NPL
National Physical Laboratory

Engineering *Precisely*

A National Measurement Newsletter

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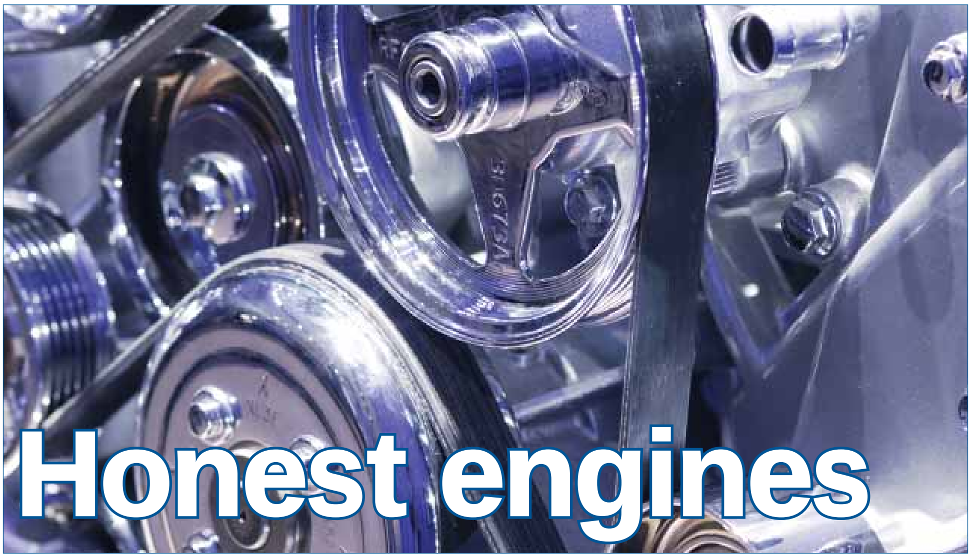

Honest engines

In a world becoming more aware of its carbon footprint we need accurate measurements of in-cylinder and fuel injection pressures to develop internal combustion engines that meet the increasingly tough emissions regulations and efficiency requirements.

Manufacturers of petrol engines are continually seeking to improve the accuracy of intake manifold and in-cylinder pressure measurements, whilst the focus for diesel engine production is to achieve better control of injector performance by direct measurement of pressures at the injectors. Sensor performance is critical under these demanding applications where the combustion of air/fuel mixtures causes flame fronts that reach temperatures of 2000 °C, and the detection of events such as engine knocking requires sensor response times that are measured in microseconds.

The accuracy of these sensors is limited by not having the means to calibrate them under conditions that match those that will be encountered during their use and, in particular, by only calibrating at static pressures. Parameters such as the resonance frequency of the sensors and associated fittings (e.g. connectors and pipe work), and damping and rise-times have to be estimated through computer modelling, increasing uncertainty in the sensor output under normal working conditions.

To help address this problem, NPL has formed a consortium with Loughborough and Cranfield Universities, Perkins Engines, Kistler, and independent automotive engine consultants. The key aims are to:

1) develop a method or methods to calibrate ‘gold standard’ reference pressure sensors at amplitudes, frequencies, and temperatures that are encountered in engines

2) build pressure waveform generators that are suitable for in-house use by manufacturers and researchers alike - these will allow calibration of engine sensors by direct comparison with the ‘gold standards’

The first stage is likely to include the further development of shock-tube and combustion-bomb facilities (already existing at Cranfield and Loughborough) and the development of a piezoelectric sonar transducer-based system at NPL

For further information about pressure sensors or the consortium please contact Stephen Downes on 020 8943 6932 or Andy Knott on 020 8943 6180 or e-mail stephen.downes@npl.co.uk or andy.knott@npl.co.uk

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Weighing up continuous calibration

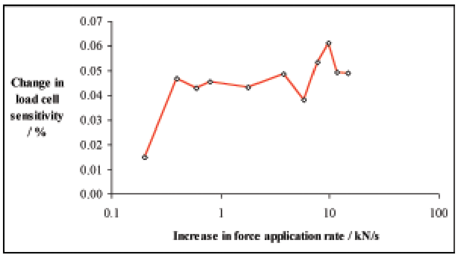
Force and torque transducers are generally calibrated statically, which is laborious, time-consuming, and expensive. NPL is finding ways to speed things up, and cut the costs, with dynamic calibration.

Most modern force and torque transducers now give a real-time electrical output, so their manufacturers could save significant amounts of time and money if they were able to calibrate their products in a continuous manner, increasing the applied force or torque from zero to maximum in one smooth operation and synchronously recording the input and output values. In order to do this, equipment capable of generating a varying but traceable force or torque value is required, and the uncertainty associated with the calibration results of such an approach needs to be determined.

NPL has been investigating the calibration of load cells using this continuous method - one load cell is first statically calibrated in a deadweight force standard machine and designated as the reference standard. The reference cell is placed in series with a second load cell (in a servo-electric testing machine) and the applied force is ramped up from zero to maximum. The output of the first load cell is used to determine the applied force and the output of the second load cell is calibrated against these calculated input force values.

Simultaneous readings can be taken from the two load cells, and repeated calibration runs have been carried out using a synchronous data-logger at different rotational positions over a wide range of force application rates. The graph demonstrates that the second load cell's calibration sensitivity is a function of the force application rate - it should also be noted that the alignment of the transducers in the machine can have a significant effect.

It might be expected that the difference between a static and continuous calibration of the second load cell would



Calibration sensitivity is a function of the force application rate.

be a function of the difference in the creep performance of the two cells. To test this theory, creep tests have been carried out on both load cells in a deadweight machine and the difference between their creep performance determined. Further work on a range of transducers is required to see if this creep effect is a good indicator of the force application rate sensitivity - if so, it could be used in combination with the continuous calibration to derive a range of load cell sensitivities for different rates.

If successful, this approach could enable force and torque transducers to be calibrated quickly and efficiently, by comparison against a master transducer in one or more fast ramps and also, if a lower uncertainty is required, in an additional short creep test.

For further information, please contact Laurence Brice on 020 8943 7054 or e-mail laurence.brice@npl.co.uk; or Alan Wilson on 020 8943 7024 or e-mail alan.wilson@npl.co.uk

Engineering Better Health

The healthcare industry needs to make a huge variety of mechanical measurements, and as in any other industry, they have to be reliable.

