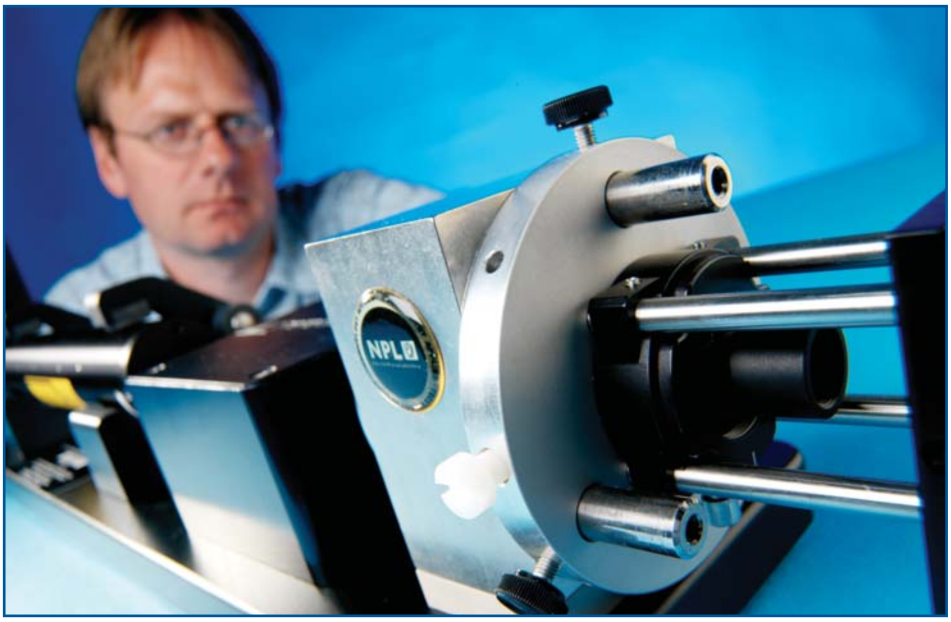
Engineering *Precisely*

A National Measurement Newsletter

Winter 2005 | Issue 2



Dr Mark Stewart using an interferometry system for characterising thin film piezo materials.

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Now hear this

Scientists at NPL, in collaboration with the Institute of Nanotechnology, are developing a novel cochlear implant using piezoelectric materials.

A major cause of deafness is degradation of the function of hair cells in the inner ear. Current implant technologies overcome this by sending electrical signals from a sound processor via an electrode system to the cochlea.

NPL has proved a concept based on a number of tuned resonators that use the piezo electric effect to produce a voltage over a narrow range of frequencies. This may allow a large number of miniature sensors to be contained in a single totally implantable and self-powered hearing device. The implant vibrates in response to sound, which causes the piezoelectric material to produce a small voltage. The electrical signal then goes down the auditory nerve into the brain.

"The use of thin-film piezoelectric materials, currently under development, presents an opportunity to miniaturise this device on a scale that could allow implantation into the cochlea," notes Dr Markys Cain, NPL principal research scientist. "This will only be achieved by characterising the materials and the response of the device using measurement technologies that we are developing at NPL".

NPL research on biocompatibility of materials and the performance of protective coatings compliments this work, as the device will need to be protected from the fluid in the cochlea.

These technologies can also support the development of miniaturised pumps and valves for medical devices and NPL is in discussions with potential partners who are developing commercial prototypes.

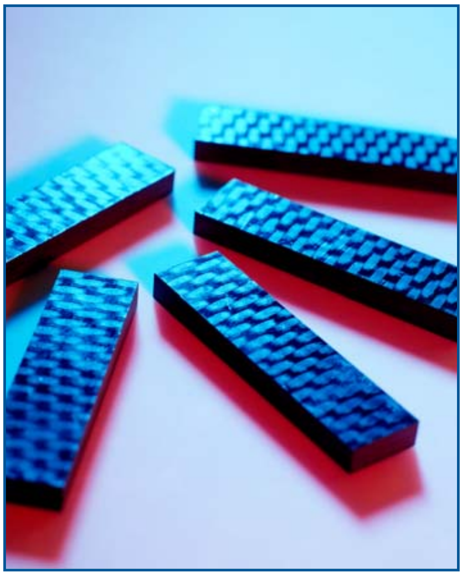
For further information please contact Markys Cain on 020 8943 6599 or e-mail: markys.cain@npl.co.uk

Thermal analysis brings clarity to glass transition measurements

Measurement of the glass transition temperature (T_g) provides important information that assists designers in selecting the appropriate material for their products. Different thermal analysis techniques can produce conflicting results, so NPL has developed an improved method for T_g determination.

Several thermal analysis techniques are commonly used to measure the glass transition temperature, and while each technique has its merits, Dynamic Mechanical Analysis (DMA) is increasingly favoured. DMA generates a mechanical vibration response in the test sample, which varies as a function of temperature, and gives a more clearly identifiable transition. However, the technique is sensitive to the applied heating rate, lacks standardised temperature calibration procedures and has a choice of analysis points.

A newly developed method incorporates the use of a temperature reference specimen that will form the basis of the new international standard procedure (ISO 6721:Part 11). The aim of the temperature reference specimen is to confirm the instrument temperature calibration and highlight to the user the ramp rate sensitivity of their equipment. This method is described in an NPL Measurement Note (DEPC MN 017 *'Polymer composites - rate dependent temperature calibration of Dynamic Mechanical Analysers (DMA) for T_g measurements'*). Following validation, NPL plans to make the reference specimens available to DMA users.



CFRP temperature reference specimens manufactured at NPL.

The Measurement Note can be downloaded from the website www.npl.co.uk/cog

For further information, or to participate in future thermal analysis research, please contact Sam Gnaniah on 020 8943 6174 or e-mail: sam.gnaniah@npl.co.uk

New life for lifetime management service

Interest is burgeoning in the new Lifetime Management of Materials Service at NPL, which has recently succeeded (and now incorporates) the National Corrosion Service (NCS).

Stress induced cracking of a polymer moulding (revealed by dye penetrant inspection).

In response to increasing demand, the remit of the new service has been broadened to encompass all forms of in-service deterioration of a wide range of structural materials, now including polymers, composites, adhesives and ceramics.

While the NCS used to focus squarely on corrosion-related phenomena the Lifetime Management of Materials Service (incorporating the NCS) now provides a gateway to expertise on all failure mechanisms affecting materials during operation. This includes advice on high temperature phenomena, fatigue, overload and wear, as well as corrosion.

