Sensors & Instrumentation

Knowledge Transfer Network

Sensors News

Detecting bootleg booze

Last gasp of a dying cell

High temperature sensing breakthroughs

Launch of new Piezo Institute

Blind sensors in murky mixtures

Volcano monitoring

The newsletter of the Sensors & Instrumentation Knowledge Transfer Network

July 2007

Measuring the last gasp of a dying cell

Manchester researchers have used alcohol to prompt the last gasp of a dying cell, which is measured as an electrical signal.

This could revolutionise the way drugs are tested, and may help monitor the effects of pollution on micro-organisms.

"Once we know the pattern of electrical activity in a cell, we can see how different drugs affect it," says Professor Andre Geim at the University of Manchester.

With funding from the Engineering and Physical Sciences Research Council (EPSRC), he and his team have set out to make the first measurement of a cellular 'heartbeat'. The work may lead to tests that can be applied long before drugs are tested on animals or people.

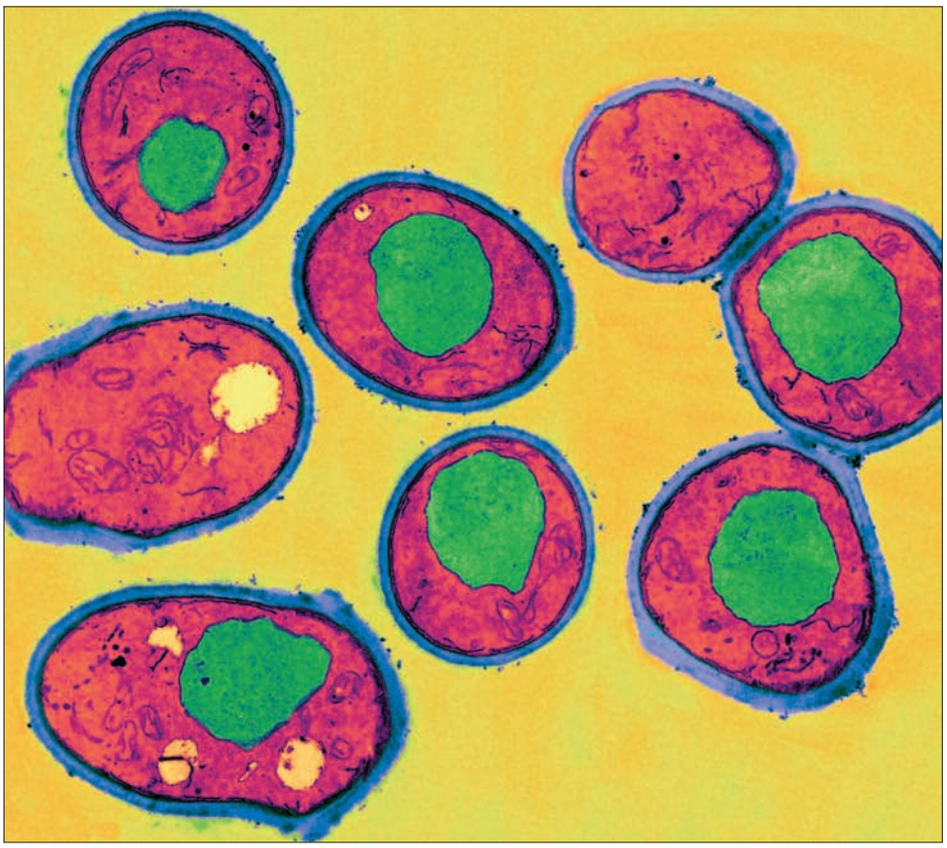


Photo: Science Photo Library

Manchester researchers are detecting electrical signals from yeast cells

Cellular cardiogram

To stay alive, cells must transfer electrically charged particles called ions across their membranes. This produces a current that could, in principle, be detected. The recognition of this electrical activity would provide a kind of 'cellular cardiogram', allowing the daily functioning of the cell to be monitored in the way a cardiograph shows the workings of a human heart.

To detect a cell's normal activity, Prof Geim and researchers modified apparatus used to detect weak magnetic fields in superconducting material, which loses electrical resistance below a certain temperature. It was the first time the technique – Hall micromagnetometry – had been used on a living cell. It uses a small (submicron) cross of a high quality semiconductor which can detect tiny magnetic fields using the Hall effect, but was modified to detect tiny electric fields.

At first it didn't detect any activity in the target yeast cell. Not to be defeated, the researchers livened things up with alcohol. "We added ethanol – which is essentially vodka – to provoke a response from the cell. Ethanol is known to increase the transparency of cellular membranes which we hoped would give a signal we could detect," says Dr Irina Barbolina, who did the experiments.

Drunken hiccup

It worked. As soon as the yeast tasted the booze, the probe registered a drunken hiccup in the form of a weak electrical signal. "It was probably the last gasp of the dying cell," says Prof Geim. The researchers had added so much ethanol it poisoned the cell.

Although not yet the cardiogram they had hoped for, the electrical signal was the smallest yet detected from a living cell, around 100 times smaller than anything previously detected. It added up to an electrical current of just 10 moving electrons.