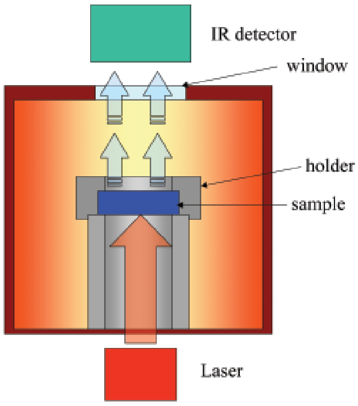
To help reduce the occurrence of pressure sores in long-term hospital patients and care home residents, the measurement of interfacial pressure is critical. Pressure sores are caused by unrelieved pressure, or shear, or frictional forces between the patient and mattress. Pressure relief mattresses are extensively used to alleviate the problem but their development and final evaluation is predominantly performed by clinical trial. The process is both time consuming and expensive, limiting the speed and economy with which technical developments can be implemented and evaluated. In order to overcome these limitations, both suppliers and the customer base frequently use the measurement of interfacial pressure (IP) to provide a means by which the effectiveness of pressure relief mattresses can be evaluated. However IP depends on a number of factors, including posture and the local shape and stiffness of both the tissue and support surface. Additionally the measured IP will be affected by the presence of the sensor. A standardised and traceable way of measuring IP and of calibrating such equipment would greatly enhance the development and evaluation of pressure relief mattresses and similar healthcare equipment by enabling the comparison of results measured over time and by different users.

Compression bandages are used in the treatment of venous leg ulcers. Bandages vary greatly in their ability to provide sustained compression due to differences in materials and construction. Additionally, factors such as limb circumference and shape have an important influence on the pressure produced beneath a compression bandage. The application of these bandages to the patient is also critical and significant variations in sub-bandage pressures have been found, even when applied by experienced healthcare staff. Again, a repeatable and traceable measurement process and a calibration procedure for sub-bandage pressures would benefit the development and evaluation of compression bandages, and would additionally provide a diagnostic tool for both training in bandage application and in the evaluation of what sub-bandage pressures are most effective in the treatment of leg ulcers.

NPL is hosting an open forum to discuss this and other issues on 27 June 2007 and would welcome your views on issues in this area. For further information, or details about the forum please go to our website at www.npl.co.uk/mass/healthcare/ or contact Stuart Davidson on 020 8943 6224 or e-mail stuart.davidson@npl.co.uk

Answers in a Flash

NPL has used Laser Flash Apparatus (LFA) to test the thermal diffusivity of an oxidation resistant coating from Diffusion Alloys. This oxidation resistant coating has now been shown to have no material effect on the heat transfer characteristics of furnace tube walls, and armed with this data an order for this coating has been won by Diffusion Alloys.



Schematic drawing showing the principle of the laser pulse method for determining thermal diffusivities of alloys

A furnace vendor was concerned that a customer's wish to have Diffusion Alloys apply an oxidation resistant coating on tubular metallic components within one of its furnaces would affect the heat transfer characteristics of the tube wall. To give reassurance to the vendor, Diffusion Alloys asked NPL to collect thermal conductivity data on both uncoated and coated tube material.

The LFA at NPL uses a high intensity laser pulse to heat the bottom face of the sample coating and records the temperature rise on the top face using an InSB infra red detector. The customer asked that the thermal conductivity data be collected between 500°C and 1000 °C. Within this temperature range, in both new and used conditions, the oxidation resistant coating was shown to have no material effect on thermal diffusivity, satisfying the company purchasing the furnace and the furnace vendor that this coating would be suitable.

For further information on LFA and heat transfer characterisation contact Lindsay Chapman on 020 8943 6596/8652 or e-mail lindsay.chapman@npl.co.uk

Feeling the heat in standards

High-temperature metrology suffers because of a lack of reference standards above 1100 °C, leading to much higher uncertainties than can routinely be achieved at lower temperatures. As energy efficiency becomes more important, and as new manufacturing processes need tighter manufacturing tolerances, NPL are helping establish standards up to 2500 °C.

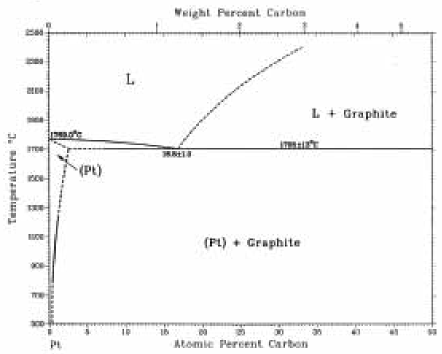
As part of a worldwide research program co-ordinated by NPL and involving USA (NIST), Japan (NMIJ), Russia (VNIIOFI), France (INM), China (NIM-Beijing), Germany (PTB), Korea (KRISS) and Australia (CSIRO), comparison of standards prepared by different institutes have been carried out. Tiejun Wang, a senior engineer from NIM-Beijing, worked at NPL in the summer of 2006 to set up new facilities and construct a series of high-temperature fixed-point standards. While he was doing this he compared an NPL platinum-carbon eutectic fixed-point with one from NIM. The agreement was within 50 mK at a temperature of 1738 °C. The results were presented in a joint paper at Tempmeko 07.

Subsequently, Dr Dave Lowe of NPL used the facilities of PTB to construct a platinum-carbon fixed-point and compared it to a standard from the NMIJ. Again this agreed within 50 mK – an extremely good result at these temperatures where even the best measurements have an uncertainty of about 500 mK. These results are the best agreement ever at this temperature.

These standards will be used as part of further studies; fixed-points from NPL and NMIJ are to be measured by INM in France and NIM in China to establish long term stability. This is a preliminary study before a concerted effort starting this year that will ultimately lead to adoption of globally accepted standards that will benefit both temperature and radiometric metrology.

For further information on high temperature metrology at NPL please contact Dave Lowe on 020 8943 6312 or e-mail dave.lowe@npl.co.uk

For more information, or to register for Tempmeko 2007 please visit www.tempmeko2007.org



The phase diagram of platinum and carbon shows a eutectic transition at an indicated 1705 °C (actually 1738 °C) and 16.8 wt% carbon. This is an invariant transition that uniquely defines a temperature. The phase diagram shows what phases are present (L-liquid, solid Pt or solid graphite) at any temperature and composition.

Hot off the press – high temperature thermal reference materials on market

Following the identification of an urgent need for high temperature thermal reference materials, NPL has led a three-year program to explore a possible solution.