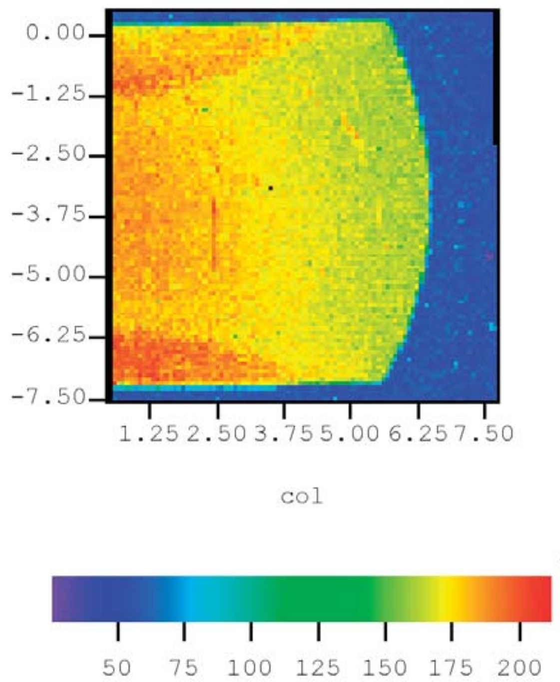
The NCS had provided impartial and highly valued advice to industry on how to manage problems with the corrosion of metals for more than thirty years, since the Hoar Report first alerted people to the huge impact of corrosion on the national economy (equivalent to 3% of GNP). The Lifetime Management of Materials Service aims to do the same but on a still larger scale.

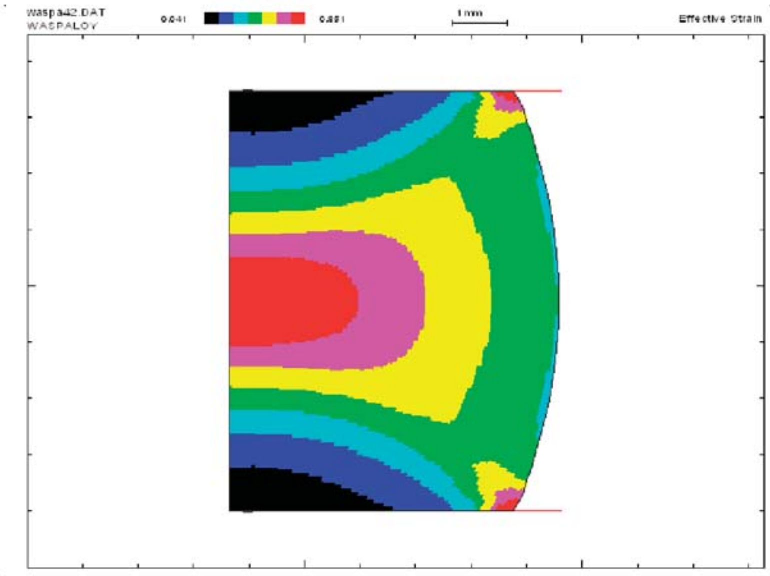
If you need advice, contact can be made by telephone on 020 8943 6142 or via the internet www.npl.co.uk/ncs

Alternatively, if your organisation can provide products, services or expertise that can help UK companies to control the lifetime of both metallic and non-metallic materials, you are welcome to submit details for inclusion without charge in SPEND, our Services, Products and Expertise National Directory (*www.npl.co.uk/ncs/spend*).

Microstructures – mapping brings benefits

Using a unique Scanning Indentation Mechanical Microprobe (SIMM), NPL are measuring the spatial variation in mechanical properties of metal alloys as a step towards providing metal forming industries with guidelines for microstructural examination and, ultimately, improved process models.





A typical hardness map (left) from the Waspaloy is compared with the numerical model prediction of variation in strain (right).

Forging, rolling, extrusion and related metal forming processes are key industrial technologies, required to produce many highly reliable parts economically. Due to competition at the low-cost production end of the market many steel manufacturers are being driven towards the production of technologically demanding steel types and the process control accuracy demanded by higher integrity and higher value components. Knowledge of microstructure development during processing is an essential input parameter for process models capable of bringing cost benefits via reduced energy consumption, reduced harmful emissions and less material wastage.

To underpin suitable process models, NPL, in partnership with the University of Sheffield and the University of Wales (Swansea), is developing good practice for microstructural examination in dynamic high temperature regimes. This includes defining local deformation conditions for comparison of computed and measured maps of microstructural evolution: information necessary for validation of models that include a consideration of the strain history of the testpiece.

Measurements of the spatial variation in mechanical properties are being made at NPL, using the SIMM (Scanning Indentation Mechanical Microprobe). The SIMM uses the principle of depth sensing hardness. The concept is a little like a nanoindenter, dynamically measuring force and penetration depth, but it works more quickly and to higher loads. The measurement process is fully automated to map large or small areas or conduct line scans. Force and displacement are monitored continuously during the complete indentation cycle. The machine operates in the micro to mesoscale range, 0.05 N to 20 N, with a load resolution of 2 mN and a depth sensing resolution of 20 nm using a specially designed capacitance displacement sensor.

