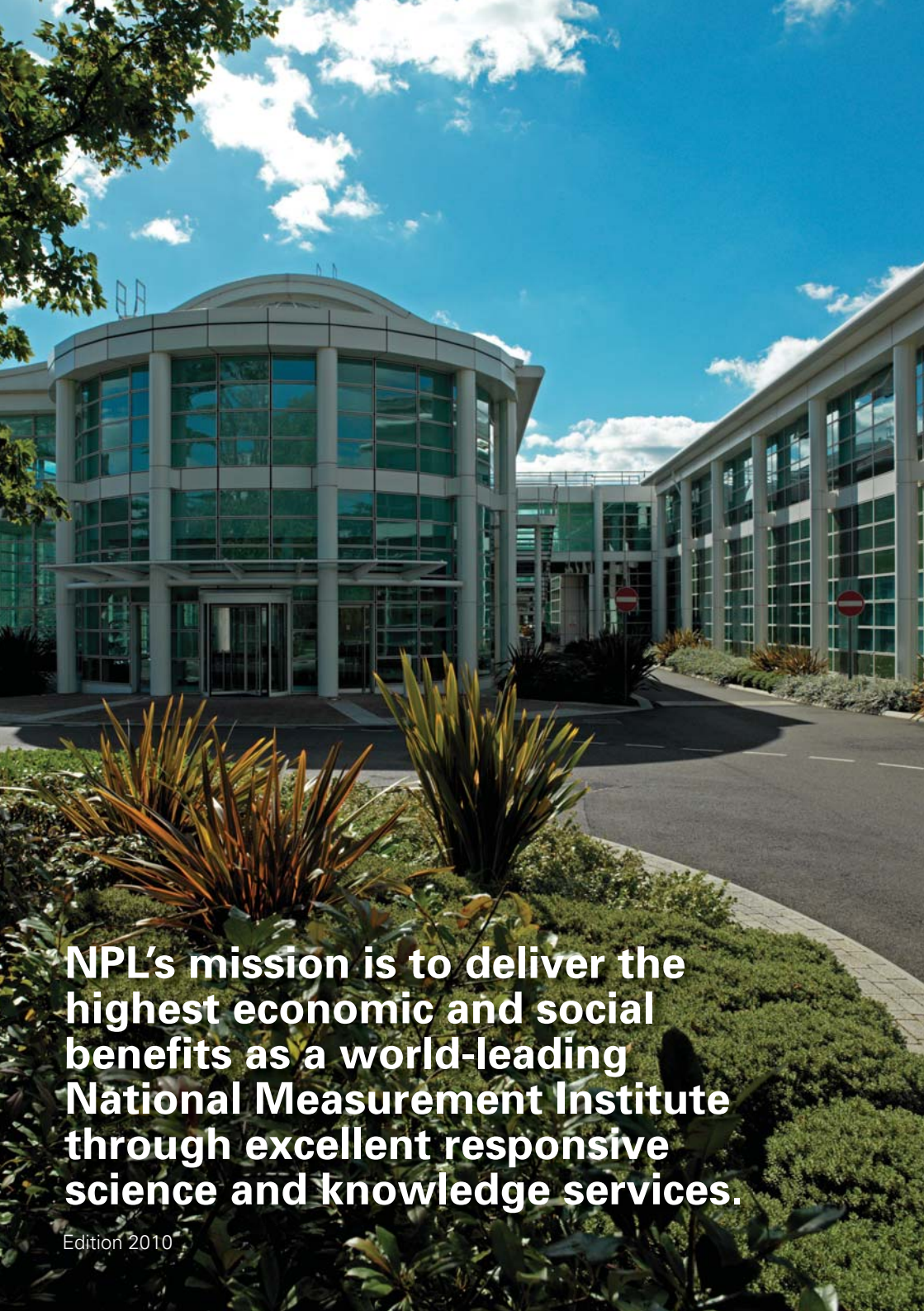




Micro & Nanotechnology Measurement Services

Details of the measurement and
testing services provided by the
National Physical Laboratory

Issue 2



NPL's mission is to deliver the highest economic and social benefits as a world-leading National Measurement Institute through excellent responsive science and knowledge services.

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Introducing NPL

Setting the standard

The National Physical Laboratory is a world-leading centre for the development of measurement related standards, technology and best practice. Quality of measurement is disseminated to our customers through a variety of means including collaborative research and development, technology transfer, licensing of intellectual property, various forms of consultancy, knowledge networking and through the provision of measurement services. Our capabilities underpin the UK National Measurement System (NMS), ensuring consistency and traceability of measurements in support of UK and overseas customer interests throughout the world.

Delivering service excellence

NPL's reputation relies on the quality of support we provide, both directly and indirectly, to hundreds of thousands of users worldwide for whom maintaining traceable and fit-for-purpose measurement is vital to their business. Our commitment to scientific excellence is coupled with a determination to offer high quality and affordable measurement services that are of the greatest possible technical and commercial benefit to our customers.

Services delivery options:

Calibration, testing and analysis of customer instruments and artefacts at our laboratories in Teddington is just one of the many ways we can deliver measurement service support to your business. In recent years, customers have also benefited from the following alternatives:

- On-site services provided on a one-off or campaign basis, whether in support of inventories of equipment and instrumentation or to solve specific measurement related problems requiring innovative or bespoke solutions.
- The provision of expert manpower support on a visiting or permanent on-site basis if long term support to measurement-critical operations is required.
- Delivery of measurement infrastructure management and maintenance: our work for DEFRA on managing the national Air Quality Network is a good example of this way of working.
- The establishment of 'bedded' out laboratory based measurement capability where a long term on-site presence, working alongside the customer organisation is desirable.
- Independent Product Assessments - NPL can reduce the risk of buying expensive equipment that may not be fit for purpose by providing a thorough pre-service evaluation of new and novel instruments before the final purchasing decision is made.