Prof Geim says the team is confident it can improve the sensitivity of the detector to measure a cell's heartbeat, and plans to trial it with a more active micro-organism than yeast.

"Through the eyes of a physicist, life can be seen as a motion of ions, and even the most primitive forms of life – like yeast – should generate electrical currents around them. I think everyone would be curious to see the 'heartbeat' of an individual cell." ***Prof Andre Geim.***

Detector of bootleg booze to save lives and profits

The unique spectral signature of whisky is being deployed in the battle against bogus booze.

Photo: iStockphoto

Booze job.... can you tell which is fake?

The spirits industry estimates that counterfeit alcohol costs £500m a year in lost sales worldwide. The problem has many fronts, from the mass production of low-quality alcohol for sale as the real thing, to bar staff increasing profits by topping up bottles with inferior products.

Illegal liquor is also a major health problem because counterfeit alcohol isn't under the control and scrutiny of regulators. "It's a huge problem for all liquor brands," a senior industry source told *Sensors News.*

Photo: John Ferguson/Spectroscopic and Analytical Developments

A portable spectrophotometer for field-testing suspect alcohol in nightclubs, bars and casinos

Tiny amounts of a harmless chemical can enable some drinks to be identified as genuine. But this doesn't work for whisky, because its legal definition forbids any substance that is not part of the natural fermentation and distillation process.

Yorkshire-based Spectroscopic and Analytical Developments (SAD) has responded with a portable spectrophotometer for non-technical personnel to field test suspect products in bars, night clubs, restaurants and casinos.

It works by passing ultra violet light through a sample and measuring how much light is transmitted at wavelengths between 200 nm (deep UV) and 400 nm (visible blue).

This is compared to the known spectrum of the genuine product, which can be selected from a drop down menu on the battery-operated device. It works because whiskies have their own spectral signature.

The device was first developed in the Scottish laboratories of a major drinks manufacturer, which asked SAD to develop a portable version. Following successful testing of prototypes in the UK, Spain, Colombia, Vietnam and Venezuela, the device is now in production and has been sold to most major liquor manufacturers as well as UK Trading Standards.

> **"New sensing technologies are proving extremely useful in our battle against bootleg alcohol and the refilling of branded spirit bottles. Detecting counterfeit spirits is important to both manufacturer and retailer profits, and to consumer safety."**
> ***Philip Scatchard - International Federation of Spirits Producers***

As many as 8% of outlets were found to be replacing branded liquor with cheaper substitutes before screening got underway, but this has been reduced to under 2%, according to the International Federation of Spirits Producers.

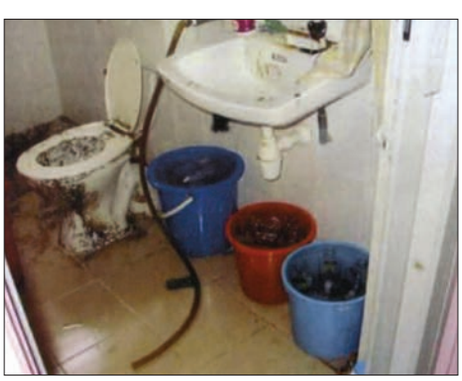


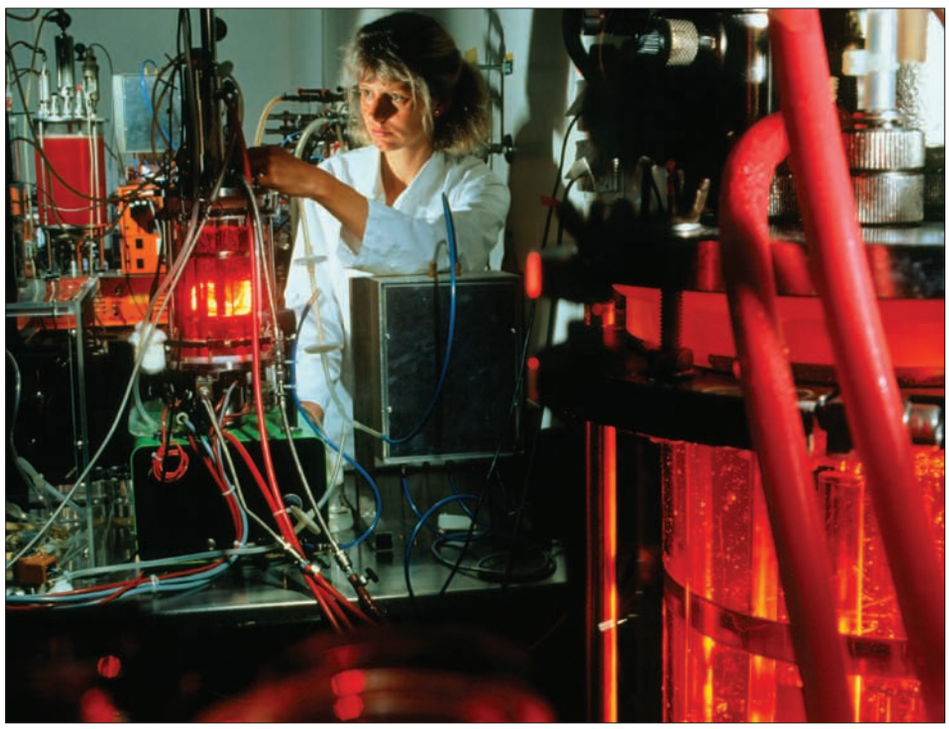
Photo: International Federation of Spirits Producers (IFSP) China

Counterfeit liquor is not just illegal – it can also be extremely unhygienic. Field inspectors report seeing fake whisky distilled in a toilet.