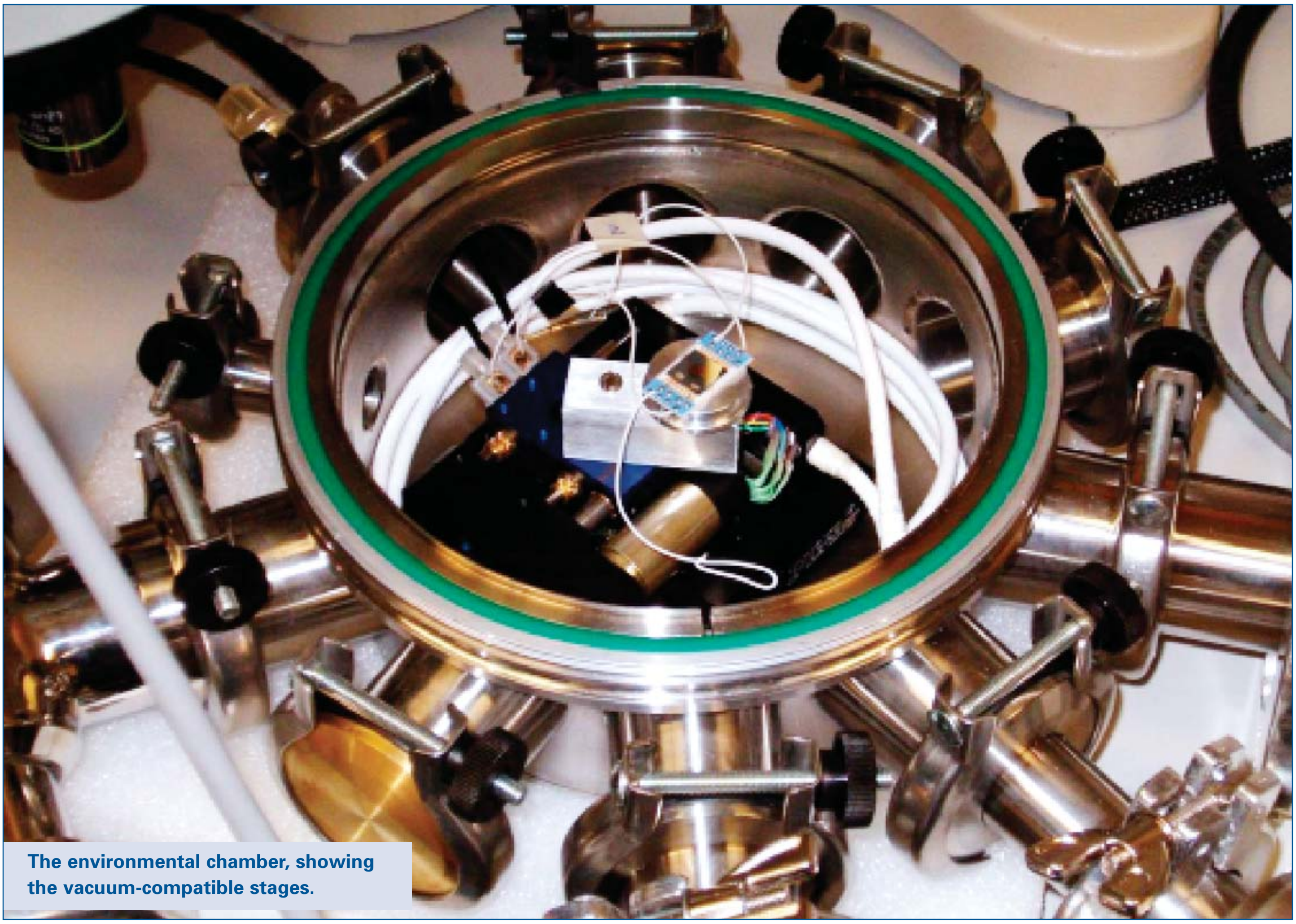
The resulting measurements are compared to measurements of microstructural variation and also compared with the outputs of numerical models, run by Sheffield and Swansea, of hot deformed compression testpieces.

Currently four representative materials are being investigated: 5052 Al alloy; Ti64 (Ti alloy); 316 stainless steel and Waspaloy (Ni alloy). So far, sets of microhardness maps have been generated on cylindrical testpieces deformed at Swansea. These were mostly conducted using a 90 × 100 array of 2 N indents with an array spacing of 80 mm.

A full set of guidelines for microstructural examination is expected by Spring 2007, in the meantime, for more information on the SIMM or mapping microstructures contact Bryan Roebuck on 020 8943 6298 or e-mail: bryan.roebuck@npl.co.uk

Measuring MEMS motion

An environmental chamber has been integrated with a micro-scanning Polytec laser Doppler vibrometer for use in characterising Micro Electro Mechanical devices at the nano-scale over a wide range of vacuum conditions.



The environmental chamber, showing the vacuum-compatible stages.

With the increased use of Micro Electro Mechanical (MEMS) devices, characterisation of their motion is becoming essential to gain an understanding of how the system is moving. The addition of integrated functionality to MEMS devices, such as by incorporating a thin piezoelectric layer, are leading to novel devices that require detailed characterisation. There is a need for a performance assessment of these functional materials at reduced length scales. Processing conditions can lead to changes in residual stresses, which may lead to degradation of device performance.

As part of a DTI funded programme, NPL has developed a scanning laser Doppler vibrometer (LDV) system for examining the motion of MEMS devices over a wide range of pressure, from atmospheric pressures down to 10^{-5} mbar. Pumping is performed by a diaphragm-backed turbomolecular pump, offering an oil-free option for reduced sample contamination. The laser beam reaches the sample through an ITO covered glass window, enabling good RFI/EMI shielding.

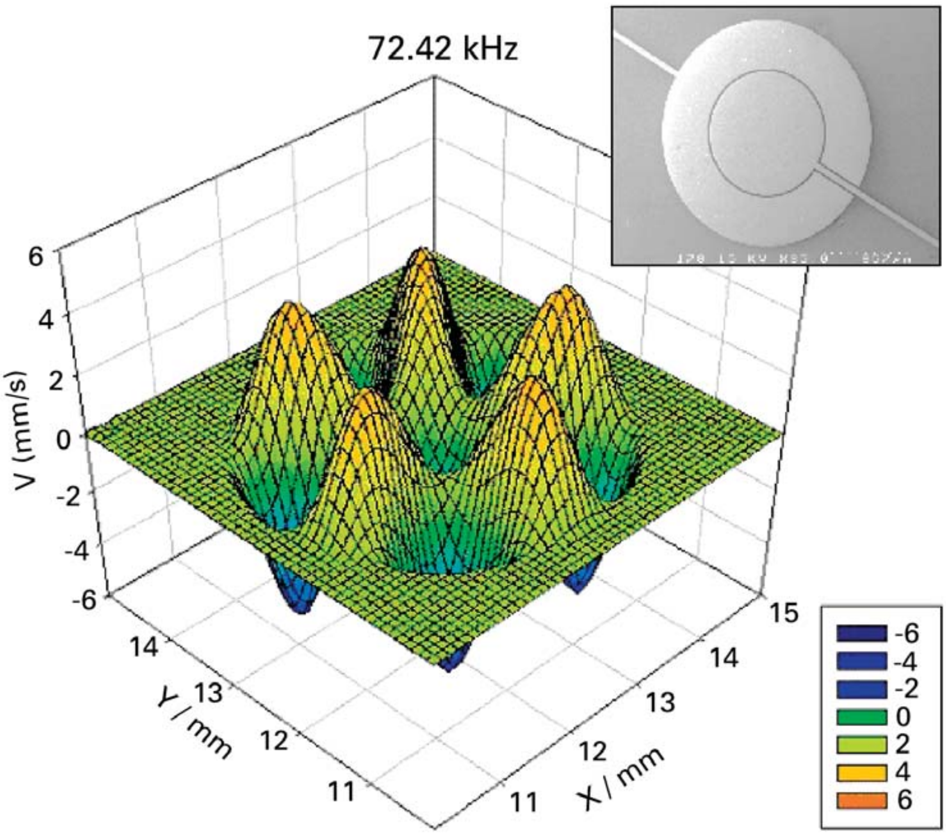
NPL's system uses a commercial scanning differential vibrometer (Polytec) in conjunction with a standard microscope and long working distance objective optics that reduce the beam size down to 1 µm, allowing for characterisation of systems with lateral sizes less than 10 µm. Scanning the laser across the sample at a given frequency then produces a displacement or velocity profile showing the out of plane motion, with a resolution of less than 1 nm. For larger samples (up to 25 mm) vacuum-compatible stages are used to scan the sample and generate the motion profile. The use of a scanning unit with a vacuum chamber allows the study of devices under more realistic working conditions, as well as opening up the option of studying effects such as air damping and friction. The system will eventually be able to allow the study of sample motion as a function of temperature and/or humidity.