Calibration, measurement and testing services

NPL continually strives to make its science and technology as valuable, relevant and accessible as possible to our customers. This guide summarises the range of Micro & Nanotechnology measurement services offered, together with the relevant points of contact who will help you select and specify the services you need, provide quotations and ensure you receive the very best levels of technical and customer service available.

Working with NPL

We actively encourage our customers to work with us to determine the most suitable means of doing business with NPL. Options include:

- Ad hoc or single orders for customers requiring irregular support. Our Customer Services Executives (CSEs) will help you define your support needs and provide 'immediate response' quotations for particularly urgent jobs.
- Call-off contracts designed to minimise the cost and time spent in managing and processing orders and generating invoices and customer reports. Often the agreement of a pre-authorised 'Limit of Liability' is used to enable customers to place orders quickly and effectively.
- For larger scale or longer term support arrangements, the agreement of a tailored Service Level Agreement (SLA) may offer particular support benefits. Customer-specific service levels can be agreed based upon simple Key Performance Indicators (KPIs).

Scheduling and batching of work:

NPL works with its customers to ensure that the timing of the work carried out is optimised to the needs of the customer's business. Due to the extremely wide range of measurement capabilities at NPL, we encourage our customers to work with us to define the most suitable date for releasing their equipment or standards into the laboratory as it helps minimise equipment downtime. By batching similar items into the same time slot, customers are able to enjoy very rapid turn round times at significantly discounted prices. Conversely, high priority, urgent requests for Micro & Nanotechnology Measurement Services of all types can be accommodated if required. NPL is able to arrange collection and delivery of equipment to and from our customers' sites. This is particularly beneficial when high value, perhaps fragile, equipment needs to be transported across national boundaries. Our CSEs will be happy to discuss these and any other special support arrangements with you. Most of our commonly used Micro & Nanotechnology services and capabilities are listed in this booklet. However, additional services or solutions are available on request and these can be discussed by contacting our Customer Service Executives.

Contacting NPL

Our team of Customer Services Executives (CSE) provides customers with a single contact point for doing business with NPL. Please contact the CSE at the telephone number or e-mail listed on the relevant page of this brochure for information relating to quotations, placing orders, scheduling of work and progressing orders.

The CSE will be also able to arrange contact with the laboratory expert in the relevant area.

For detailed technical issues or if you need to discuss highly complex technical problems or requirements, please contact the laboratory expert in the relevant area. For more general enquiries where it is not clear who best to contact, we provide a Helpline that acts as a gateway to the business, particularly for customers new to NPL.

For all general enquiries please contact:

Helpline: **+44 20 8943 7070**

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Bio-Molecular Characterisation

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Loading of an ELISA plate for detection of specific cardiac biomarkers

The NPL's bio-analytical group brings together experienced, research orientated staff with an impressive range of instrumentation and facilities that allows us to support companies working in the drug development, manufacturing and bio-diagnostics sectors. NPL offers many contract analysis and research services focusing on the structure, activity and physical properties of biotherapeutic products, biomarkers and diagnostic assay components.

Service	Instrument used	Application
<p>Circular Dichroism (CD) NPL's leading position in international pilot studies looking at the precision and accuracy of measurements and data analysis underpins its expertise in this area of spectroscopy.</p>	<p>Jasco J-810 Spectropolarimeter</p>	<p>Measurement of the protein structure including secondary structure (far UV region) and tertiary structure (near UV region), measurement of protein-ligand interactions.</p>
<p>Dynamic Light Scattering (DLS) Cross correlation with other sizing techniques. Expertise in the measurement of nanoparticle and protein systems. Flow mode system similar to SEC-MALS.</p>	<p>Malvern Zetasizer Nano ZS/auto titrator accessory/ flow cell for linking HPLC</p>	<p>Measurement of mean size and polydispersity (size range 1 nm to 6 µm), size distribution, measurement of weakly scattering samples (e.g. low concentration protein samples). Absolute sizing of proteins using SEC-DLS flow mode set up.</p>
<p>ELISA Category 2 safety level laboratory in which we routinely analyse blood, serum and plasma samples.</p>	<p>Victor 3 multi label plate reader</p>	<p>Immuno assay development and validation using multiple detection methods:</p> <ul style="list-style-type: none"> • Absorbance • Fluorescence • Chemilluminescence • Electrochemistry • SERS
<p>Fluorescence Spectroscopy A highly sensitive optical technique for the detection and characterisation of biomolecules and their dynamic processes such as folding and binding.</p>	<p>Perkin Elmer LS 55 Luminescence Spectrometer. Filters for generation of polarised incident light.</p>	<p>Measurement of tertiary structure changes, measurements of biomolecular interactions using fluorescence anisotropy. Intrinsic fluorescence, fluorescence-quenching studies with different quenchers, dye binding (i.e. ANS)</p>

