical Diagnostics

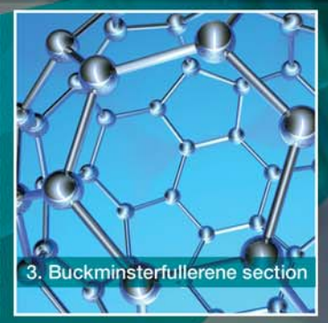

2. MEMS microfluidic chip

At the moment doctors are unable to prescribe a treatment for many conditions because they cannot diagnose the ailment properly and quickly enough. Diagnosing disease is a very difficult process, one that often requires the disease to be well established in the body before it can be detected and the results often take a long time to be analysed. In the future, nanotechnology may well diagnose a range of illnesses much more quickly and much more easily, thus facilitating the correct treatment much sooner. One method of diagnosis is to develop a device that uses easily obtainable human samples, such as saliva or blood, and detects proteins within it that correspond to a certain illness. If a particular virus or disease attacks or disrupts the human body, the immune system will automatically produce antibodies against it. This device could detect these antibodies and thus identify the nature of the organism that the body is harbouring. Such a device would require nanoscale control where analysis of individual protein molecules would be possible, resulting in an easily understood output.

These devices are likely to be based on a technology known as 'microfluidics' which require reliable methods of controlling the fluid flow at the nanoscale. As experts in measuring the rheological properties of fluids at the micro- and nano-scale, NPL scientists are researching and developing the measurement methods to investigate and understand the behaviour of these fluids on a chip. A biological molecule such as a protein when immobilised on the surface of the chip also needs to be fully understood. NPL's pioneering approach to single molecule detection using Surface Enhanced Raman Spectroscopy (SERS) in collaboration with Imperial College is making progress in this area. This non-invasive technique can identify active chemical groups within the structure of complex molecules. Using signal-boosting enhancements, SERS has monitored dye molecules as they undergo *photobleaching*, a process that effectively blanks out the vibrational spectrum of the molecule. This high-definition and precise technique enables one to see the molecules switch off one by one as they are bleached out. The technique will be of great use to scientists in research-assisting drug development and teasing out disease-related molecular interactions.

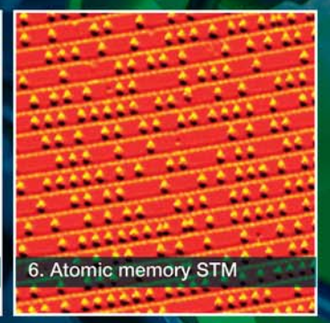
The Paperless Newspaper

Newspapers are one of our main sources of information, entertainment and news. In an age of 24 hours internet and television news, the challenge is how can the print media compete with these other media in delivering to us current news in the convenient, consumer-friendly, portable medium that is the newspaper. The answer may be the development of the 'Paperless Newspaper' using nanotechnology. What is needed is a plastic sheet with a high-definition, flexible electronic display screen that can communicate without wires with various news service providers and with your bank, for payment of this service, whilst also having an energy source to power it. NPL is researching the optical and electrical properties of useful light-emitting polymer materials for use in these novel paperless newspaper displays. The research that NPL is carrying out will make it easier for manufacturers of these products to control the brightness and power consumption of these displays. As the displays get more and more intricate and smaller, NPL measurement expertise and techniques will be imperative in controlling and manufacturing at the molecular or nanoscale level.


3. Buckminsterfullerene section


4. Carbon nanotubes


5. Alex Knight | NPL nanotechnologist


6. Atomic memory STM

1. ALFRED PASIEKA / SCIENCE PHOTO LIBRARY
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3. ALFRED PASIEKA / SCIENCE PHOTO LIBRARY
4. EYE OF SCIENCE / SCIENCE PHOTO LIBRARY
5. NPL PHOTOGRAPH
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Seeing Single Molecules – Summer Science Exhibition 2004

A National Physical Laboratory and Imperial College Exhibit
The Royal Society, London: 5 – 8 July 2004

A hands-on and interactive exhibit highlighting the science of looking at single molecules in furthering nanotechnology research will be featured in the Royal Society's Summer Science Exhibition. Competitively selected from around the country, this exhibition includes 24 other exhibits which will be showcasing the best of the UK's science and technology.