As an example of the scale over which the scanning vibrometer system can operate, tests have been carried out on a macro-scale PZT membrane (4 mm diameter) and an atomic force microscopy (AFM) tip (feature size ~ 20 µm). For both samples, measurements were recorded in air and in vacuum as a comparison of their dynamic response. The PZT membrane, excited directly by applying a sinusoidal voltage between top and bottom electrodes, exhibits a fundamental mode of vibration at a frequency of 20.78 kHz in air and 17.81 kHz under a vacuum of 4 x 10^{-5} mbar. This reduction in frequency is caused by a sealed air gap behind the sample membrane. In contrast, for "freely" vibrating samples, an increase in frequency is observed on reducing the pressure, which gives rise to a reduction in the frictional forces acting on the sample. As well as the expected higher order harmonics, further vibrational modes can also be observed, a result that would be more difficult to observe with a point vibrometer.

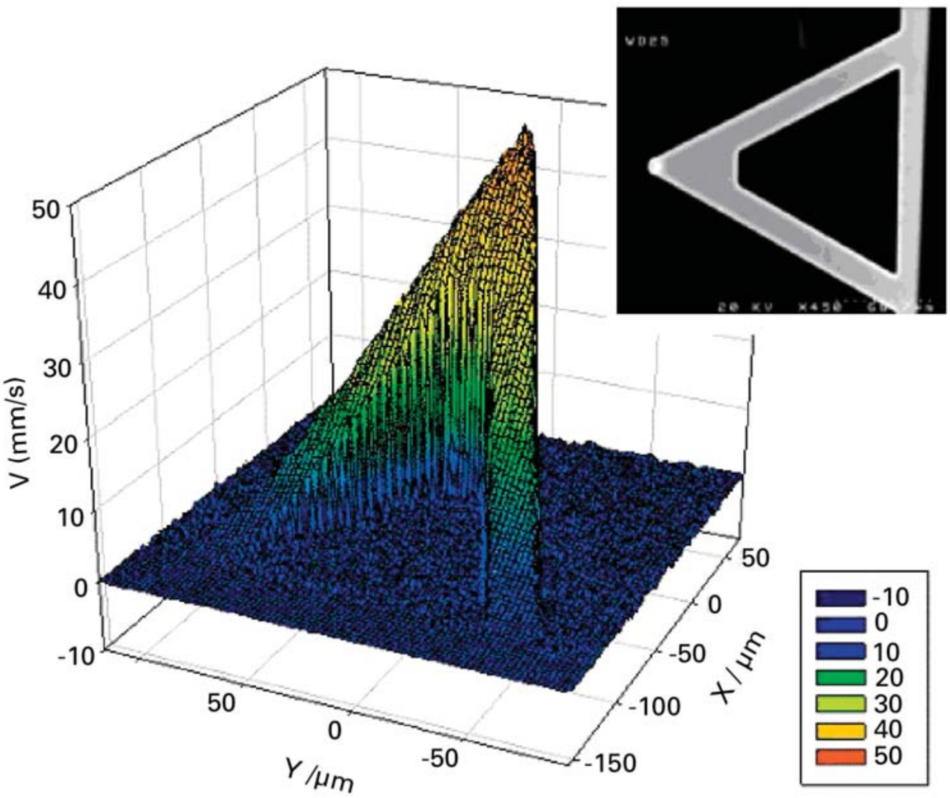
For smaller devices, laser scanning can save time when compared to physically scanning the sample and also reduces any effect caused by lateral motion and backlash due to the scanning stages. Depending upon the spatial resolution required, a complete scan of the out of plane motion can be achieved in a matter of minutes.

Results from an AFM tip demonstrate the lateral resolution of the system. A typical V-shaped cantilever used for contact mode AFM was scanned in both air and under vacuum. The resonant frequency of the cantilever was found to be 62.12 kHz in air and 62.59 kHz at a pressure of 3 x 10^{-5} mbar, with the amplitude of vibration also increasing by a factor of 50. Knowledge of the fundamental frequency of the tip allows calculation of the force constant which can then be compared with the values provided by the manufacturer.

For more information contact Martin Lowe on 020 8943 8626 or e-mail: martin.lowe@npl.co.uk



Scanning-LDV image of a harmonic mode of vibration from a 4 mm diameter PZT membrane. Insert: An SEM image of the top surface.



Scanning-LDV image of the resonant mode of a contact mode AFM tip taken at a pressure of 3 x 10^{-5} mbar. Insert: An SEM image of the AFM tip.

Meeting measurement needs, reducing risk

In October the European Commission and the United States Department of Commerce highlighted a 'fundamental market failure in the provision of early-stage financing' for small innovative businesses and start-ups.

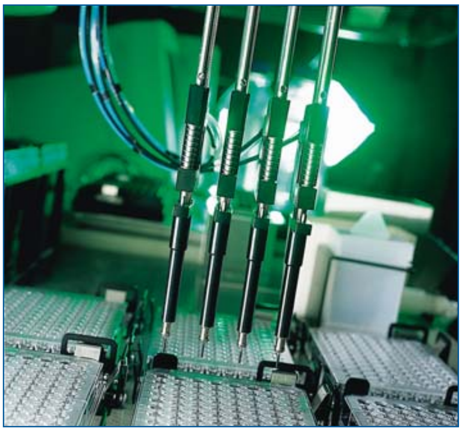


Image courtesy of LGC

"The DTI through its multidisciplinary and mid-term focused MET Programme is underpinning the all important measurement requirements of a number of essential new industries including regenerative medicine, thus helping facilitate not only world class metrology but also keeping the UK competitive in the emerging technology markets such as stem cells and tissue engineering."