Heavy reliance is placed on thermal conductivity values in the marketing of reference materials, and the refractory and ceramic products industries in particular have a need for a low to moderate thermal conductivity reference material (1 < λ < 10 W·m-1·K-1) which is stable and reproducible at temperatures up to at least 1000 °C. However, different organizations in different countries measure or derive the property by a variety of methods which include the line source hot wire method, the guarded hot plate technique and the laser flash diffusivity method. It is well known that there can be significant differences in the conductivity values obtained by these different techniques and hence the requirement for a fully characterized reference material.

As a result NPL led a three year programme of work supported by the European Commission involving eleven partners from six countries to select, procure, characterize and certify the thermal transport properties (thermal conductivity and thermal diffusivity) of Pyroceram 9606, a polycrystalline glass ceramic material for use as reference material up to at least 1000 °C. The project reports and the batch of prepared Pyroceram 9606 specimens were sent to IRMM who had the task of checking the partner's Certification Report and completing any additional issues. We are pleased to be able to announce that IRMM have finally released the material for sale as a Certified Reference Material. Their contact details are:

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For further information on thermal reference materials please contact David Salmon on 020 8943 6510 or e-mail david.salmon@npl.co.uk

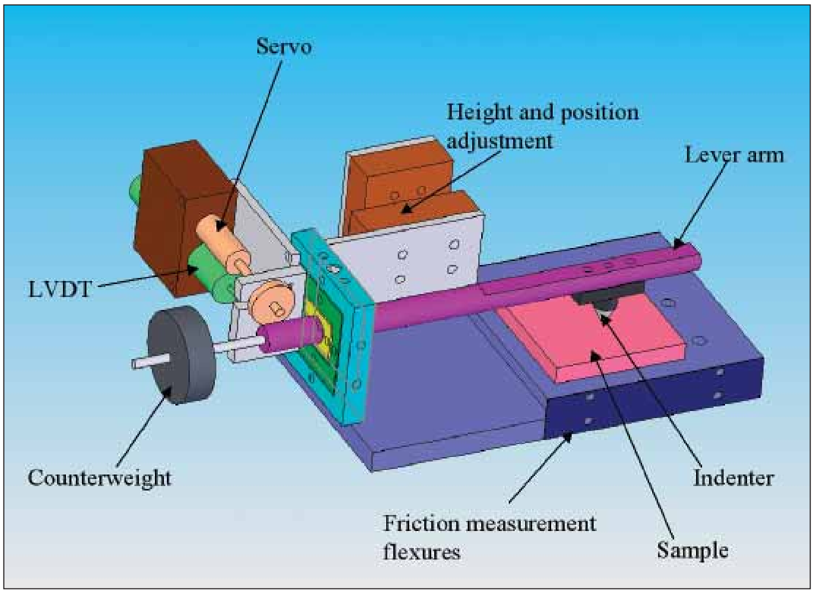
Cost Effective Micro-Tribology Rig

The measurement of the wear and friction that occurs between contacts in micro devices is crucial to understanding their behaviour. NPL has developed a new cost effective test system for micro-tribology testing.

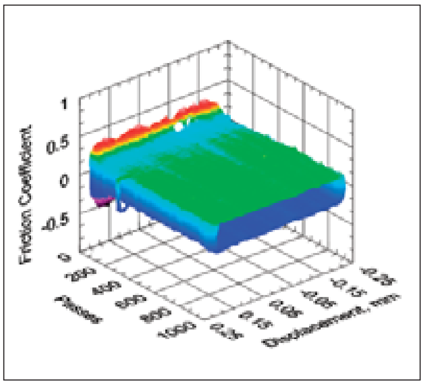
Understanding the processes involved in micro-devices enables improved design, but it has to be affordable. A new NPL paper 'A cost-effective test system for Micro-Tribology', to be published in the journal Wear, describes a simple cost-effective test system to carry out these measurements. This system is designed to make use of off the shelf high technology components that give the necessary precision, but at a reasonable cost, and is also designed so that in-situ experiments can be carried out in a scanning electron microscope.

The utility of the test system has been demonstrated by the results of experiments on WC/Co hardmetals, and also on a range of ceramic and carbon based coatings.

For further information on the test system, or a copy of the report please contact Mark Gee on 020 8943 6374 or e-mail mark.gee@npl.co.uk



Above: Schematic of a test system



Left: Evolution of friction coefficient with numbers of passes for polymer nanoparticle composite coating

Bonding Solutions - Adhesive Design Toolkit

The large number of adhesives and issues involved in the design of adhesive joints can be bewildering, even for an experienced engineer. Whether you are a first time user or looking to improve your production process, the Adhesives Design Toolkit can help you navigate through the options available.

The Adhesives Design Toolkit is a new web-based resource that provides free access to information on a wide range of topics relating to adhesive technology. A systematic approach has been adopted in providing information on the design of an adhesive joint in a readily usable format for both novice and expert users. It aims to help people make informed decisions about designing with adhesives, and to locate adhesive suppliers and related equipment. There are now EIGHT interactive modules to assist the user to design with adhesives including:

- Adhesive selection
- Adhesive suppliers
- Case Histories
- Stress analysis
- Design guidance
- Standards *(NEW)*
- Design, Preparation and Testing *(NEW)*
- Forensic assessment *(NEW)*

To access the Adhesive Design Toolkit visit: www.adhesivestoolkit.com and simply register as a new user.

For further information visit the website or contact the Adhesives Toolkit Coordinators, Dr Ewen Kellar (TWI) on 01223 891162 or Dr Bill Broughton (NPL) on 020 89436834 e-mail: adhesivestoolkit@twi.co.uk

Measurement surgeries join forces with the West Midlands Metrology Centre

As part of NPL's ongoing direct support for SME's and UK industry as a whole, the first Partnership Measurement Surgery was held with the West Midlands Metrology centre on the 31st January 2007.

For two years NPL has been running the Measurement Surgery programme, a series of one-to-one meetings between an NPL measurement expert and local companies with measurement or metrology issues with a view to providing a complete measurement solution to the company, funded either partly by the DTI or directly by the company. The events are always run in collaboration with a local business support organisation in various regions around the UK.

In conjunction with the West Midlands Metrology Centre, regular Partnership Measurement Surgeries will be held every six months to meet the demand for specialist metrology assistance in the local industrial base.