Measuring the mechanics of biotechnology

By measuring the mechanical properties of biocultures, an innovative sensing company hopes to increase productivity and reduce costs in the fast-growing biotech industry.

Photo: Science Photo Library



Measuring mechanical properties of biocultures may reduce costs and increase productivity in the fast-growing biotechnology sector

Vast amounts of research in genetic engineering and molecular biology has created promising new chemicals and bio-systems for the pharmaceutical and food industries, but there is an emerging bottleneck in production.

"Not enough work has gone into process control and optimisation for these new compounds, so it's costing a lot more than it should to get the results to market," says Dr Joanna Vlahopoulou, technical director and founder of Bioinnovel, a member of the Sensors KTN. "Manufacturers are finding it hard to achieve consistent production, which leads to high failure rates and low yields."

The bottom line is that manufacturing represents too high a share of the budget in an industry already known for large research costs. The bio-pharma industry urgently wants to improve its engineering and manufacturing capacity, and the US Food and Drug Administration (FDA) is promoting new guidelines to support innovation in sensing technologies and measurement control for bio-processing. Its Process Analytical Technology (PAT) Initiative, for example, aims to understand and control the manufacturing process, and says quality should be designed into processes rather than tested in products.

Dr Joanna Vlahopoulou

"Process control is the new strategic buzzword for success in the biopharma industry," Dr Vlahopoulou says.

Bioinnovel has developed a prototype probe that uses ultrasonics inside a bioreactor to measure properties such as viscosity, elasticity and bubble distribution – which provide a unique mechanical "fingerprint" of the biological process.

"The probe lets us see the mechanical evolution of a physiological process," Dr Vlahopoulou says. This is used to create an intelligent model that helps to predict and control production.

By correlating the physical and biological characteristics, and applying hybrid modelling techniques, Bioinnovel proposes to increase consistency and productivity as biotech research scales up from the laboratory to the pilot plant and into production.

It should also enable optimal use of manufacturing capacity and better overall product quality.

Bioinnovel Ltd was founded in February 2006 and won a Research Award from the East of England Development Agency to file a patent and fund its proof of concept stage. Based at the Babraham Institute bioincubator, it is currently developing a prototype model of its probe and sensor software and hardware.

Blind sensors excel in murky mixtures

Cambridge spinout Akubio Limited has developed a novel acoustic detection technology for life sciences research and drug development. It has potential for portable detection of biological threats.

Akubio's 'resonant acoustic profiling' technology relies on the piezoelectric effect of a quartz crystal. Typically a protein is linked to the surface and as another molecule specifically binds to the protein mass accumulates on the surface of the crystal.

The increase in mass results in a reduction in the resonant frequency, and with data points being taken continuously, the change in response is accurately measured.

This flow-based technique enables real-time detection and characterisation of molecular interactions, and the physical nature of the technique facilitates measurement in crude or complex mixtures including bacterial and mammalian cell cultures, urine and serum.

Akubio is able to provide pharmaceutical researchers with precise information on how well proteins interact with each other and with drug candidates by providing real time data on specificity, binding rates and binding affinity, and concentration. This offers the potential to design better drugs.

Akubio's first product, RAP◆***id*** 4, is targeted at biotechnology researchers. It can be calibrated to detect and measure specific proteins, viruses and bacteria on the sensor surface. St George's medical school in London is using a version to detect HIV. Other customers include UCB-Celltech and Genzyme. Future models are aimed at environmental testing and in vitro diagnostics.

Akubio is also developing a portable version that measures bacteria, viruses and toxins, and collaborating with the US Army on development of a bio-threat detector.

Business development director, Dr Ian Campbell, a biochemist and molecular biologist, says Akubio's acoustic technologies provide equivalent sensitivity to optical sensors and can measure the interactions in turbid liquids where traditional optical techniques are extremely inefficient.

"Our acoustic sensors are effectively blind because they rely on sound rather than light. This makes them insensitive to the solution in which they work, but still able to detect specific interactions in complex samples."

"We get sensitivity equivalent to the top biosensors, but with a unique ability to measure complex samples and a broad range of molecular weights," Campbell says.

Akubio was spun out of Cambridge's chemistry department in 2001.