Service	Instrument used	Application
<p>FTIR</p> <p>Facilitates the structural analysis of proteins in different chemical environments, which makes it a valuable tool for the biotechnology and pharmaceutical industry. Measurement reliability and robust data analysis methods.</p>	<p>Bruker Tensor 27 with BioATRcell II accessory. ATR accessory specially designed for protein solutions and powders - enable the analysis of proteins in formulation buffer as well as in powder form.</p>	<p>Measurement of secondary structure of proteins in powder and solution formulations. Complementary to CD Measurement of protein flexibility using hydrogen/deuterium exchange. This technique can be utilised to analyse the structure of protein therapeutics at higher concentrations than CD.</p>
<p>Isothermal Titration Calorimetry (ITC)</p> <p>Complete thermodynamic characterisation of binding interactions under true in-solution and label free conditions.</p>	<p>MicroCal VP-ITC</p>	<p>Measurement of the binding affinity of a given biomolecular interaction and determination of the enthalpy (ΔH), entropy (ΔS) of binding and the stoichiometry of the interaction.</p>
<p>MALDI-TOF/TOF</p> <p>Molecules are ionised and resolved according to their mass-to-charge ratio (m/z), providing information on the relative abundance of each ionic species present. For large and structurally complex biological molecules, mass spectrometry.</p>	<p>Bruker Autoflex II</p>	<p>Measurement of intact protein mass or detection of peptide fragments to identify the amino acid sequence (primary structure). Measurement of structural modifications: identities and sites of post-translational modifications.</p>
<p>Electrospray Ionisation (ESI) Mass Spectrometry</p> <p>Mass spectrometry technique where the sample is dispersed and ionised by electrospray into a fine aerosol. This ionisation approach lends itself to the ionisation of macromolecules such as proteins without causing fragmentation. It can also be easily coupled to a liquid chromatography system for rapid analysis of column separated fractions.</p>	<p>Applied Biosystems Qstar Elite ESI Mass Spectrometer</p>	<p>Sensitive protein, peptide and metabolite coverage, by direct infusion or after chromatographic separation.</p>

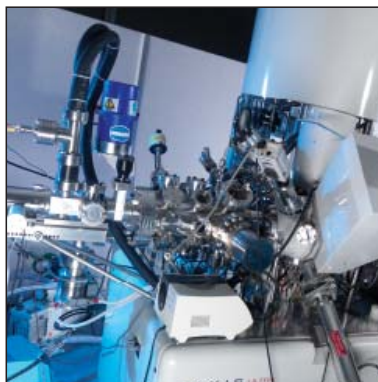
Service	Instrument used	Application
<p>Surface Plasmon Resonance (SPR)</p> <p>Services focussed on analysis and assay development. Technique can be used for rapid, real-time, label free analysis of biomolecular interactions providing information on the interaction specificity, on and off rates (kinetics) and binding strength (affinity).</p>	<p>Biacore T100. This is the market leading instrument.</p>	<p>Measurement of biomolecular interactions, measurement of binding kinetics, measurement of binding thermodynamics, epitope mapping of antibody libraries, measurement of active protein concentration.</p>
<p>UV-Vis Spectrometry</p> <p>Ultraviolet-visible spectroscopy measures the absorption of light in the visible and UV regions by macromolecules.</p>	<p>Perkin Elmer Lambda 850 UV/Vis Spectrometer with multi cell holder and water bath temperature control accessories.</p>	<p>Measurement of protein concentration, measurement of protein purity, measurement of protein specific conformation changes.</p>
<p>Zeta Potential</p> <p>Measurements on nanoparticle dispersions in aqueous and biological media, proteins and other biological molecules.</p>	<p>Malvern Zetasizer Nano ZS / auto-titrator accessory</p>	<p>Measurement of aqueous based colloid stability. Screening of ideal formulation conditions for particle suspensions and protein solutions. Measurement of protein pI and isoelectric point of colloid systems.</p>
<p>Raman Spectrometry</p>	<p>Renishaw Raman Microscope</p>	<p>Spectroscopic analysis of materials and molecules including nanoparticles, polymers and proteins. The microscope function allows mapping of certain samples.</p>

Surface Chemical Analysis

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NPL's X-ray Photoelectron Spectroscopy

The chemical composition of structures, particles and other objects on the micro and nanoscale is often the main factor affecting their performance. Surface chemistry is of particular importance as it is at this interface that interactions with the local environment occur. Powerful surface analysis techniques are essential for the understanding and characterisation of surfaces used in today's high technology and innovative industries. NPL has one of the world's leading surface analysis groups and we are able to offer cost effective solutions to a wide range of problems in areas such as aerospace, chemicals, pharmaceuticals, health, personal care, packaging, electronics, IT equipment, polymers, sensors, transport, biofilms and nanoparticles using the latest instrumentation. NPL's expertise is based upon the underpinning scientific research we perform in the fields of innovation, trade, industrial competitiveness and quality of life.

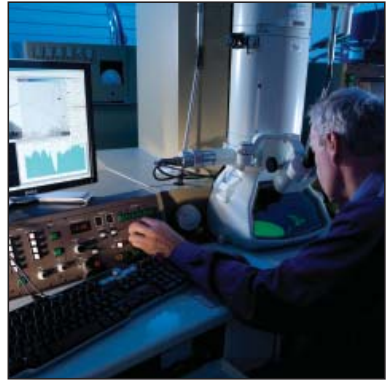
Service	Instrument used	Application
<p>Desorption Electrospray Ionisation (DESI)</p> <p>High mass resolution and imaging capability. An ambient surface mass spectrometry technique capable of analysing and identifying a wide range of molecules direct from all types of surfaces, e.g. textiles, hair, skin, tissue, plastics and glass, under ambient conditions.</p>	<p>Adaptation of a ABI Qstar MS/MS</p>	<p>Measurement of surface adsorbed materials, lateral imaging of surface (200 μm resolution) in ambient atmosphere.</p>
<p>Secondary Ion Mass Spectrometry (SIMS, GSIMS, Cluster SIMS, Multivariate Analysis)</p> <p>State of the art primary ion beams including new Bi/ Mn 'G-tip' and a high energy (120 keV) C60 source. Better than 2 % repeatability.</p>	<p>IONTOF TOFSIMS IV</p>	<p>Detailed chemical analysis of surfaces better than 1 ppm sensitivity for some molecules, spatial resolution of 200 nm and depth resolution of 1 nm.</p>
<p>X-ray Photoelectron Spectroscopy</p> <p>Traceable chemical analysis.</p>	<p>Kratos Axis Ultra</p>	<p>XPS, Auger electron spectroscopy, UV-photoelectron spectroscopy. Measurement of chemical composition, imaging and chemical state information.</p>
<p>Nanoscale Raman Spectroscopy</p> <p>Tip Enhanced Raman Spectrometry at spatial resolutions of up to 30 nm.</p>	<p>Leading-edge, custom designed and built instrument.</p>	<p>Nanoscale resolution Raman Spectroscopy measurements of thin films, nanoparticles and carbon nanotubes.</p>
<p>Scanning Ion Conductance Microscopy (SICM)</p> <p>Unique measurement capability on soft surfaces in liquid.</p>	<p>Ionscope</p>	<p>Measurement of topography of soft surfaces in liquid environment. Nanoscale electrochemical characterisation of surfaces and biological samples in liquids.</p>