The first Partnership Measurement Surgery, held on the 31 January 2007, demonstrated the collaborative spirit of the surgery model. The day resulted in two projects with SME's from the West Midlands area that fitted well with the West Midlands Metrology Centres ultra modern metrology laboratory and metrology training capabilities. Two other projects with larger research and development elements arose from the one-to-one meetings where a new measurement technique or process was required, fitting well with the NPL's extensive 106 years experience as the UK's National Measurement Institute.

The next Regional Measurement Surgeries will be 18 July 2007, and 21 November 2007, at the Coventry Metrology Centre, Coventry University Technology Park, CV1 2TT.

For further information on the West Midlands Metrology Centre please visit

www.metrology-wm.org/ and for more information on up coming Measurement Surgeries in your local area please visit www.npl.co.uk/measurement_surgeries/

Understanding rejection

The body has an excellent defence mechanism that rejects foreign materials. Whilst this is highly desirable for preventing infection, it is a hindrance when trying to introduce materials into the body as implants or devices. A team at NPL, as part of the Measurement for Emerging Technologies Programme (MET), is working to understanding the effect the surface chemistry and topography has on cell behaviour, and how it is critical for the success of implants.

Implants manufactured from metals and plastics are commonly used throughout the body to repair fractured bones, replace damaged or diseased joints, restore blood flow to blocked arteries or simply to provide an access port. A common problem with all these materials is that the body will not see them as natural and will react against them in some way or other, the severity of this problem depending on the implant and the patient.

Just a brief look at some applications shows the magnitude of the problem. Cardiovascular disease is the single largest cause of mortality in the developed world, in the UK there are some 245,000 deaths a year, and in the US some 4 million people suffer from angina. The latter can be relieved by restoring blood flow to the coronary arteries by using an expandable mesh-like structure known as a stent. Typically stents are made from a metal, usually stainless steel. For some people this approach only provides temporary relief. Around 20% to 30% of recipients will experience restenosis – reclosure of the blood vessel due to in-stent smooth muscle cell growth (neo-intimal hyperplasia). The mechanism of this process is not well understood but it is believed to be a response of the body to wound damage caused by the initial procedure and poor biocompatibility of the bare metal stent. Restenosis needs to be relieved by further treatments including more stenting or a coronary artery bypass.

More than 478,000 total knee replacements were carried out in the US during 2004 compared to 418,000 in 2003 and 160,000 in 1991. The cost of revising failed implants rose to $42,000 per patient in 2003, which is 35% more than the cost of the initial total knee replacment. Some 120,000 total joint replacements were carried out in the UK during 2004-2005 requiring 1.1 million hospital bed days. Joint replacements have an expected lifetime of around a decade which is not good news for the patient or healthcare provider. The challenge is therefore to improve the performance of implants both in terms of the body's physiological acceptance of them as well as their mechanical integrity.

An example of a pelvic cup with a covering of fused beads designed to encourage bone ingrowth.

Even after decades of development, fewer than ten materials are used to interface with the body and even these have some degree of interaction with the surrounding biological environment. Interactions occuring at the interface between the two phases determine the success or failure of the implant or device. The ultimate challenge in this area is therefore to produce material surfaces that the body does not see as being 'foreign'. This goal can only be achieved if the complex relationships between the surface chemistry and topography, protein adsorption on to it and its effect on subsequent cell-surface interactions, are understood. Reliable, quantifiable measurements are key to this understanding, such as being able to map the local topography of a surface rather than resorting to the usual suite of engineering parameters that average data over an area or highlight particular aspects of the surface (such as the highest peak).

A commercially available orthopaedic hip joint has been designed to encourage bone growth into a titanium coated fused bead structure. The different textures that are present on the surface of the fused beads range from 'plates' to repeating furrows. The question of which texture is most suitable for encouraging cell attachment in a clinical environment is almost impossible to answer, especially when one considers how the implant is placed and secured to the surrounding bone. In some regions the reamed out cavity created in the pelvis will be distant from the surface of the implant whilst in other areas the bone is likely to be under compression. Both scenarios will lead to bone remodelling if only to accommodate the altered loading pattern. Hence there are significant advantages in working in-vitro to study the relationship between cell behaviour and surface texture across the measurement scale that will help to improve in-vivo performance.

The textures seen on the surface of the fused beads of the pelvic up implant range from furrows (A) to plate-like structures (B). The scale bar is 1 µm.

Comparator blocks with surface textures produced by different machining methods or finishes are commercially available for assessing roughness. The textures on these comparator blocks range from repeating furrows produced by grinding to the pocked surfaces caused by shot blasting. Changes in the tooling or particle size will result in changes in the size of the features. When coated in titanium these textured blocks become a good model for the range of textures seen on orthopaedic implants in general, since these are also produced using a variety of methods including casting and sintering and finished in many different ways.

A model cell system based on mouse calvarial (MC) 3T3-E1 cells is being used to study the interactions of cells with these different surface textures. This system was chosen as the cells have a comparable phenotype (appearance) to bone forming osteoblast cells and express several of the biological markers associated with osteoblasts. In a typical experiment a cell culture is exposed to a titanium coated comparator plate that has eight different textures on it.

The cells and plate are incubated for 10 days after which the plates are removed from the culture and an adhesion assay performed using toluidine blue, a metachromatic dye. An optical micrograph of one of the comparator blocks shows there are significant differences in the number of cells that have attached to the different surface textures. This can be simply quantified in terms of the number of cells per given area or studied in more detail at higher magnifications using an optical microscope that is capable of producing 3D representations of structures.