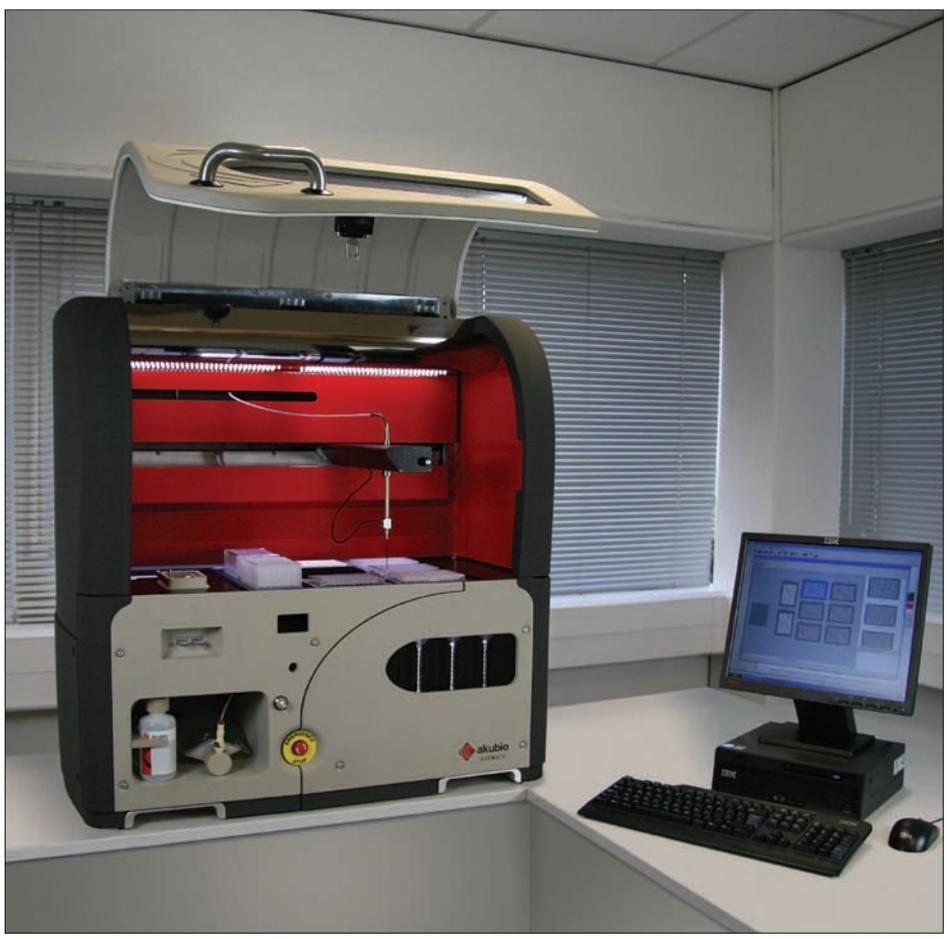


Photo Akubio

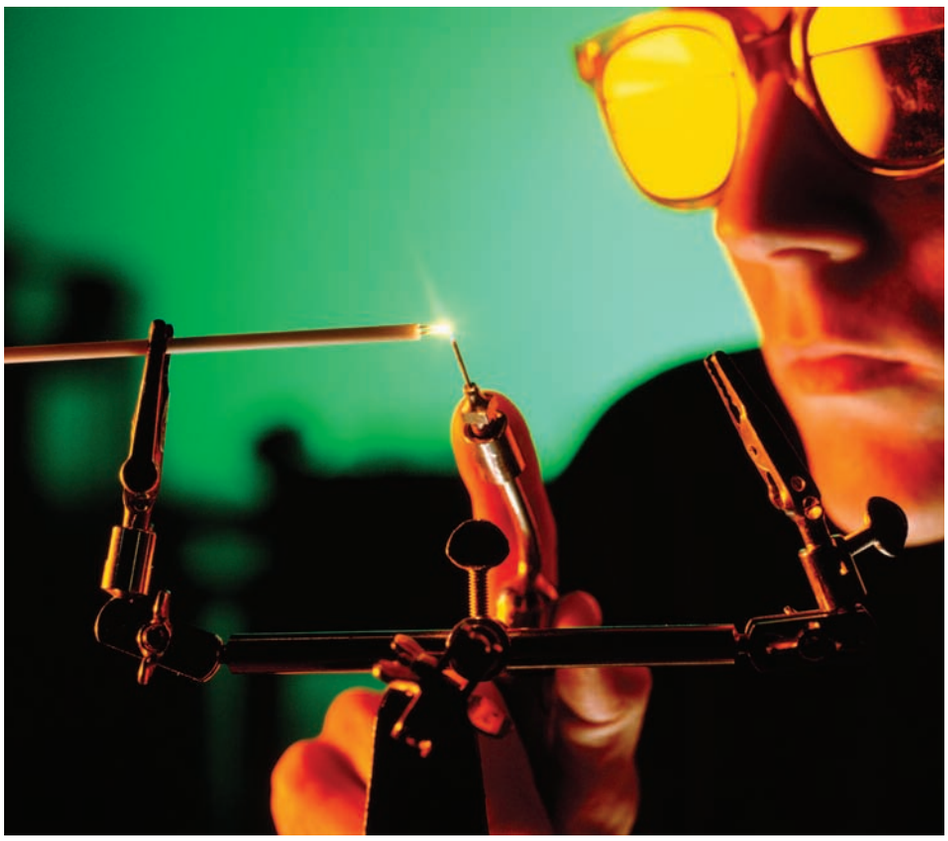
Akubio's technology can be calibrated to detect and measure specific proteins, viruses and bacteria on the sensor surface

Rising to the challenge of

High temperature sensing is essential to energy efficiency in everything from p have experienced rapidly increasing uncertainties as temperatures climb abov

New metal alloys boost high-temperature heat treatment of jet engine components

Photo: Science Photo Library



Welding thermocouple junctions using a specially designed microwelding torch

Measurement scientists at the National Physical Laboratory (NPL) have reduced the uncertainty of thermocouple temperature sensors at high temperatures to within a degree. This may allow manufacturers to improve efficiency and reduce wastage in the quest for more efficient jet engines and lower aircraft emissions.