Electron Microscopy

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Transmission Electron Microscope

Electron microscopy uses a beam of highly energetic electrons to analyse objects on the micro and nanoscale. The optimum resolution of a microscopic technique is limited by the wavelength of the radiation used. The wavelength of light is approximately 600 nm, whereas that of electrons is 6 pm, which increases the overall resolution by 100 000.

This technique can provide data on the topography, morphology, composition, and crystallographic signature of the material, and is a powerful tool in material characterisation. NPL has world-class facilities in both scanning electron microscopy (SEM) and transmission electron microscopy (TEM). NPL can also calibrate grids used for SEM calibration.

Service	Instrument used	Application
<p>Scanning Electron Microscopy</p> <p>High resolution imaging of surfaces using a variety of detectors. Electron Back Scattered Diffraction (mapping of crystal structure and grain orientation with resolution down to 10 nm), EDX (chemical analysis) with resolution down to 0.5 μm; STEM detector for thin films and nanoparticles; imaging resolution of 1.5 nm.</p>	<p>Carl Zeiss Supra 40</p>	<p>Quality control, imaging of 50+ nm objects, mapping of powder based materials. High resolution imaging, microstructural analysis, crystallographic orientation and texture measurement, local chemical analysis, nanoparticle sizing, 3D imaging for topographical information.</p>
<p>Transmission Electron Microscopy</p> <p>Imaging of thin specimens at high resolution. Up to and including the resolution of the lattice structure in crystalline specimens (sub nm resolution). Electron energy loss spectroscopy (EELS) provides quantitative elemental analysis and chemical mapping (10 nm resolution) on suitable specimens. Expertise on nanoparticles and tubes.</p>	<p>JEOL 2000FX with high resolution digital camera and Gatan energy filtering system.</p>	<p>Measurement of nanoparticles, nanotubes, other samples.</p>
<p>Calibration of SEM Gratings by Optical Diffractometry</p> <p>Expertise, calibration of pitch standards.</p>	<p>Optical Diffractometer</p>	<p>Calibration of gratings standards for SEM. Optical diffractometry can be used to calibrate one dimensional and two dimensional pitch standards with periods in the range 290 nm to 50 μm.</p>

Optical Microscopy

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Research Optical Microscope

Optical microscopy provides important information on the structure and makeup of materials and micro devices. NPL has a range of modern optical microscopes that provide high quality digital images. A comprehensive range of imaging techniques are available. Image analysis can also provide measurements of the size of features including the depth and volume of wear scars and similar structures.

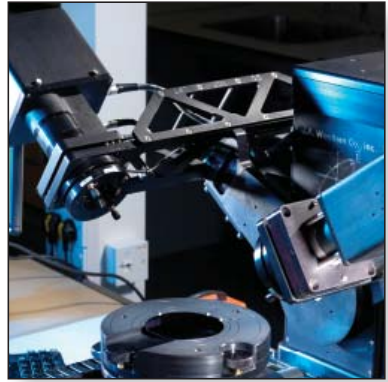
Service	Instrument used	Application
<p>Confocal Microscopy High resolution images, depth and volume of surface features.</p>	Olympus Lext	High quality optical micrographs and 3D imaging of material surfaces, measurements of the depth and volume of surface features such as wear scars, scratches and indentations. Particularly suited to transparent or highly reflective material surfaces. Depth resolution to 10 nm.
<p>Focus Variation Microscopy High resolution images, depth and volume of surface features.</p>	Alicon Infinite Focus Microscope	High quality optical micrographs and 3D imaging of material surfaces, measurements of the depth and volume of surface features such as wear scars and fracture analysis. Capable of lateral imaging over several centimetres with a depth resolution down to 10 nm.
<p>Image Analysis Measurement of microstructural features from images obtained from optical and scanning electron microscopes.</p>	Leica DMXRE research microscope with comprehensive range of imaging techniques. Nikon MM60 measuring microscope. Kontron KS400 software.	Traceable measurement of microstructural features, grain size measurement, corrosion depth, inclusion measurement. Resolution to 0.5 μm for optical images and to 3 nm for SEM images.

Thin Films

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*Variable Angle Spectroscopic
Ellipsometer*

Thin films are important in many industries to provide, electronic, optical and barrier properties. The development of films through oxidative, electrochemical and biofouling processes are also of interest in terms of the performance of materials. It is often of critical importance to determine the thickness of such films and to obtain diagnostic information on the optical properties, from which other behaviour, such as electrical conductivity, can be derived. By measuring the change in polarisation of light after reflection from the surface, spectroscopic ellipsometry is able to provide both sets of information. At NPL detailed chemical characterisation of thin films can be performed using Raman spectroscopy.