Dr Chris Mason, Advanced Centre for Biochemical Engineering, UCL

The reason for this failure was found to be due to venture capital funds concentrating on larger deals to avoid the higher risk associated with early stage companies. The DTI's 2003 Innovation Report identified the need to support innovation to exploit a range of key emerging technologies, particularly the development of embryonic, segmented and disruptive markets.

Measurement for Emerging Technologies (MET) is a DTI supported programme that was created as a response to the Innovation Report. It will help allay the fears of the EC and US in creating conditions for venture capital financing. The programme has been designed within the National Measurement System Directorate to assist the process of innovation by industry through exploiting a range of key emerging technologies and draws together the skill base of the UK NMI contractors (NPL, LGC and NEL). The direct result will be a new range of measurements and the infrastructure to support new technologies in embryonic markets. In turn this will facilitate the introduction of new products and processes in markets where the UK can be competitive. The indirect result will be a reduced risk in these embryonic markets, which will enable companies to raise funds more easily and ultimately create competitive, productive industries.

Five emerging technology market sectors have been targeted within MET:

- Medical, particularly regenerative medicine and bio-processing technologies
- Materials
- Manufacturing
- Energy and Environment e.g. increasing efficiency of hydrogen fuel cells
- Communications

Eleven projects have been funded in these sectors so far, but MET recognises the need to ensure that these projects are relevant and remain relevant to the solutions within the sectors. So the projects are being run in collaboration with industrial partners and universities. Over the eleven projects there are 38 companies and 15 academic groups contributing 26% of the programme value.

It is expected that through these projects MET will deliver, over the medium and long term, a series of solutions to the measurement issues within emerging technologies. These solutions will enable UK companies to derive significant competitive advantages both through the application of science and raising of finance.

The projects are:

- Scale out bioreactor systems for tissue engineered products
- Micro and Nanoparticles: rapid, reliable multi-property analysis techniques
- Biocompatible coatings and optimising efficiency of medical implant devices
- Sensor techniques for drug discovery and diagnostics
- Micromeasurements for multifunctional materials and systems
- Nanostructured multilayer characterisation
- Micro and Nanoparticles: rapid, reliable multi-property analysis techniques
- Bioprocess development
- In-situ measurement and modelling of fuel cell systems
- Effective wireless sensor networks with context identification and communications
- Microfluidics

For more details on these projects – their objectives, timescales and how to join the partnership, please look on the website at ***www.metprog.org.uk*** or contact the MET programme formulator, by e-mail: ***MET@npl.co.uk***

Thick or thin skinned?

A collaboration research project has found a way to increase accuracy when measuring the rate of water loss from human skin. It could help doctors make more informed decisions about the health of small babies and burns victims.

Trans-Epidermal Water Loss (TEWL) is a measurement of the evaporation rate of water through the skin. It is considered a reliable measure of whether human skin is functioning properly. It is used to identify skin damage before it becomes visible to the eye and to monitor the rate at which skin heals or recovers from trauma.

The medical industry uses TEWL to monitor skin development in premature babies at risk from germs and dehydration if their skin hasn't matured in the womb. TEWL could also be used to monitor the progress of burns patients during the long healing process. Industry uses it to check the skin condition of factory workers constantly exposed to industrial solvents, whilst researchers measure TEWL to identify the impact of products on skin. All of these practices rely on TEWL measurement devices to give correct readings. Yet there are currently no methods of calibration which can ensure accuracy.

An industry collaboration, led by NPL and funded by the NMS Thermal Programme, solved the problem with a new calibration technology. The prototype uses calibration 'wells' which produce a known rate of evaporation when primed with a measured droplet of water. Using several of these 'wells', each producing a different rate of evaporation, the team can take readings with TEWL devices. They can compare the readings from each device with the known rates of each 'well' to identify inaccuracies. A calibration calculation can then be developed and applied.

"TEWL instruments of different types can disagree by up to 50%," says NPL scientist Stephanie Bell, "which presents a huge margin for error, considering the applications for TEWL are related to critical health decisions. We aim to ensure people can rely on equipment to take accurate and replicable readings."

The project now has prototype calibration assemblies for almost all available TEWL measurement devices. The team is also considering whether to offer a measurement and calibration service to the global network of TEWL measurement device manufacturers and users.

"This is a developing field of measurement," explains Bell. "The existence of a reliable calibration service would accelerate the growth rate."

For further information about TEWL calibration please contact Stephanie Bell on 020 8943 6402 or e-mail: stephanie.bell@npl.co.uk

Formulation of the NMS Thermal Metrology Programme 2007-2010

Your help is needed in the formulation of the new NMS Thermal Metrology Programme.

The work of this programme ensures that thermal measurements in the UK are valid, fit for purpose and internationally recognised. The technical areas covered by the programme are temperature, humidity, novel methods for temperature measurement and thermophysical properties. Every three years the programme of work is re-formulated to ensure that the programme continues to meet the requirements of the UK thermal measurement user community. This process has just started, and your input is vital to ensure that the work undertaken by the programme continues to meet these requirements. This is your opportunity to influence the programme's technical content for the benefit of your business and more generally UK plc.

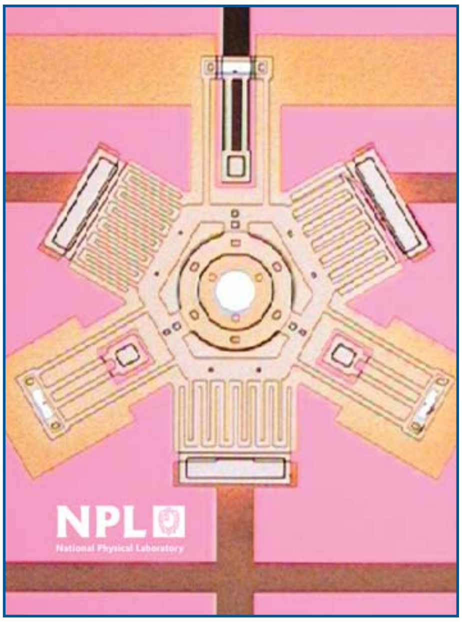
An orientation meeting was held at the DTI in November to map out the future trends and drivers for the programme, and the first of four focus groups reviewed cryogenic thermal measurement requirements. Three further focus groups will be held in the new year, centring on automotive, power generation and aerospace; the built environment, including thermal performance and moisture transport; and medical and food. Notes from these meetings, and details of upcoming focus groups will be available on *http:/www.npl.co.uk/formulation/thermal.* Alternatively if you are not able to attend these meetings, you can make your views of thermal measurement issues known through the web enquiry page, again at the above web link.