Aircraft engines are more efficient at higher temperatures, but this requires thermal treatment of engine components at very specific high temperatures in excess of 1300 °C. If the heat treatment temperature deviates too much from the optimal temperature, the treatment may be inadequate.

Thermocouples are calibrated using materials with known melting points (fixed points). But the available reference materials in the region of the very high temperatures required to treat jet engine components have a large uncertainty compared with the lower temperature fixed points.

Using a new type of metal alloy, NPL scientists have identified a range of reference points for thermocouples beyond 1100 °C. With this added confidence in thermal sensors, component manufacturers are expected to start improving hotter thermal treatments and reducing wastage during production of parts for engines which can run at higher temperatures.

A thermocouple is a device which generates a voltage related to the temperature at its tip

"This demonstrates the importance of measurement research and the development of new calibration techniques," says Sensors KTN director Dr Simon Aliwell. "Metrology, standards and calibration advice are available to the KTN through NPL and we urge all members to take advantage of them."

Photo: iStockphoto

Improving jet engine efficiency

high temperature sensing

n power stations to jet engines. But until now commercially-available sensors ove 1,000 ºC. Sensors News reports on two innovative approaches.

Double sensor built on single-crystal sapphire

A sensor based on single-crystal sapphire, which has a melting point above 2000 ºC, has been developed to simultaneously measure pressure and temperature in harsh environments.

Oxsensis, a spinout from the Rutherford Appleton Laboratory in Oxfordshire, developed the unique double sensor by micro-machining the sapphire for fibre optic interrogation.

Laser light is used to measure the size of microscopic cavities in the sapphire, with exact pressure and temperature determined by physical movement in its membrane and changes in its optical properties.

"There is nothing on the market which can measure above 800 ºC," says Oxsensis CEO David Gahan. "We're overcoming this with super-resistant sapphire and fibre optics which are stable at high temperatures and avoid the need for unstable electronic interfaces."

Photos: Oxsensis

Oxsensis sapphire pressure sensor

The fibre optic interrogation techniques also give high sensitivity and immunity from electro-magnetic interference (EMI) that is common in turbo-machinery such as gas turbines.

The fully packaged sensor has been successfully tested in a jet engine.

"The lack of quality data from the hottest parts of the engine limits the deployment of better designs and controls," says Gahan. "Measuring two variables at extreme temperatures enables the design of more efficient engines."

Oxsensis won the small businesses award at the 2007 Carbon Trust/Daily Telegraph Innovation Awards.

Oxsensis is one of 17 European organisations collaborating on an €8.8m power turbine instrumentation programme called HEATTOP. With partners like Siemens and Rolls-Royce, and Oxford and Cambridge Universities, the project will use precise high-temperature engine measurements to advance technologies for gas-turbine life optimisation, performance and condition monitoring. It aims to help European gas turbine manufacturers reduce emissions and increase engine efficiency, reduce product development time, reduce cost of ownership and improve competitiveness of their products in global markets.

Sensing volcanic eruptions

Cambridge volcanologists are sensing emissions from one of the most active volcanoes on Earth.

The Cambridge University Volcanology Group is working with the US Antarctic Program to better understand volcanic activity on Mount Erebus in Antarctica.

The work may help to forecast eruptions and assess the hazards that volcanoes pose to communities.

Dr Clive Oppenheimer from the Department of Geography at Cambridge University says the project is an example of sensors being used in increasingly challenging environments.

"The challenge is to sense emissions from a 1000 ºC lava lake at the bottom of a 200m deep crater in Antarctica, at an altitude of four kilometres above sea level. That's about as extreme as you can get," Oppenheimer says.

The team uses absorption spectroscopy, which detects and quantifies gas molecules according to their ability to absorb certain frequencies of light.

The spectrometer used on Mount Erebus is about the size of a shoebox, and is resilient to the corrosive gas plumes inside the volcano. It is attached to a telescope and mounted on a tripod at the edge of the crater. It can be tilted to view the lava lake across a distance of around 300m.

Mt Erebus

Photos: Cambridge University Volcanology Group

Working on the edge - Cambridge volcanologists are using absorption spectroscopy to detect emissions from Mt Erebus, the most active volcano in Antarctica

The incandescent surface of the lake provides abundant infrared light, some of which is absorbed by the volcanic gases before reaching the spectrometer. The technique can make a measurement every second, which allows detection of the rapid variations in gas emissions that are associated with explosions.