Service	Instrument used	Application
<p>Variable Angle Spectroscopic Ellipsometry</p> <p>Variable angle ellipsometric measurement facility and a spectral range from 193 nm to 1700 nm.</p>	<p>J A Woolam Co.</p>	<p>Measurement of film thickness from sub-nanometer to 10 μm.</p>
<p>Raman Spectrometry</p> <p>Spatial resolution is set by the laser spot ~ a few micrometres. Two lasers 514 nm and 633 nm.</p>	<p>TERS (tip enhanced Raman Spectrometer) system</p>	<p>Powerful chemical fingerprinting method - not problematic with aqueous media.</p>
<p>Magnetic measurements</p> <p>Ultra-sensitive measurements of magnetic properties (SQUID magnetometry).</p>	<p>MPMS (Quantum Design)</p>	<p>The system is able to operate across a broad range of temperatures (1.7– 400 K), in the magnetic field up to 5 T and has the required magnetic sensitivity as small as 10^{-11} Am^2. It also provides operational versatility, allowing measurements of DC magnetization, AC susceptibility, Hall effect, magneto-resistance, etc.</p>

Surface Energy

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DSA-100 Contact Angle Analyser

The ability of a liquid to wet a surface is essential in many industrial areas, ranging from mature processes, such as printing and packaging to emerging technologies, such as biosensors and microfluidics. The ability of surfaces to resist wetting is important in advanced textiles and fluid handling, whilst good wetting is often required for products in the personal care and adhesive industries. Contact angle measurements directly assess the wettability of a surface with a given liquid and, by careful selection of the liquids, an estimate of the surface energy of the solid can be obtained. NPL has the capability to measure the contact angles of a number of different liquids on a solid surface using an automated dispenser to provide advancing, receding and static contact angles. A piezo head can be used to dispense picolitre water droplets to measure contact angles on single fibres, or to map changes in wettability across a surface.

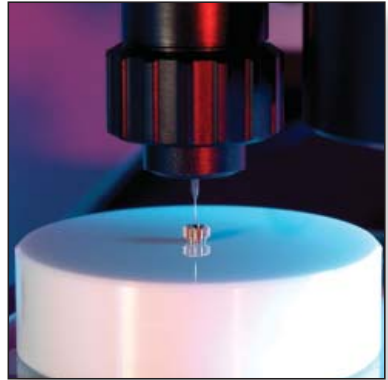
Service	Instrument used	Application
<p>Contact Angle Measurement</p> <p>Surface energies of liquids, contact angle of liquids on solids.</p>	<p>Kruss</p>	<p>Pendant drop shape, contact angles, micro-droplets, surface energy of solids, wetting, surface tension of liquid, mapping of surface wettability.</p>
<p>Drop Shape Analysis</p> <p>Use of micro-droplet allows efficient wettability mapping of the surface.</p>	<p>Kruss (DSA100)</p>	<p>Mapping of surface wettability, measurement of surface energy, measurement of surface tension.</p>

Geometry

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F25 Micro CMM Probe

NPL has increased its micro co-ordinate metrology capabilities in direct response to the extreme demands of quality assurance for the measurement of size, form and position of microsystem parts.

With the purchase of a Zeiss F25 micro CMM, NPL can now make highly accurate, three dimensional measurements of complex, precision-engineered components within a working volume of 100 mm x 100 mm x 100 mm. Such components include: micro electromechanical systems (MEMS), microfluidic devices and products from the semiconductor, medical, energy, automotive, aerospace and optical industries.

The new NPL-Mitutoyo high-precision Vision CMM delivered in 2009, significantly extends our measurement capabilities for supporting advanced micro- manufacture. The non-contact measurement technique offered by the Vision CMM is neither invasive nor destructive and particularly appropriate for complex 2D components, which are thin, soft, elastic and brittle. NPL offers a range of services devoted to supporting non-contact dimensional measurements including, custom chrome on glass microstructures and analysis of customer owned artefacts.

NPL can perform a wide range of measurement tasks on standard geometric forms, using a variety of measurement strategies.

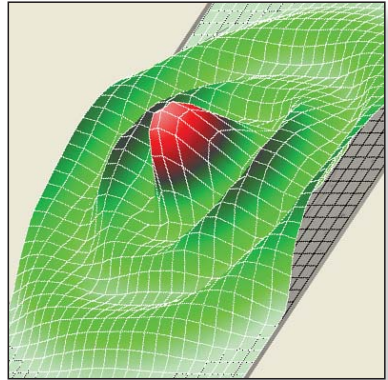
Service	Instrument used	Application
<p>Co-ordinate Metrology Access to complex, miniature parts, often high aspect ratio, high accuracy.</p>	<p>Zeiss F25 with contact and optical probes. A piezo-resistive silicon touch probe with precision tip is capable of achieving a measurement uncertainty of 250 nm at a resolution of 7.5 nm. The F25 can also make use of an integrated high quality Zeiss ViScan camera sensor and objective.</p>	<p>Measurement of millimetre sized objects and smaller, sidewall measurement.</p>
<p>Calibration of Linewidth, linescale and pattern (spot and square) standards, including stage micrometers and reference stage graticules.</p>	<p>NPL built traveling stage optical microscopes using precision positioning systems and laser interferometers provide traceable length measurement.</p>	<p>Provides traceability for magnification and image based length measurements in atomic force, optical and electron microscopes. Calibration uncertainties range from 0.05 μm to 0.5 μm (depending on scale type).</p>
<p>Calibration of 1-D and 2-D SEM/AFM grating standards with pitches between 0.29 μm and 50 μm.</p>	<p>Bespoke diffraction equipment incorporating a stabilised laser and calibrated angle table. Calibration uncertainties range from 0.06 nm to 100 nm, depending on grating pitch.</p>	<p>Provides traceability for high magnification electron microscopes and AFM imaging.</p>
<p>Vision CMM Measurement of complex, precisely fabricated items and materials such as automotive and aerospace components, printed circuit boards, microelectronic circuits and features that cannot be accessed by conventional contact type machines and gauges.</p>	<p>Mitutoyo high-precision Vision CMM</p>	<p>Supply and calibration of reference artefacts. Non-contact measurement of components using NPL's high precision X-Y vision measuring machines. Verification of 2D systems and machines.</p>