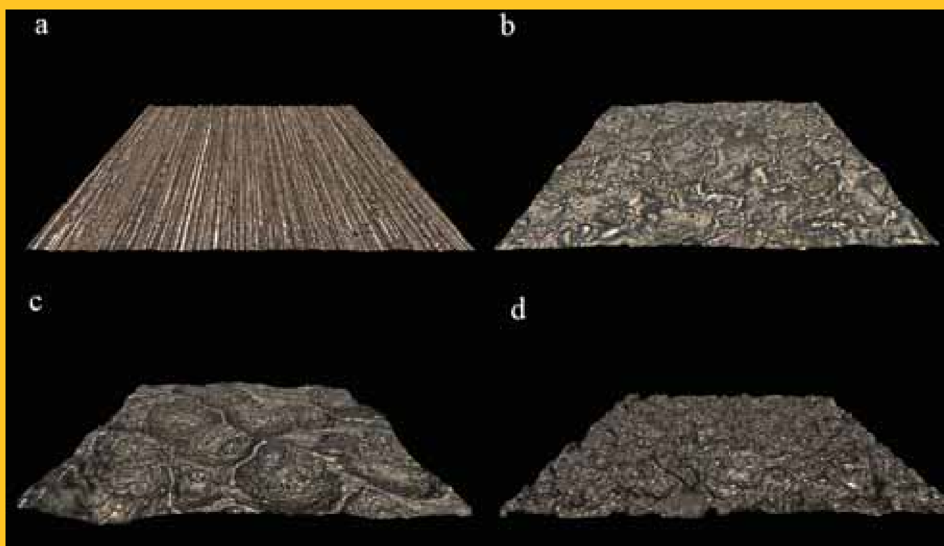
Having 3D data enables both the area covered by each cell to be determined as well as the relationship between surface features and cell attachment to be studied, requiring a new approach to quantifying surface texture to be developed. The basis of this new method is to represent the surface as a 'vector' map where each vector corresponds to the standard deviation in height from the mean plane. This approach reveals variations in local texture in a way that isn't possible using the range of parameters used by engineers that are typically based on averages which lose the in-plane spatial information.

Stained cells attached to different surfaces very clearly show that the degree of cell spreading varies enormously depending on the surface texture to which they are adhered. Preliminary studies of the linkage between surface texture and the presence of cells suggest that they prefer flat or shallow concave surfaces and will seek these out in highly textured finishes.

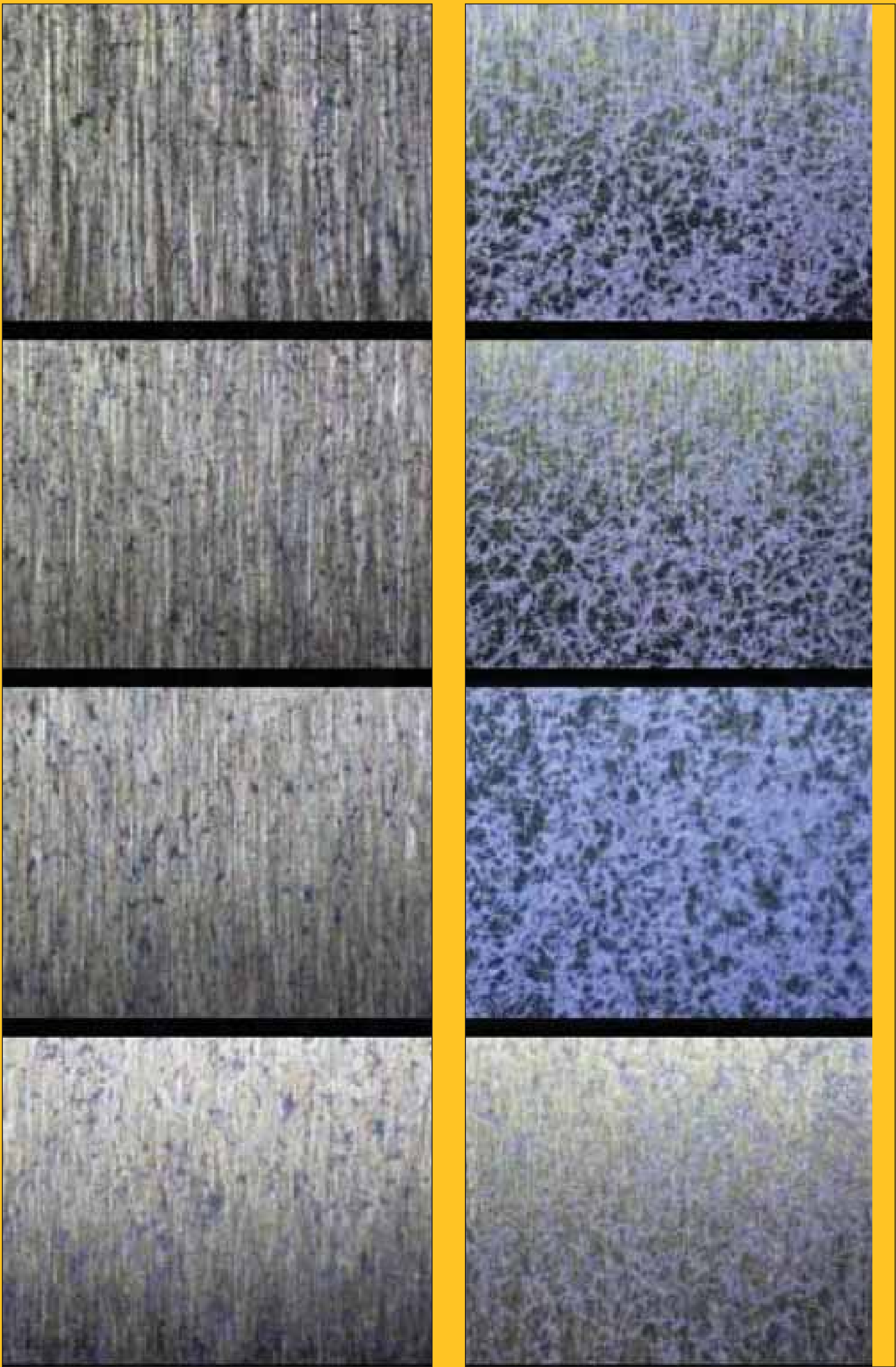
The response of a cell to the underlying surface is partially mediated through the layer of adsorbed proteins that coat the surface. Protein adsorption is a rapid process occurring within milliseconds of exposure to contact with proteins in solution. The composition of this adsorbed layer can, and does, change over a period of time as less abundant but more strongly interacting proteins displace those already bound. Once adsorbed the proteins are not easily removed even after washing with detergents. In a protein mixture such as serum there is a 'binding' sequence of proteins that is thought to be albumin; immunoglobulins; fibrinogen; fibronectin; high molecular weight kininogen and Factor X11. The binding sequence is highly dependent on the surface of the material and for hydrophobic materials tends to stop after adsorption of albumins.