The lava lake on Mount Erebus emits a steady stream of hot gases which forms an acid cloud stretching downwind from the crater.

"The chemical composition of the cloud reveals how molten rock is transported within the Earth's crust, and why it erupts. It provides many clues to what goes on beneath a volcano," Oppenheimer says.

Scientists are also interested in how volcanic pollution from Mount Erebus affects the pristine Antarctic atmosphere. The volcano never switches off, so there is a continuous output of chemically-reactive gases into the atmosphere that may affect ozone concentrations.

Silent skies

A new position sensing system is helping UK airports minimise noise pollution. It will identify noisy aircraft, track planes that stray from their flight paths and aid the generation of noise maps.

Aircraft noise causes stress and other health problems for people living close to airports, according to the Aviation Environment Federation. The EU's 2002 Environmental Noise Directive calls for noise maps and action plans which identify quiet areas and hotspots around large civil airports. This will be used to assess how many people are affected by the aviation industry.

Airline operators and aviation authorities don't have a sufficiently precise picture of aircraft movements on their approach to airports, so the Vigilance™ system has been developed by Roke Manor Research to accurately track aircraft and thereby help meet the directive's requirements.

It is based on the height monitoring equipment which in the early 1990s enabled the vertical separation of aircraft to be safely reduced from 2,000 to 1,000 feet.

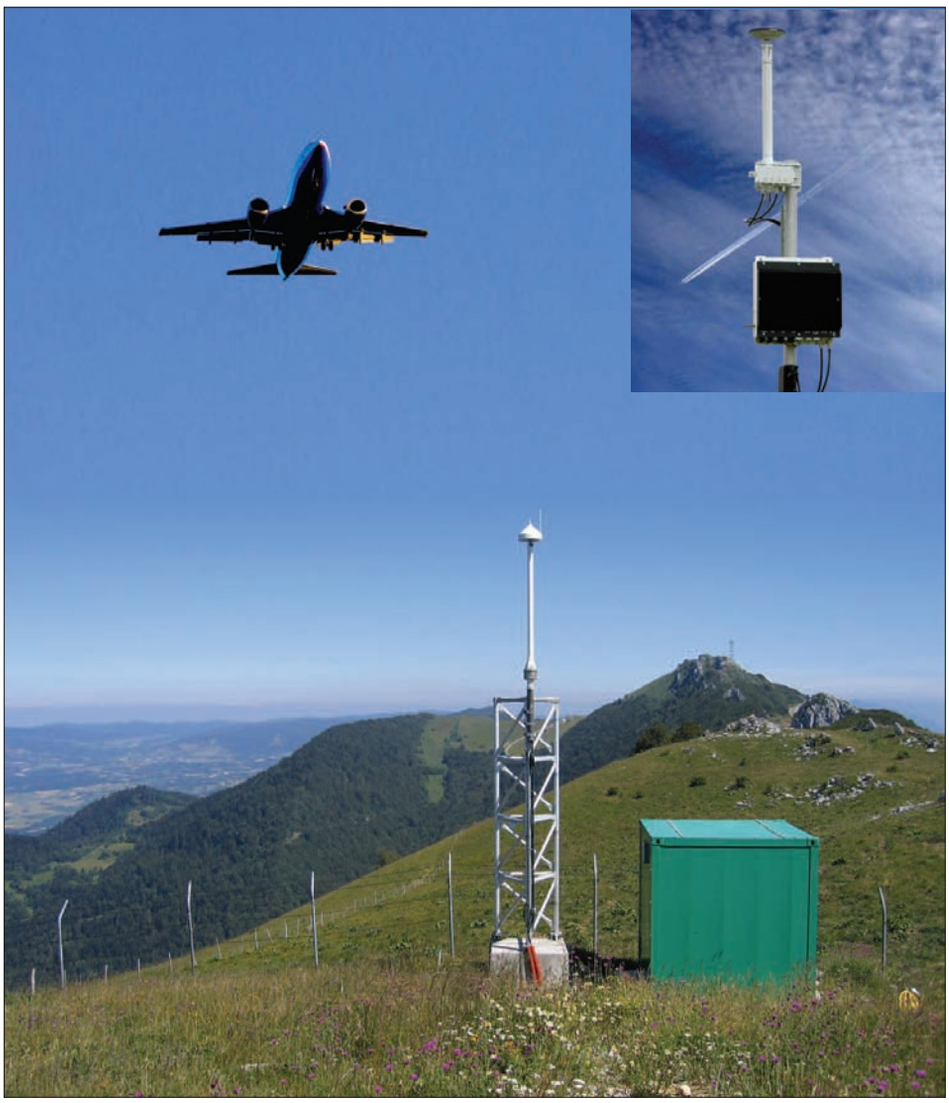
Vigilance™ is deployed around an airport as a network of ground-based sensors which detect the transponder signals which aircraft routinely transmit to air traffic control. The different arrival times of the signal at each receiver are calculated with sub-nanosecond accuracy using advanced satellite time transfer and synchronisation.