Materials Testing

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Modal analysis of a piezo MEMS device using NPL's Laser Doppler Vibrometer

NPL has invested in state of the art facilities for the characterisation of materials at the microscale to the nanoscale. The integration of new materials into MNT devices such as piezoelectrics have led to the development of a new range of measurement capabilities, many of which have been developed at NPL. From materials property evaluation at the macroscale to nanoscale probing using modified scanning probe microscopies, NPL is able to characterise your materials and microscale-structures from the viewpoint of mechanical, electrical, vibrational, and structural considerations using the techniques described in this section.

Service	Instrument used	Application
<p>Micro-scale Abrasion Test System Microscale abrasion</p>	Plint TE66	Wear, abrasion, coatings.
<p>Micro-tribology Test Systems Applied loads from 10 mN to 500 mN, measurement of friction, in-situ measurement in SEM.</p>	Unique NPL built facility	Friction, degradation under wear for coatings, surface engineering, MEMS devices.
<p>Interferometer Interferometer for very small dynamic displacements and vibration measurements of piezoelectric and multiferroic materials.</p>	Bespoke NPL equipment. World leading and unique (0.02 µm noise floor), to 1 MHz.	Novel miniaturised sensors and actuator characterisation. Materials development- assess intrinsic materials properties over the system (bending) performance.
<p>Laser Doppler Vibrometer Microscope vibrometer system for vibrational studies of MEMS devices. MEMS chamber for temperature control and humidity and vacuum control of environment.</p>	Polytec Micro Systems Analyser MSA-400 with NPL environmental chamber.	Mode shape testing of MEMS structures. MEMS actuators, sensors, piezoelectric and other functional material active systems.
<p>Instrumented Indentation Testing (IIT) Testing, expertise and specialised test methods.</p>	Nanoindenter II and NanoTest 600	Mechanical property determination of surfaces, interfaces and coatings (modulus, hardness, creep, relaxation, work of indentation, viscosity). Includes nanoimpact measurements for damage resistance determination.
<p>Surface Acoustic Wave Spectroscopy (SAWS)</p>	Alotech LaWave laser induced ultrasonic surface acoustic wave spectrometer.	Measurement of modulus, density or thickness of surfaces and coatings from few nanometres to ~ 50 µm thick.
<p>DataSure-IIT</p>	Certified Reference Material toolkit produced and calibrated at NPL.	ISO 14577 compliance. Validation and calibration of indenter area functions and instrument compliance.

Particle Analysis

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Monitoring Airborne Nanoparticle Size Distribution

Particles play an important part in both the environment and as essential constituents of many products. As technology advances new applications are being found which exploit the novel characteristics of particles that develop as the particle size shrinks to the nanoscale. As particles get smaller, measurement and characterisation of particle properties generally becomes more difficult, especially when the particles are suspended in a complex media. NPL is at the forefront of developing measurement techniques and instrumentation for the rapid, accurate analysis of engineered particles, environmental particles from natural and combustion sources and particles in biological media such as tissues and cells.

NPL can provide a range of standard analyses for particles within a wide variety of media. An expanding range of properties can be reliably determined for powders such as particle size, BET surface area analysis and surface chemistry. Suspensions of particles in various liquid media can also be characterised for particle size and other characteristics such as zeta potential. For both powders and suspensions NPL has a wide portfolio of standard imaging capabilities such as SEM, TEM, AFM and confocal microscopy. NPL is also developing powerful new spectroscopic imaging techniques along with other characterisation methods, which can be used as part of a bespoke research project or custom consultancy.

Service	Instrument used	Application
<p>Aerosol Particle Sizing</p> <p>Traceable measurements of aerosolised nanoparticles.</p>	<p>Differential mobility spectrometers providing a size coverage from 1 nm to 2.5 µm.</p>	<p>Environmental and workplace monitoring. Vehicle emission testing and research. Laboratory characterisation of nanoparticle samples from solid or liquid suspension.</p>
<p>BET (Particle Surface Area)</p> <p>Research instrumentation - comparison to other methods.</p>	<p>Quantachrome Autosorb for BET surface area, porosity and related measurements.</p>	<p>Surface characterisation of bulk powder samples with particle sizes down to the nanoscale.</p>
<p>Airborne Nanoparticle Counting</p> <p>Only traceable calibration service for Condensation Particle Counters (CPCs) in the world to date</p>	<p>Comparison of CPCs to NPL reference aerosol electrometer using an application-matched test aerosol.</p>	<p>Environmental and workplace monitoring. Vehicle emission testing and research. Instrument development.</p>
<p>Dynamic Light Scattering (DLS)</p> <p>Measurement of size of Micro and Nanoparticles in suspension.</p>	<p>Malvern Zetasizer Nano ZS / auto-titrator accessory</p>	<p>Measurement of the mean size, size distribution, agglomeration and particle dynamics for particles dispersed in liquids from pure water to complex biological media.</p>
<p>Disc Centrifuge</p> <p>Measurement of size distribution of Nanoparticulates in Suspension</p>	<p>CPS Instruments Disc Centrifuge DC20000</p>	<p>High resolution and high sensitivity measurement of particle size distributions. Offers significantly improved discrimination between different particle sizes compared to DLS based measurements.</p>
<p>Nanoparticle Tracking</p> <p>Allows the size measurement of individual nanoparticles suspended in a liquid medium via the analysis of the movement of its as detected by light scattering.</p>	<p>NanoSight LM-10</p>	<p>Mean size and distribution analysis of nanoparticle samples. The unique capability of this technique is that it can analyse agglomerated and polydisperse samples.</p>
<p>Zeta Potential</p> <p>Measurements on nanoparticle dispersions in aqueous and biological media, proteins and other biological molecules.</p>	<p>Malvern Zetasizer Nano ZS / auto-titrator accessory</p>	<p>Measurement of aqueous based colloid stability. Screening of ideal formulation conditions for particle suspensions and protein solutions. Measurement of protein pI and isoelectric point of colloid systems.</p>