If your area of thermal measurement is not represented at the above meetings, you are still welcome to attend and make your requirements known. If you would like a personal invitation to one of the focus groups then please register your interest, again with the formulator.

For any further information please contact Graham Machin, formulator of the thermal programme on 020 8943 6742 or e-mail: graham.machin@npl.co.uk

New measurement techniques in nanomechanical and nanochemical analysis

Under the Valid Analytical Measurement (VAM) programme, NPL has developed new measurement techniques for the calibration of nanoscale chemical forces and nanomechanical measurements using the Atomic Force Microscope (AFM).



A microfabricated NPL Electrical Nanobalance, around 0.3 mm in diameter, used to calibrate force, nanomechanical and nanochemical properties using AFM.

The AFM has become one of industry's most popular tools for surface analysis. In the past, industrial use of AFMs has typically been focused on generating quantitative ultra-high resolution topographical images to investigate characteristics such as surface roughness. This has allowed new levels of topographical detail to be observed. However, in skilled hands, it is also possible to use an AFM to measure a range of further surface attributes at atomic or near-atomic resolution. These measurements of chemical forces on the nanoscale and characteristics such as Young's modulus have enabled researchers to develop the ideas that drive much of today's frontier nanoscience developments. Over the past few years, under the VAM programme, the Surface and Nano-Analysis team at NPL have been developing calibration methods and protocols for quantitative measurement techniques using the AFM. This work is essential for the development of new technologies and products in the healthcare, aerospace, packaging, medical and pharmaceutical industries.

The VAM programme has addressed key measurement challenges in order to enable traceable, quantitative AFM based measurements to be made. Primarily, the team investigated the calibration of AFM cantilever spring constants, k_z. This is necessary in order to calibrate force measurements using the AFM, which then leads to a wide variety of applications from measuring the rupture force of protein bonds to determining the Young's modulus of materials such as polymers at surfaces. Accurate methods are essential as manufacturers' nominal values can be up to a factor of two or more in error.

There are many methods to calibrate the spring constant. The basic approach via dimensional measurements has unfortunately not been popular with analysts as there are many different published equations. This has been resolved in a recent paper by NPL scientists, 'The determination of AFM cantilever spring constants via dimensional methods', published in *Nanotechnology*, Issue 16. This review paper explains how these differences in equations arise, corrects errors in the literature and provides a single accurate equation for analysts to use.

A new method was also developed to calibrate AFM spring constants. This method is the first traceable measurement of the forces applied by AFM cantilevers. A compact and easy-to-use MEMS (micro electro-mechanical) calibration device, called the NPL Electrical Nanobalance, is used to determine the AFM cantilever spring constant. This device is traceably pre-calibrated via electrical measurements undertaken at NPL or a UKAS-accredited laboratory. To calibrate an AFM cantilever, the user then simply lands and presses their working AFM cantilever onto the nanobalance.

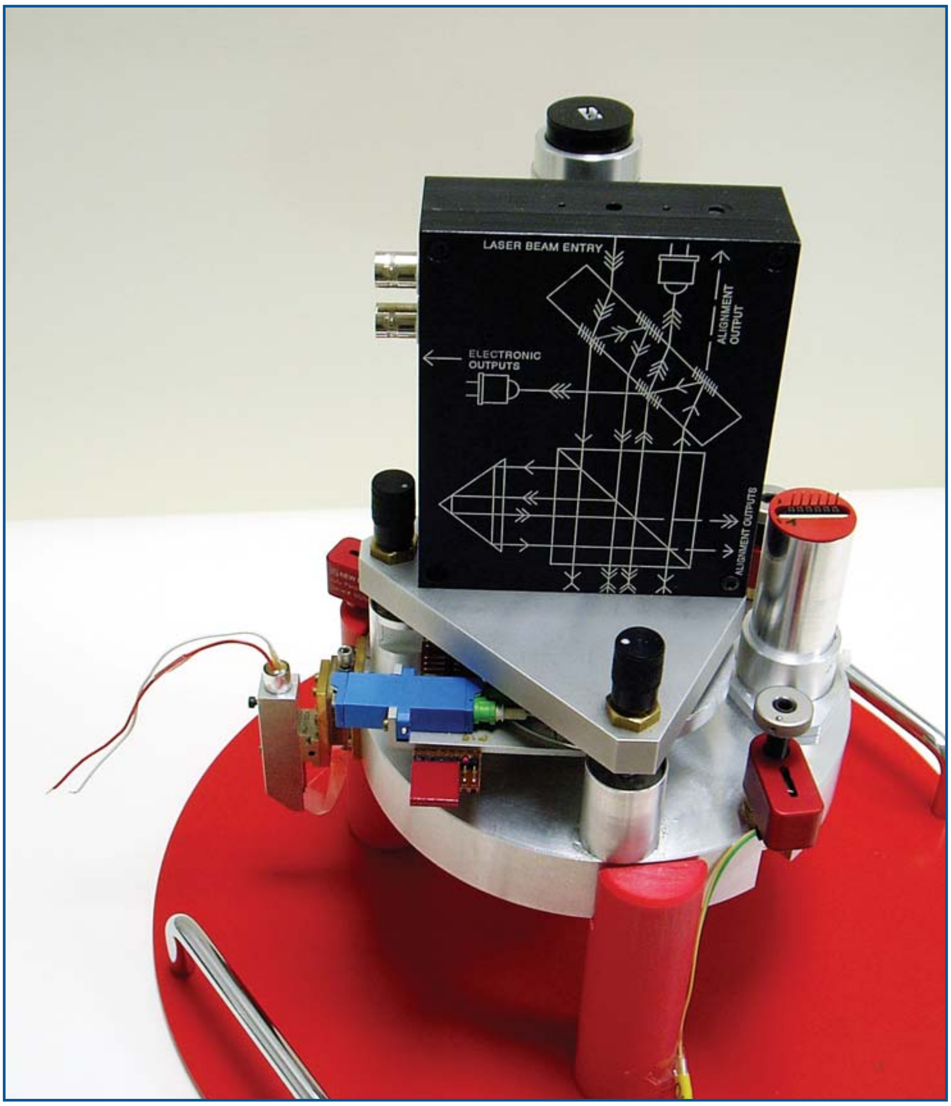
Measurement techniques have also been developed for the application of AFM to the identification and characterisation of polymers at surfaces at the nano-scale with high spatial resolution. This is achieved using measurement of the modulus. Two routes to quantitative modulus measurement have been developed, to address two different measurement requirements, using both the AFM on its own and in combination with a nanoindenter. The first involves the direct measurement of modulus using a fully calibrated instrument and allows depth analysis. The second employs indirect measurement through calibration using reference materials of known reduced modulus, E^*. The first method determines parameters, such as the AFM spring constant and tip shape, which entail significant uncertainties arising from the tip shape, but has the advantage of giving the modulus as a function of indentation depth. The second method uses calibration with reference materials of known bulk moduli where direct calibration is not necessary and uncertainties are significantly reduced.