The aircraft's precise location – even while moving at hundreds of miles per hour – is then determined through a digital signal processing algorithm and presented in real time to airport authorities. The exact path of an aircraft can subsequently be reviewed in response to public complaints or requests from regulatory authorities or lobby groups.

The Vigilance™ technology can monitor aircraft positions over thousands of square miles of air space, up to 41,000 feet and with accuracy to within 25 feet.

"People living around airports are very concerned that aircraft should stick to their agreed flight paths, but radar isn't always accurate enough to monitor the exact location of a plane," says Simon Atkinson at Roke Manor Research.

"If the public complain about noise, Vigilance™ will give airports the ability to identify individual planes and detect if they strayed from their flight path."
The system is scheduled for deployment at a leading UK regional airport this year.



Photos: Roke Manor Research

Position sensing systems can detect planes that stray from their flight path

Euston, we have a solution

Remote monitoring of infrastructure is a major part of plans to reduce railway maintenance costs by hundreds of millions of pounds.

Photo: SensorNet Works

Monitoring the safety and stability of mine tunnels with networks of low-powered sensors

The aim is to create an 'intelligent infrastructure' which recognises problems and advises when maintenance is required, rather than fixing problems once they have occurred.

A lot of railway infrastructure is widely dispersed, and difficult or inconvenient to access, but nevertheless essential to efficient and safe network operations. Sensors are already used for condition monitoring, but the cost of sensors and cabling, and the practicality of sending a person to take data readings, severely restricts deployment in the field.

SensorNet Works, a spin-out company from the electronic engineering department at University College London, is trialling an intelligent meshed system which provides early warning of movement on railway embankments and overhead power gantries, and could be used on anything from points to bridges.

"The shift is from reactive to predictive maintenance and building intelligence into the infrastructure, "says SensorNet Works commercial director Simon Maddison.

Did the earth move?

Movement of earth in an embankment can alter the geometry of railway tracks, or warn of a future landslip. SensorNet Works, in partnership with Network Rail, has installed its wireless nodes with tiltmeters, which enable the data to be sent back to a central control point in near real-time. This also gives a much more detailed and dynamic picture of the infrastructure than is currently possible.

Importantly, the meshed system allows each sensor to talk to its peers and verify whether its reading is consistent with the rest of the network.

"A single reading can't distinguish between a substantial shift in the embankment and a sensor which has been knocked over by a fox or a falling tree," Maddison says. "By giving each sensor the ability to collaborate with the rest of the network, we can instantly gauge the scale of the problem."

Additional intelligence can be built into the network. If a group of nodes detect movement, for example, they can instruct themselves to take more frequent measurements.

The transmitters have a range up to 100m and save power by only turning on for a few milliseconds at a time.

"They are synchronised to turn themselves on, take a measurement, share and transmit the data, and then go dormant again," notes Maddison. This allows the sensors to operate for years on a single small battery.

SensorNet Works is integrating micro-electromechanical sensors (MEMS) with their wireless nodes. Coupled with remote data collection, this will enable a much wider deployment of sensors.

SensorNet Works sees further applications for its systems in construction, civil engineering, mining, utilities and agriculture.

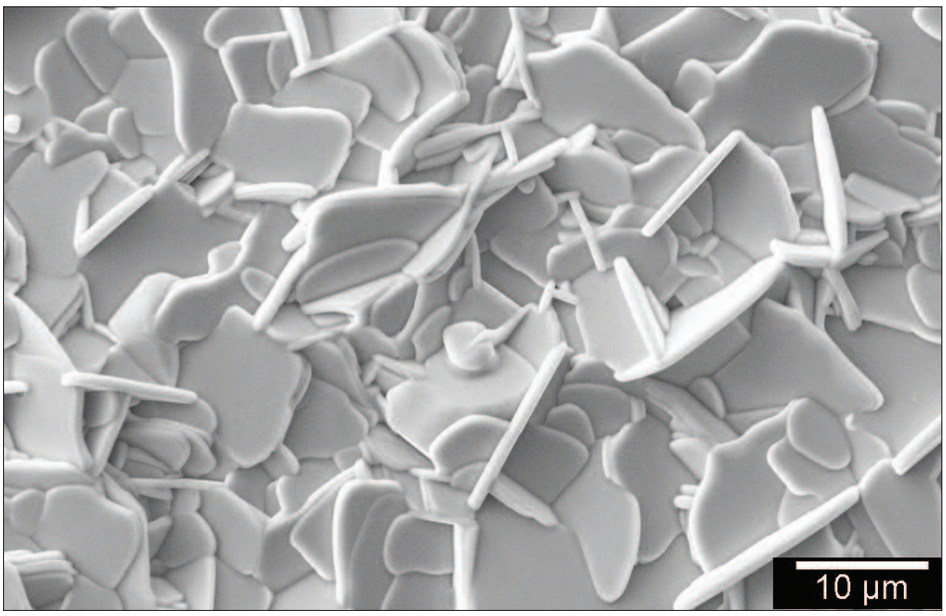
Photo: Network Rail

A mesh of intelligent sensors can provide early warning of movement in earth embankments supporting railway infrastructure

New institute signals Europe's commitment to piezoelectric technologies

The European Institute of Piezoelectric Materials and Devices will be launched by a network of researchers and industrialists this Summer.