Exploring the relationship between the adsorbed protein layer and subsequent cell attachment is a research goal for this project. Initial investigations are tackling this problem by focusing on creating surfaces with the same chemistry that have different surface textures. In terms of inducing changes in protein conformation the critical length scale is 20 nm and below – anything larger than this is just additional area for protein adsorption. Ideally such textured samples need to be produced in millimetre sized regions so that they can also be used for cell adhesion studies. This obviates the use of many nano-texturing methods. We are therefore looking at the surface of etched waveguides and metal coated quartz crystals that have textures imparted on them as a result of vapour deposition to see whether these are suitable for studying protein adsorption behaviour. Initial characterisation of the surfaces is being done using a range of surface analytical techniques including ellipsometry and x-ray photoelectron spectroscopy (XPS) as well as atomic force microscopy.

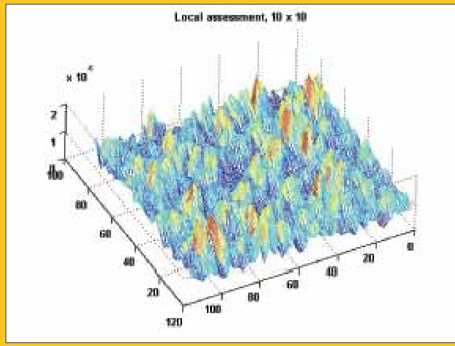
Generating consistent, homogenous textures over large areas at the sub 20 nm level that influences protein conformation is only part of the challenge. Methods are



Examples of widely differing surface textures produced by machining or finishing that have the same Ra value (3.2 µm).



Mouse calvarial 3T3-E1 cells stained with toluidine blue show a preference for some textures over others as suggested by the 'blueness' of the image. The different textures shown have all been produced by surface grinding.

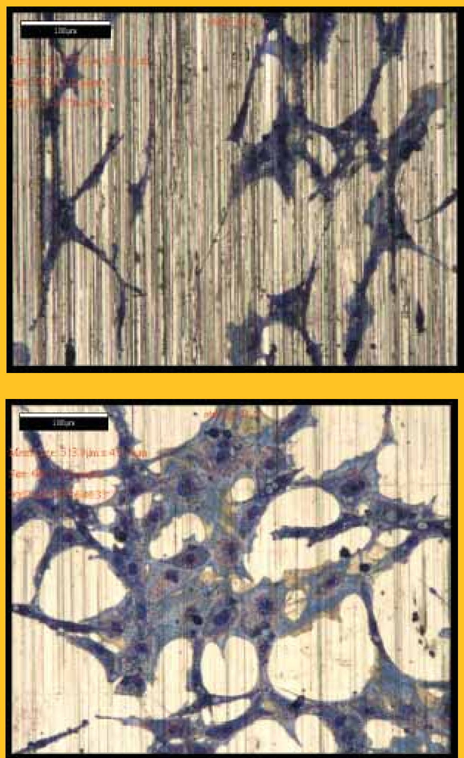


Plotting the standard deviation of each individual point with respect to a mean plane clearly shows the differences in local texture.

required to map the location of specific proteins and to provide information on their shape and size. Techniques that focus on the proteins themselves include methods that determine the refractive index of the layer via evanescent waves (dual polarization interferometry and surface plasmon resonance), ellipsometry and mass detection methods such as the quartz crystal microbalance. All of these approaches are indirect methods for probing the adsorbed layer. The results of such studies are therefore open to an indeterminate degree of uncertainty. Some of the techniques i.e. ellipsometry and evanescent waves are severely affected by surface texture due to loss of signal, although by how much and at what level has yet to be determined.

The body's reaction to the presence of artificial surfaces that are in contact with blood-based media is determined by the composition and conformation of a layer of adsorbed proteins that coat the material within a very short period of time after initial contact. The surfaces also influence the conformation of the adsorbed proteins. How these changes influence cell behaviour is the key to biocompatibility and the route to substantially improving the performance of implants in the future. The challenge this project faces is to improve the underpinning metrology that will help to understand this incredibly complicated relationship.

For further information e-mail paul.tomlins@npl.co.uk or visit www.metprog.org.uk/medical and click on project 1.4



Toluidine blue stained cells on different surface textures show differences in cell density as well as the degree of spreading. The darker blue areas correspond to individual cell nuclei. This image viewed from above is captured in 3D.

NPL develops crossed rod high stress sliding test

NPL has shown the feasibility of adapting commonly available scratch test systems to evaluate the response of materials to high stress sliding contacts.

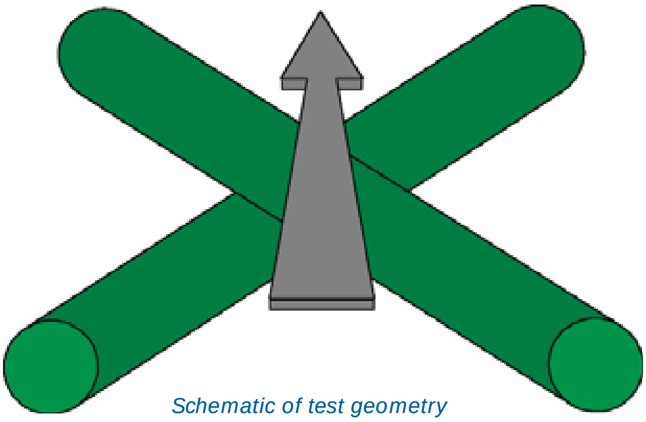
Load scanning tests, originally devised by Uppsula University, examine the response of materials to high stress sliding contacts. NPL has examined conventional scratch test systems, which are often used for the mechanical testing of coatings, to see if they could be used for effective load scanning tests.

A simple test jig has been designed and built, which will enable load scanning tests to be run on existing scratch test systems.

The test jig was used to test three test materials: EN3b, 316 stainless steel and a 10% Co binder phase hardmetal. These tests were able to show good discrimination between the responses of these three materials in the fitted load scanning tests.

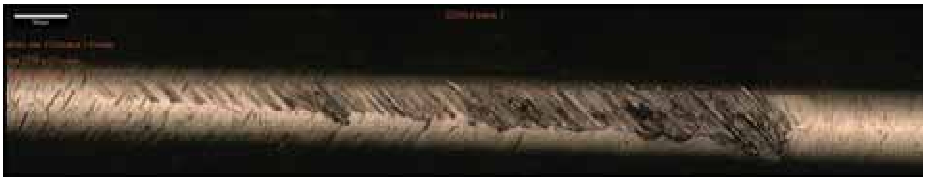
In a new extension to this testing, NPL carried out multiple repeat tests with the same samples. This showed that the damage to the materials built up as the number of repeats increased.