For more information on the range of nanomechanical and nanochemical analysis being undertaken, please contact Charles Clifford on 020 8943 6620 or e-mail: charles.clifford@npl.co.uk or Peter Cumpson on 020 8943 7177 or e-mail: peter.cumpson@npl.co.uk

www.npl.co.uk/nanoanalysis

National Metrology labs join forces to provide AFM measurements with lower uncertainty

The National Physical Laboratory (NPL) and the Physikalisch-Technische Bundesanstalt (PTB) in Germany are studying the effect of interactions between the tip and the sample on atomic force microscope measurements.



The Atomic Force Microscope developed jointly by NPL and PTB for tip-sample interaction studies.

In both industry and academia there is an increasing use of atomic force microscopes (AFMs) for inspection and measurement of samples with micrometre and sub-micrometre size features. Although NPL and other national metrology institutes such as the PTB in Germany have invested much effort to provide traceability for AFMs, there are still sources of uncertainty that are yet to be fully quantified. These include the effects of the AFM tip on the measurement of a sample, and the effects of surface forces acting on the tip, including electrical charging, van der Waals forces, and the thin film of water that lies on the surface when measurements are made in air. These tip-sample interactions can give rise to apparent topographical features and a small but increasingly significant source of uncertainty of measurement, particularly when measurements are made of nanometre sized features or micrometre sized features with nanometre uncertainties.

In the last few years work has identified the surface forces that can affect an AFM tip, but the effects on traceable dimensional measurements have yet to be determined. In order to address these problems, NPL and PTB have taken the lead to develop an atomic force microscope specifically for measuring tip-sample interactions and their effects.

This unique instrument can work in the three standard modes of operation namely, contact, non-contact and intermittent contact. It combines two different types of optical interferometer with the conventional AFM beam deflection system to not only measure the topography of the sample, but also movements of the AFM tip that go unnoticed in conventional AFMs and can lead to measurement errors. The instrument has already revealed hitherto unobserved twisting of the AFM tip when calibrating step height standards that are later used to calibrate AFMs in industry.

NPL and PTB are continuing their collaboration to use the newly developed AFM in the various modes of operation in order to measure the effects of tip sample interactions on a variety of different samples of industrial importance. The results of this study will be published in scientific journals and will be used to improve measurements made by AFM measurement services at the two institutes.

Further details please contact Andrew Yacoot on 020 8943 6955 or e-mail: andrew.yacoot@npl.co.uk

Time to talk torque

From the tightening of wheel nuts on a car to the assembly of caps for pill bottles, the accurate measurement of torque is essential to UK industry. This autumn a new transducer calibration facility became available at NPL, able to generate torque from 1 N·m to 2 kN·m.

The need to provide national standards for torque was recognised by the UK's Department of Trade and Industry when the National Physical Laboratory was commissioned to design and manufacture the first national standard torque calibration machine. The machine will be used to calibrate transfer devices and to disseminate the unit of torque within industry.

The 2 kN·m lever-deadweight torque machine designed with a vertical torque axis, generates a symmetric pure torque via identical weight stacks located at either end of a lever arm. Both clockwise and anticlockwise torques can be applied in the range 1 N·m to 2 kN·m.

The machine makes use of several novel and innovative sub assemblies including a twin beam carbon fibre lever arm and boron fibre tapes used to transfer the force.

Complimenting NPL's new torque calibration facility is a suite of four Deadweight Force Standard Machines, including a new 120 kN Deadweight Force Standard Machine, with forces ranging from 2.5 kN to 120 kN. The suite of Deadweight Force Standard Machines was designed and manufactured by NPL, and offers a force transducer calibration service to industry in the UK and overseas. The machines include austenitic stainless steel weight stacks in their design, and allow calibration of force transducers in both tension and compression modes. A range of forces from 25 N to 1.2 MN is achieved over the suite of four machines, with an uncertainty of applied force of 0.001%.

NPL can also undertake force calibrations, in tension and compression, from 1.2 MN to 5 MN, with an uncertainty of applied force of 0.02% to 0.05%, using a hydraulically amplified deadweight machine. Larger forces from 5 MN to 30 MN are available in compression mode, using two hydraulically operated force machines.

The 2 kN·m lever-deadweight torque machine.

For further information on NPL's Torque and Force calibration services please contact Andy Robinson or Paul Twite on 020 8943 6194/7157 or e-mail: andy.robinson@npl.co.uk or paul.twite@npl.co.uk

API master gauge calibration, a well-oiled service

NPL's calibration service for reference master gauges manufactured to API (American Petroleum Institute) specifications is supporting a vast infrastructure and helping to keep fuel supplies flowing and costs down.

Although the calibration service has been provided by NPL for over 50 years, under a Euromet agreement NPL is the sole European agency for the calibration of these gauges and during the past year alone has calibrated gauges from more than 17 different countries worldwide including the UK, Ukraine, Japan and Algeria. The lead times and turnaround times for this service have been improved by the training of two new calibrators and the introduction of improved processes.

API tapered threads are used extensively in the oil and gas industry from attaching the drill bits used to drill new wells, to the tubing and casings used to transport the oil. The threads that are machined onto these components rely on a hierarchy of gauges manufactured to API specifications. NPL is one of only 10 organisations worldwide authorised to carry out the calibration of API master gauges, 4 of these being in China. As well as providing a calibration service NPL has a technical representative on the API gauging committee and is frequently approached to give advice on gauging issues to the industry.