Photo: Ferroperm



Piezoelectric materials are a basic component in many automotive and healthcare technologies

The Piezo Institute will develop piezo-based sensors and other applications. It will be the European hub of expertise and resources in piezo technologies, offering research, resources, education and training. Its expertise includes ferroelectricity, electrostriction and pyroelectricity in materials including ceramics, single crystals, polymers and composites.

"The science of piezoelectricity has been known for more than a century," notes Dr Markys Cain at the UK's National Physical Laboratory, a founding member. "The institute is Europe's recognition that there is now far greater potential for piezo applications in healthcare, transport, energy harvesting and environmental protection. It will help us to keep up with the rapid pace of piezo development in Asia and North America."

The institute is being formed by the EU's MIND network of excellence, which includes researchers from the UK, France, Germany, Italy, Switzerland, Slovenia, Spain and Latvia. Companies involved include Fiat, Siemens and piezo ceramics manufacturer Ferroperm in Denmark.

The institute offers research and consultancy in chemistry and process engineering, solid state physics, materials characterization, metrology, standards and the manufacture and testing of piezo devices. It is creating the first Pan-European Masters degree in piezoelectricity.

Applying piezo phenomena

The aims of the new institute include miniaturisation and integration of piezo structures into multifunctional devices, such as sensors for monitoring radiation, temperature and biological threats. New transducers for medical imaging, underwater acoustics and telecommunication systems are improving sensing performance and environmental efficiency. Innovative piezo-based devices enable implants for health monitoring and targeted drug delivery, and disposable probes to inspect and treat cardiovascular disease.

Transport

Piezoelectric materials are the basic component of many automotive sensors, including accelerometers and infra-red detectors. Improvement of sensor performance will reduce fuel consumption and improve safety. Piezoelectricity is becoming a lead technology in diesel fuel injection. The high pressures generated by piezo injectors improve efficiency of engines and reduce pollution. The Piezo Institute aims to develop self-testing structures with embedded sensors to monitor the effects of age such as micro-defects, cracks, delaminations and fatigue-related flaws.

Piezoelectricity is the ability of certain materials to generate an electric charge in response to mechanical stress. They also have the opposite effect – the application of electric voltage produces mechanical strain in the materials.

This effect makes piezoelectric materials effective in sensors and transducers used in the automotive and healthcare industries, and for environmental monitoring.

The word is derived from the Greek piezein, which means to squeeze or press.

News in brief

Sensing project takes off

Sensors are taking to the skies in the next phase of the Wireless Intelligent Sensing Devices (WISD) project. The project aims to sense the remaining lifetime of helicopter components such as rotor blades. It will assist helicopter operators by reducing the need for unplanned maintenance.The next demonstration will be carried out on an AgustaWestland Lynx aircraft (pictured) while flying. Initial tests were successfully carried out on a ground rig. Strain gauges will be fitted to the main rotor head to monitor its condition, with live data being sent via an RF signal back to the central unit. This will be compared to the data sent conventionally via slip rings. The robustness of the airborne RF link will be demonstrated.

Photo: AgustaWestland

The last issue of Sensors News mistakenly featured a helicopter that has not been involved in the project.

The WISD project partners include AgustaWestland, Engineering and Assessment Ltd (SEA), Conekt and Bristol University, and the project is part-funded by the DTI Technology Programme.

New multi-million sensing fund

QinetiQ and Advantage West Midlands are providing a new multi-million investment fund for the development of advanced sensors. The fund will be available to businesses to stimulate the technical development of advanced sensors and their integration into technologies used in everyday life.
To find out more visit www.qinetiq.com

Wearable sensors

A major car manufacturer needs academic collaborators to develop wearable sensors for wakefulness. The sensors will detect signs from a driver before they fall asleep, and gauge alcohol consumption.
To express your interest contact Phil Pettitt of InnovITS
Phone 01865 338412
Email phil.pettitt@innovits.com

Sensing events diary

RUNES Summer School
9-11 July 2007
University College London
www.ist-runes.org/summer_school

CITRIS – Europe Research Symposium: Innovative Technologies in the Service of Society
11-12 July 2007
www.citris-uc.org/CITRIS-in-Europe-2007/agenda

International Crime Science Conference
16-17 July 2007
British Library
www.crimescience.org

Instrumentation from Space Workshop
18 July 2007
Institute of Physics, 76 Portland Place, London
www.qi3.co.uk/events

4th Meeting of WiSIG
13 September 2007
Aston University, Birmingham
www.wisig.org

Instrumentation South 2007
3-4 October 2007
Royal Berkshire Conference Centre
www.instrumentation.co.uk

Intelligent Sensing Programme
10 October 2007
IET, Savoy Place, London
www.sensorsktn.com

SPIE Defense + Security 2008
16-20 March 2008
Orlando, Florida
http://spie.org/defense-security.xml

Sensors & Instrumentation KTN online

A powerful online platform and sensors knowledge base serves the UK sensing community. It features news, events and information about sensors, personalised search functions, a collaboration space for special interest groups and efficient tools for online meetings and seminars.

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