For further information on load scanning tests and related issues please contact Lindsay Chapman on 020 8943 6596/8652 or e-mail lindsay.chapman@npl.co.uk



Schematic of test geometry

Single pass test on 316L stainless sample



Five pass test on 316L stainless sample

NPL/TWI collaboration on coating adhesion assessment

Surface performance is critical to almost every engineering material, and the ability to apply a durable coating (functional and/or decorative) is a key requirement. NPL and TWI have teamed up to find out more about them.

The integrity of surface coatings is a major performance requirement as the cost of failure may be significant. Quality assurance of coated structures at the time of manufacture is critical to ensure that sub-standard components with a reduced lifetime are not put into service.

NPL, in collaboration with TWI, has just completed a major project to investigate techniques for the non-destructive evaluation (NDE) of coatings. Funded by the DTI, the 30 month project has concentrated on a range of functional engineering coatings produced by thermal spraying, plating, physical and chemical vapour deposition as well as paint systems for corrosion protection. These have been evaluated using over 10 different NDE methods including thermography, C-scan ultrasonics and laser shearography.

The wide range of coatings investigated has given diverse results leading to the principle conclusion that there is not one technique that can be universally applied to all possible coating types, a major factor being the thickness of the coating. Flash thermography has proved particularly useful in detecting areas of delamination on vapour deposited chromium nitride (5 microns) on steel, whilst terahertz pulsed imaging has been able to detect suspect areas on painted marine structures.

The key output of the project will be a Good Practice Guide which will assist end-users with this selection of the most appropriate NDE techniques for their particular surface coating. This guide will be made freely available via the Adhesives Toolkit at:

www.adhesivestoolkit.com

For further information on inspection of engineering coatings, contact Tony Maxwell on 020 8943 6454 or e-mail tony.maxwell@npl.co.uk

Do you measure up?

Have you made a significant contribution to the field of measurement in the last year? Would you like the opportunity to share your research successes with fellow colleagues? Have you submitted your nomination for the IET Measurement Prize 2007?

Sponsored by NPL, this prestigious award is given for an outstanding contribution to the science, art or practice of measurement using electrical, electronic or electromagnetic techniques.

The winner (either individuals or groups) will be awarded a £1,000 cash prize, a certificate of recognition and a medal, presented Wednesday 5 December 2007 at the IET Wheatstone Measurement Lecture.

Individuals or groups can nominate themselves. Alternatively, an organisation or those with knowledge in the subject area may nominate an individual or group.

The closing date for nominations is Friday 27 July 2007.

For nomination forms and further details visit www.theiet.org/measurementprize or contact

Naomi Bunn on 01438 765636 or nbunn@theiet.org

Introducing the new Thermal/Materials programme

The new Thermal/Materials programme has started at NPL. The programme combines four previous programmes into one. The objective of the programme is to promote innovation through improvements in measurement. Additionally it will support the measurement infrastructure of the UK.

An intensive consultation exercise was undertaken throughout 2006 and projects were created on the results of that consultation. The projects were ranked and winnowed by a combined working group (66% from the Materials sector, 33% with an interest in Thermal) to create a programme of over £15 m. Part of the selection was to ensure that the programme developed the metrology to support rapid development of new industries in the UK, and that it aligned with the government's technology strategy.

For further information on the new programme, please contact enquiry@npl.co.uk

Soft and hard option?

NPL has provided data and Finite Element Analysis (FEA) expertise to help Micro Materials Ltd develop confidence in the capability of its nano-impact module to test soft, ductile materials.

Micro Materials Ltd (MML) have identified a strong commercial need to develop testing procedures for soft, ductile materials for their NanoTest nano-impact module. These tests would be highly useful to the valuable polymeric materials and microelectronics markets.

In the past, nano-impact (repetitive high speed nano-indentation) has almost exclusively been used to test the fracture of hard materials. NanoTest is the only UK manufactured, nano-indentation equipment - but MML required modelling of the relationships between this test and properties measured at low strain rates for soft samples.

By taking advantage of the Measurements for Innovators (MfI) scheme, a DTI funded initiative for SME's, MML were able to consult NPL on the predicted impact response of ABS material as a function of rubber content. Due to NPL's previous underlying research in this area, it already possessed hardening curves over a range of strain rates and rate-dependence could be included in the analysis.

NPL were able to use a mesh developed for a previous DTI funded project, enabling rapid FE model generation. Three different elastic-plastic models were employed – von Mises, linear Drucker-Prager and the NPL cavitation model. Of these, the von Mises analyses worked well and the cavitation model looked promising. Results were obtained for force, velocity, depth as a function of time, and time in contact as a function of wt% rubber.

This work will enable MML to present NanoTest's capabilities to potential customers in the near future. MML also hope to publish a technical note on the research during 2007.

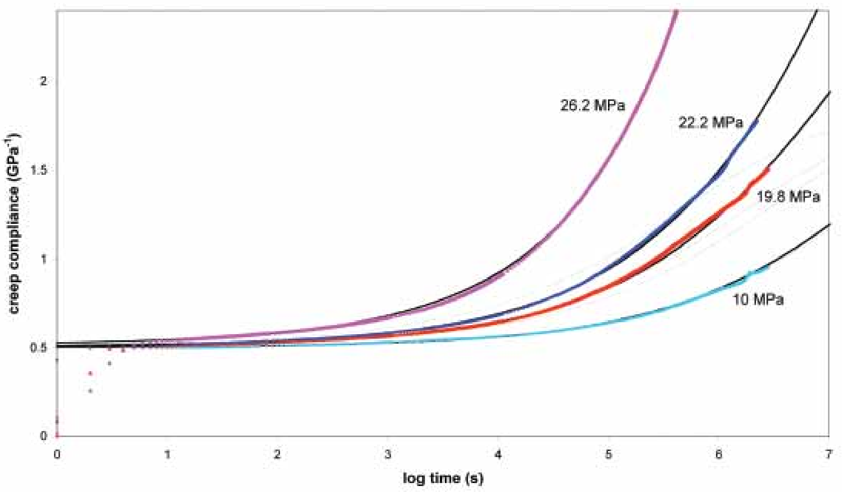
For further information on NPL's FEA modelling capability contact Louise Crocker on 020 8943 6798 or e-mail louise.crocker@npl.co.uk

For further information on NanoTest, please contact Dr Ben Beake on 01978 261 615 or e-mail ben@micromaterials.co.uk

For further information on MfI support please contact the NPL Helpline on 020 8943 6880 or enquiry@npl.co.uk

Creep modelling of adhesives

Any adhesive joint under a long-term load of constant magnitude is liable to undergo deformation and failure. NPL is developing improved models for determining this creep behaviour of structural adhesives.