For further details, please contact the Royal Society on 020 7451 2581 or see website at www.sc1.ac.uk

For further information on NPL's nanoscale metrology research and services, please see www.npl.co.uk/nanotech

FORTHCOMING EVENTS

27 Jun - 02 Jul 2004
24th Conference on Precision Electromagnetic Measurements
Queen Elizabeth II Conference Centre, London
E-mail: cpem2004@npl.co.uk

29 - 30 Jun 2004
ORM Club Annual Meeting 2004
Contact: Fiona Jones
Tel: 020 8943 6743
E-mail: fiona.jones@npl.co.uk

20 Sept 2004
Workshop on Uncertainty in Dielectric Measurements
Contact: Sara Fletcher
Tel: 020 8943 6827
E-mail: electromagnetic@npl.co.uk

21 Sept 2004
EMMA-Club - Electromagnetic Materials, Measurements and Applications
Contact: Sara Fletcher
Tel: 020 8943 6827
E-mail: electromagnetic@npl.co.uk

28 Sept 2004
NPL Time and Frequency Club Meeting
Contact: Sara Fletcher
Tel: 020 8943 6827
E-mail: electromagnetic@npl.co.uk

06 Oct 2004
Harmonics Measurement Workshop
Contact: Sara Fletcher
Tel: 020 8943 6827
E-mail: electromagnetic@npl.co.uk

06 - 08 Oct 2004
3rd Gas Analysis Symposium & Exhibition, Amsterdam, Netherlands
Contact: Suzanne Wells
Tel: 020 8943 6171
E-mail: suzanne.wells@npl.co.uk

07 Oct 2004
Cure Monitoring Workshop
Contact: Maria Lodeiro
Tel: 020 8943 6034
E-mail: maria.lodeiro@npl.co.uk

02 - 03 Nov 2004
Nano-molecular analysis for emerging technologies
Contact: Charles Clifford
Tel: 020 8943 6620
E-mail: charles.clifford@npl.co.uk

09 Nov 2004
ORM Club Focused Interest Group meeting: Characterisation of Photoresponsive Materials
Contact: Fiona Jones
Tel: 020 8943 6743
E-mail: fiona.jones@npl.co.uk

09 Nov 2004
Airborne Radioactivity Monitoring Users Group 4th Meeting
Contact: Andrea Woodman
Tel: 020 8943 6435
E-mail: andrea.woodman@npl.co.uk

For further NPL events please go to www.npl.co.uk/news-and-events

FURTHER INFORMATION

For additional copies of this newsletter, or for more information on any aspect of NPL's work and the range of services available from the Laboratory, call the NPL Helpline:
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NANOTECHNOLOGY

Imagine a computer the size of a sugar cube or a 'Star Trek' hand-held medical device to diagnose your ailment. Science fiction? Maybe not. As outlined in this issue, it may be possible through the emerging field of nanotechnology.

Nanotechnology is an area of research which requires the ability to control and manipulate matter at a scale ranging from less than a nanometre up to 100 nanometres. One nanometre is one billionth of a metre. To put this scale into perspective, a single human hair is around 100,000 nanometres in width. For a process to be described as 'nanotechnology', it must involve the manipulation of matter at or near the atomic and molecular level of precision - making measurement techniques crucial to the growth of this new field. Once this precision is mastered, nanotechnology could bring an improvement to our quality of life in a number of ways, such as making manufacturing cheaper with less waste, improving our health or by making products that perform functions that we cannot presently do. This makes nanotechnology one of the most challenging and exciting fields of research in the 21st century.

Quantum Computing

In the late 1960s, Gordon Moore, Director of Research and Development at Fairchild Semiconductor, predicted that the number of transistors on a given area of silicon would double around every 18 months. This doubling would in turn double the speed of the computer chips data processing. In fact this prediction has been confirmed every 18 months since Moore made it; this is 'Moore's Law'.

However, the dilemma arises when features reach nanometre size. The laws of quantum mechanics mean that those chips having features of a few nanometres in size will behave differently from those with larger scale features. Also, it is impossible to create feature sizes smaller than 1 atom - about a tenth of a nanometre. So is Moore's Law doomed? Not necessarily from the point of view of performance. These strange quantum properties that would make it difficult to create new conventional computer processors can be used to make exciting new types of computers known as 'Quantum Computers' which, if successfully developed, will outperform any computer that exists today. This future generation of computers will use nanotechnology to create computer processors which use the quantum properties of the chips to store and read out the data more quickly and in much greater quantities than has previously been possible.

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NEWS FROM THE
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