Scanning Probe Microscopy

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*The NPL Metrological Atomic Force
Microscope*

Scanning probe microscopes (SPMs) are used widely in universities and industry to image and measure surface features and properties at the micrometre to sub-nanometre level. An ultra sharp tip on the end of a cantilever probes a surface and the force between the two is measured via the deflection of the cantilever enabling quantitative information to be obtained. Although having atomic resolution, these instruments can suffer from inherent non-linearity and as with any instrument should be calibrated before use. This is usually realised using transfer standards. NPL offers a service for calibrating suitable standards either with the NPL Metrological Atomic Force Microscope (MAFM) or optical diffractometry. This supports a range of measurements using a suite of scanning probe microscopes for different applications in ambient air (with variable temperature and humidity) or in ultra high vacuum (UHV). Some of the sample characteristics that can be studied using such methods include dimensional, mechanical, topographic, magnetic, electrical, thermal and adhesion strength.

Service	Instrument used	Application
<p>Metrological Atomic Force Microscopy</p> <p>Directly traceable dimensional measurements via laser interferometers.</p>	<p>The NPL built instrument for traceable AFM.</p>	<p>Traceable calibration of transfer artefacts for AFM, surface texture measurement and SEM.</p> <p>This is realised with the NPL built Metrological AFM that uses a high precision linear translation stage with 100 µm scan range in x and y for lateral scanning and three orthogonal differential optical interferometers for traceable measurement of tip movement when scanning a sample. Calibration of gratings with pitches in the range 100 nm to 10 µm and step height standards with steps up to 2.5 µm high.</p>
<p>Optical Calibration of Gratings</p> <p>Calibration of pitch standards for AFMs and SEMs.</p>	<p>Optical Diffractometer</p>	<p>Calibration of gratings standards for scanning electron microscopy (SEM) and atomic force microscopy (AFM). Optical diffractometry can be used to calibrate one dimensional and two dimensional pitch standards in the range 290 nm to 50 µm.</p>
<p>Certification of Indenter Area Function</p>	<p>Traceably calibrated Thermomicroscopes M5 AFM</p>	<p>Certify reference indenters for low uncertainty testing and indirect validation and calibration of instrumented indentation instruments. Uncertainty typically < 3 % (95 % confidence) for depths over 4 nm.</p>

Service	Instrument used	Application
<p>Atomic Force Microscope for Materials Properties</p> <p>Traceable measurements cantilever stiffness calibration with better than 5 % uncertainty.</p>	<p>Park XE-100 with all electrical and liquid modes, heating stages in air and liquid, environmental control.</p>	<p>Kelvin probe microscopy, current-AFM, scanning capacitance microscopy, spreading resistance microscopy, adhesion and chemical maps, nanolithography.</p>
<p>Analytical Atomic Force Microscopy</p> <p>State of the art equipment, calibration.</p>	<p>Asylum Research rk3 and Park Scientific (CP-II and CP-Autoprobe-with Hysitron nano-indentor).</p>	<p>Friction and chemical force measurements, rk3nanomechanics, stiffness measurement of polymer thin films, atomic force microscopy, dip pen nanolithography in air and liquid.</p>
<p>Piezoresponse Force Microscopy</p> <p>Special feature set up at NPL on Veeco D3000 system to characterise the piezoelectric response of ferroelectric and piezoelectric materials: bulk, thin films, patterned films.</p>	<p>Bespoke NPL equipment</p>	<p>Any material or device with piezo actuation or sensing components.</p>
<p>Scanning Ion Conductance Microscopy (SICM)</p> <p>Unique measurement capability on soft surfaces in liquid.</p>	<p>Ionscope</p>	<p>Measurement of topography of soft surfaces in liquid environment.</p>

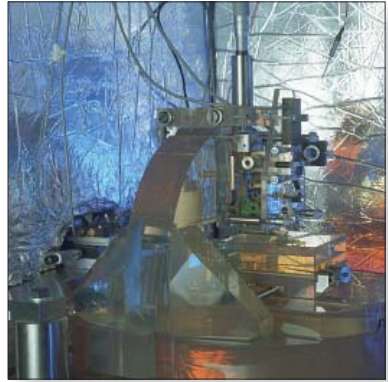
Service	Instrument used	Application
<p>UHV-Atomic Force Microscopy</p> <p>Unique in the UK: virtual temperature and magnetic field.</p>	<p>Ultra high vacuum AFM, variable temperature, independent electric and magnetic field (AC and DC), dual controller.</p>	<p>Advanced characterisation of nano-materials, Seebeck measurement on nanotubes, atomic resolution on flat surfaces, coupled transport in functional materials.</p>
<p>Magnetic Force Microscopy</p> <p>Imaging and measurements of the ferromagnetic samples (bulk, thin films, patterns).</p>	<p>MultiMode (Veeco)</p>	<p>Visualization of ferromagnetic domain pattern and stray magnetic fields.</p>

Surface Topography

Contact

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Profile Surface Texture Measuring Instrument

NPL provides a complete solution for all surface texture measurement requirements, including calibration of surface texture artefacts, and surface characterisation using both contact and non-contact measurement techniques. Surface texture plays a vital role in the functionality of a component. It is estimated that surface effects cause 10 % of manufactured parts to fail. The measurement of surface texture offers information to control production and can provide valuable functional information about a surface.