Increase in tensile compliance with time during creep tests at different stress levels on the epoxy adhesive that has been stored under ambient humidity. Continuous lines = model with two relaxation processes. Broken lines = calculated contributions from the short-time process.

The results of creep testing have shown that adhesives which have been stored under ambient conditions generally exhibit significantly higher creep rates than dry material.

A new model developed at NPL describes the creep behaviour of a structural adhesive, with absorbed water, in terms of two overlapping relaxation processes, such that the contribution from the short-term process is sensitive to the concentration of absorbed water. Creep results for the dry material have also been analysed using this two-process model with a smaller contribution from the short-term process, and this has produced a better description of behaviour, at high stresses and for long times, than that obtained with the function which models only a single process.

The model has recently been extended to polypropylene, and takes into account the effects of physical ageing, a time-dependent process.

For further information on creep modelling and related issues on mechanical behaviour of polymers contact Greg Dean on 020 8943 6779 or e-mail greg.dean@npl.co.uk

Keeping a clean sheet

Modelling a scientific theory; calculating the profit and loss of the company; designing a new product; analysis of any set of numbers; project planning - all these activities are very different, but they all, at some point in the process, can involve the use of a spreadsheet.

The final numbers will be extracted and will assumed to be correct. But what if there's an error? Unlikely? In fact errors in spreadsheets are both common and difficult to detect. Even when the spreadsheets are checked, detection rates are normally only about 60%. The errors are not picked up, and that can have dire consequences. For example a financial services company made an error in reported unrealised gains of $1.2bn due to spreadsheet errors.

In addition to human error, many widely used spreadsheets have inherent errors built in which can result in strange computation outcomes. NPL has many years of experience of using and developing spreadsheet applications in a scientific arena. Good Practice Guides are available, and NPL runs training courses for engineers and scientists on how to get the best from using spreadsheets. The next course will be run in November 2007 and further courses will be arranged depending on demand.

For further information on the course, please visit www.npl.co.uk/training/ under Mathematics & Scientific Computing.

For further information on human and spreadsheet errors, please visit Ray Panko's website panko.cba.hawaii.edu/ or the European Spreadsheet Risks Interest Group at www.eusprig.org/

Good Practice Guide No. 7, 'Development and Testing of Spreadsheet Applications' is available from NPL www.npl.co.uk/ssfm or e-mail ssfm@npl.co.uk

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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Helpline: 020 8943 6880 | **Fax:** 020 8943 6458 | **E-mail:** enquiry@npl.co.uk

Forthcoming events

Innovation in the modern built environment

28 June 2007

NPL, Teddington

www.npl.co.uk/tman/

Form metrology in the process loop

28 June 2007

Cardiff University, Cardiff

DMAC session at Lamdamap Conference

www.npl.co.uk/eman/meetings/index.html

NPL Training level 1 course: Dimensional

2-5 July and 10-13 Sept 2007

Contact: m.connors@cad.coventry.ac.uk or t.toman@cad.coventry.ac.uk

www.npl.co.uk/training/industry/tech_content.html

Thermography & thermal imaging measurement: mapping the future

5 July 2007

NPL, Teddington

www.npl.co.uk/tman/

Online interactive meeting featuring an introduction to and update on the safenano project

6 July 2007

To join this online meeting, log on to the MSET KTN site and click ‘Conference Centre’, then ‘Join Meeting’ for the event you wish to join. You must be a member of a KTN to join this meeting. If you are not in a KTN, or in a KTN other than the MSET KTN, you can register when first prompted. Log in at:

http://mset.globalwatchonline.com

If this is your first Interwise meeting, arrive 15 minutes early and select ‘Getting Ready’ from the conference centre first.

Thermodynamic calculations for materials

10 July 2007 (10 am)

Alan Dinsdale & Hugh Davies

NPL, Teddington

Contact: martin.rides@npl.co.uk

Thermodynamic and transport models for multiphysics applications

24 July 2007 (10 am)

Simon Roberts and Jim Robinson

NPL, Teddington

Contact: martin.rides@npl.co.uk

In-process measurement on a machine tool - fact or fiction?

25 July 2007

Hexagon Metrology, Telford

(EMAN- DMAC meeting)

www.npl.co.uk/eman/meetings/index.html

Millimetre-wave users group meeting

1 August 2007

NPL, Teddington

A Millimetre-Wave Users Group has been set up recently for people and organisations interested in the mm- and sub-mm-wave bands of the electromagnetic spectrum, i.e. typically from 50 GHz to 500 GHz and perhaps beyond.

Contact: gill.roe@npl.co.uk

Structured surfaces - applications & control

11 September 2007

Cranfield University

(EMAN - DMAC meeting)

www.npl.co.uk/eman/meetings/index.html

Eman uncertainties seminar @ instrumentation south

4 October 2007

Madjeski Stadium, Reading

In these drop-in presentations NPL experts will introduce the principles behind uncertainty calculations, the common pitfalls and worked examples in relevant technical areas such as pressure and force.

www.instrumentation.co.uk/default.htm

Laser safety standard workshop

30 October 2007

NPL, Teddington

The workshop will instruct in safe working practices for users of lasers and light emitting diodes (LEDs) and is aimed at scientists and engineers using lasers in the laboratory and in industry.

www.npl.co.uk/photonics/training/laser_safety.html

Electrical laboratories day

28 November 2007

NPL, Teddington

NPL is proud to be hosting an event in partnership with UKAS, the UK Accreditation Service. This day will discuss the benefits of accreditation and traceability of measurements in the Electrical area.

Contact: katherine.robinson@npl.co.uk

ELECTROMAGNETICS DAY

29 November 2007

NPL, Teddington

A three track event with six specialist sessions - the themes of these sessions are: DC & Low Frequency, SAR, Communications technology, Digital Signal Processing, CISPR standards, RF& MW Traceability.

Contact: nancy.moore@npl.co.uk