The tapered thread gauges are difficult to calibrate due to the tight tolerances and the specialist equipment and expertise required. All the parameters of the thread have to be measured e.g. pitch, taper, pitch diameter at the gauge plane, major and minor diameter, thread form and a number of other items on the gauges. The female gauge is then screwed onto the male gauge using a prescribed torque, and the amount of male gauge protruding (the standoff) is measured. This also has to be within tight limits.

For further information on the API gauge calibration service please contact Nigel Cross on 020 8943 6731 or e-mail: nigel.cross@npl.co.uk

The long and the short of it

NPL have recently published two new measurement good practice guides in the area of dimensional metrology, aimed at those who are new to the subject area.

The guides are available in both paper form and electronically. The CD-ROM will include the electronic version of the guide and electronic versions of the images so that teaching professionals can incorporate the images in to their lectures.

No. 79 ***"Fundamental good practice in the design and interpretation of engineering drawings for measurement processes"*** is intended to help metrologists to interpret the designer's specification and to give the designer some background to modern measurement methods.

No. 80 ***"Fundamental Good Practice in Dimensional Metrology"*** is written for engineers and technicians who have to make dimensional measurements as part of their job. An introduction to the units of length and key issues such as traceability and uncertainty is followed by some examples of typical sources of error in length measurement. The guide employs a less formal and more accessible style of writing than previous guides and includes short anecdotes to illustrate the key messages to the reader.

These guides are available from NPL at no charge and complement the existing dimensional metrology good practice guides and e-training modules.

For further details contact David Flack on 020 8943 6347 or e-mail: david.flack@npl.co.uk

It's a matter of course

NPL's popular temperature training course took place in October and for the first time was followed by a new humidity training course.

The three-day temperature course covered all established methods of temperature measurement and calibration, with almost half the course time devoted to laboratory demonstrations and hands-on activities.

The new humidity course proved popular on its first run, with 25 attendees from 8 countries attending an intensive day on humidity measurement, calibration, uncertainty analysis and more, again with a lab-based element. Many attendees stayed for both courses, and some of those who didn't said they would be back next time for the humidity module.

The associated instrument exhibitions saw bumper attendance from NPL site staff as well as delegates. At least one exhibitor was heard lamenting that he hadn't brought more staff to handle the rush of interest!

The courses are both due to run again next year. For details contact Stephanie Bell on 020 8943 6402 or e-mail: stephanie.bell@npl.co.uk

Quality problems, quality answers

Presentations given by NPL at this October's INSPEX show are now available on the web.

The seminars were designed to answer some of the latest quality challenges for industry. Topics as diverse as uncertainty calculations for CMMs and measuring the stickiness of liquid adhesives were covered.

Dimensional measurement was approached from both ends of the scale: the basic fundamentals through to the advanced techniques of mulitlateration and interferometry. Uncertainties were covered in some depth, with presentations on both the GUM and Monte Carlo methods of calculation. Techniques for optical dimensional calibration and surface topography measurement were also presented, as was the significance of temperature effects on dimensional measurement.

Quality aspects of materials performance were also on the agenda. NPL's work to: combat environmental degradation of polymeric materials in hostile environments; optimise the use of hot melt adhesives; and model passenger impact for the improved safety of car interiors were all presented.

All the presentations are available to download from: ***www.npl.co.uk/dmac/meetings/ inspex_oct_05/presentations***

If you would like further information on any aspect of
NPL Engineering Precisely, *please contact:*
Tel: 020 8943 6880 | **Fax:** 020 8943 7160 | **E-mail:** engineering@npl.co.uk

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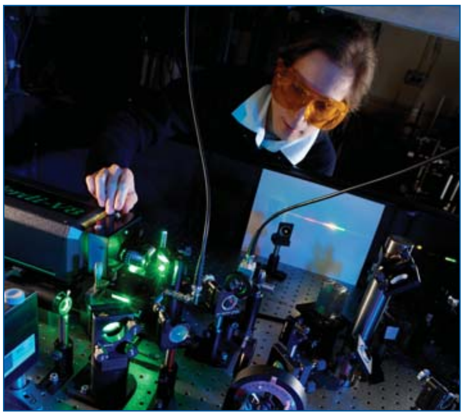
A brush with the future

Femtosecond optical frequency combs have already led to a revolution in the field of optical frequency metrology, enabling optical frequencies to be connected in a single step to the primary caesium microwave standard.



The comb technology provides stable, well-defined, absolute frequencies in the optical range, and will enable research and product development in a number of new areas, including spectroscopy; laser interferometry and distance measurement; and secure communications.

NPL are investigating the metrological requirements across such applications. In order to gain a wider appreciation of the potential uses of the comb technology, NPL would like to hear from organisations that are looking to develop products or services that could exploit the advantages the femtosecond comb provides.

If you are interested in guiding this research and would like to discuss practical applications and your future metrological requirements, please contact Helen Margolis on 020 8943 6113 or e-mail: helen.margolis@npl.co.uk

Forthcoming events

7th December 2005, NPL, Teddington
DC&LF Club meeting: Power quality
http://www.npl.co.uk/electromagnetic/clubs/dclfclub/
E-mail: DCLFClub@npl.co.uk

8th December 2005, NPL, Teddington
EMMA Club meeting: A celebration of dielectrics - EMMA's 21st meeting
http://www.npl.co.uk/electromagnetic/clubs/emma/
E-mail: emmaclub@npl.co.uk

9th December 2005, NPL, Teddington
The measurement and characterisation of medical biosensors
www.npl.co.uk/metrology_clubs/mnt
E-mail: robert.angus@npl.co.uk

28th February 2006, Grimsby
Measurement surgery - Food
http://www.measurement-surgery.com
E-mail: emma.mulligan@npl.co.uk

March 2006, Leeds
Measurement surgery - Medical
http://www.measurement-surgery.com
E-mail: emma.mulligan@npl.co.uk

March 2006, Leeds
Measurement surgery - Electrical
http://www.measurement-surgery.com
E-mail: emma.mulligan@npl.co.uk

15th March 2006, NPL, Teddington
High temperature mechanical testing meeting
http://www.npl.co.uk/tman/
E-mail: roger.hughes@npl.co.uk

25th – 26th April, NPL, Teddington
Rapra: Joining plastics 2006
http://www.rapra.net/conferences/JoiningPlastics06/index.asp
E-mail: sgarrington@rapra.net

NPL would like to wish all our readers a Merry Christmas and a Happy New Year!

For information on Engineering Precisely, event details and contacts visit the website: www.npl.co.uk

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