The continuous research work in this area carried out by NPL together with our involvement in the development and evolution of ISO standards in the field of surface texture metrology underpins our reputation as an authoritative source of advice and knowledge.

NPL offers a very high level of expertise and high quality services. We calibrate and provide surface texture calibration artefacts compliant to:

ISO 5436-1:2000 and ISO 5436-2:2001 Geometrical product specification (GPS)

Service	Instrument used	Application
<p>Coherence Scanning Interferometry</p> <p>Areal measurements, non-contact, high resolution, comprehensive analysis software.</p>	<p>Taylor Hobson Talysurf CCI</p>	<p>Surface topography of smooth surfaces, step heights.</p>
<p>Confocal and Variable Focus Instruments</p> <p>Areal measurements, range of equipment, non-contact, comprehensive analysis software.</p>	<p>Alicona Infinite Focus, Olympus LEXT</p>	<p>Measurement of engineered and structured surfaces, tribological measurements, materials analysis, volume analysis.</p>
<p>Stylus Instruments</p> <p>Directly traceable dimensional measurements, areal and profile measurements, range of equipment, comprehensive analysis software.</p>	<p>Profile (Talysurf, NanoSurf IV) and areal instruments (Mahr, NPL Areal Instrument)</p>	<p>Measurement of profile and areal transfer artefacts, measurement of engineered and structured surfaces.</p>

Other types of support offered by NPL:

Measurement Services represent just one way in which our customers can benefit from the wealth of scientific and technical resources at NPL. Other areas of support include:

- **Consultancy:** ranging from free advice over the telephone to fully or part-funded secondment of NPL experts into customer organisations
- **Sale of reference artefacts, samples and measuring equipment**
- **Licensing of our portfolio of technology Intellectual Property, developed over many years at NPL and now accessible under a variety of exploitation arrangements**
- **Facility Hire:** access to many of NPL's unique laboratory facilities on a pre-booked basis. Customers are able to operate these facilities under the impartial guidance of our technical experts
- **Training:** our established range of world-renowned measurement-related training products, delivered to meet the specific training and development needs of our customers
- **Network Management, including both knowledge network facilitation and measurement infrastructure management**
- **Modelling of all types, using a wide-range of state-of-the-art techniques and covering the entire breadth of NPL's science and technology base**
- **Measurements solutions:** the development and delivery of bespoke measurement techniques, practices and business solutions, especially at high levels of accuracy or for use in difficult or unusual environments
- **Test and measurement instrument design, development, application and impartial evaluation**
- **Independent measurement, testing and validation of software and systems**
- **Development of specialist mathematical software for measurement and instrumentation applications.**

General business enquiries concerning the above services should be referred to our dedicated Business Development team:

Defence, Security & Aerospace	Tim Prior:	+44 20 8943 6679
Defence & Security	Gareth Edwards	+44 20 8943 7046
Energy	Ray Chegwin	+44 20 8943 6375
Advanced Manufacturing – Materials	Matt Smith	+44 20 8943 7022
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Measurement Services	Andy Morris	+44 20 8943 8749
Training	Tom Ashby	+44 20 8943 8672
Knowledge Services	Francis Tuffy	+44 20 8943 8738

NPL's commitment to quality

As the national measurement standards laboratory in the UK, NPL offers services at the highest available levels of accuracy. Customers depend on these to achieve direct traceability to nationally and internationally accepted standards. These services are operated within the most stringent quality and procedural requirements. To demonstrate this formally, it is NPL's policy to seek accreditation, where feasible, for its measurement services.

ISO 9001

NPL's quality management system has been registered for scientific R & D and the provision of internal services by LRQA to ISO 9001:2000 and where appropriate in accordance with TickIT.



ISO 17025 and ISO Guide 34

Many of NPL's standard calibration, measurement and testing services have been accredited by UKAS. The accredited capability of those services may be found in calibration and testing schedules issued by UKAS.



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CIPM MRA

Many NPL certificates now display the CIPM MRA logo and statement, indicating the mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes.



Customer Satisfaction

At NPL we aspire to provide a world-class service to all of our customers. Your views on our performance are important to us. We would appreciate it if you would tell us how we are doing and suggest areas to us where we could improve our service to you. For more details please visit us at www.npl.co.uk/customer_satisfaction

Terms & Conditions of Business

For detailed information please refer to the Terms & Conditions page on our website:

www.npl.co.uk/terms_conditions

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Public Transport



By Rail,
Teddington Station
20 minutes walk to NPL.



By Air
Heathrow Airport

Bus 285 travels to Teddington and stops outside NPL. Bus X26 is faster and stops at Broad Street, a short walk from NPL. Or take a taxi, approximately 30 minutes to Teddington.



Buses.
Teddington is well served by buses from Heathrow, Kingston, Twickenham and Richmond (285, X26, 281, R68 and 33).



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