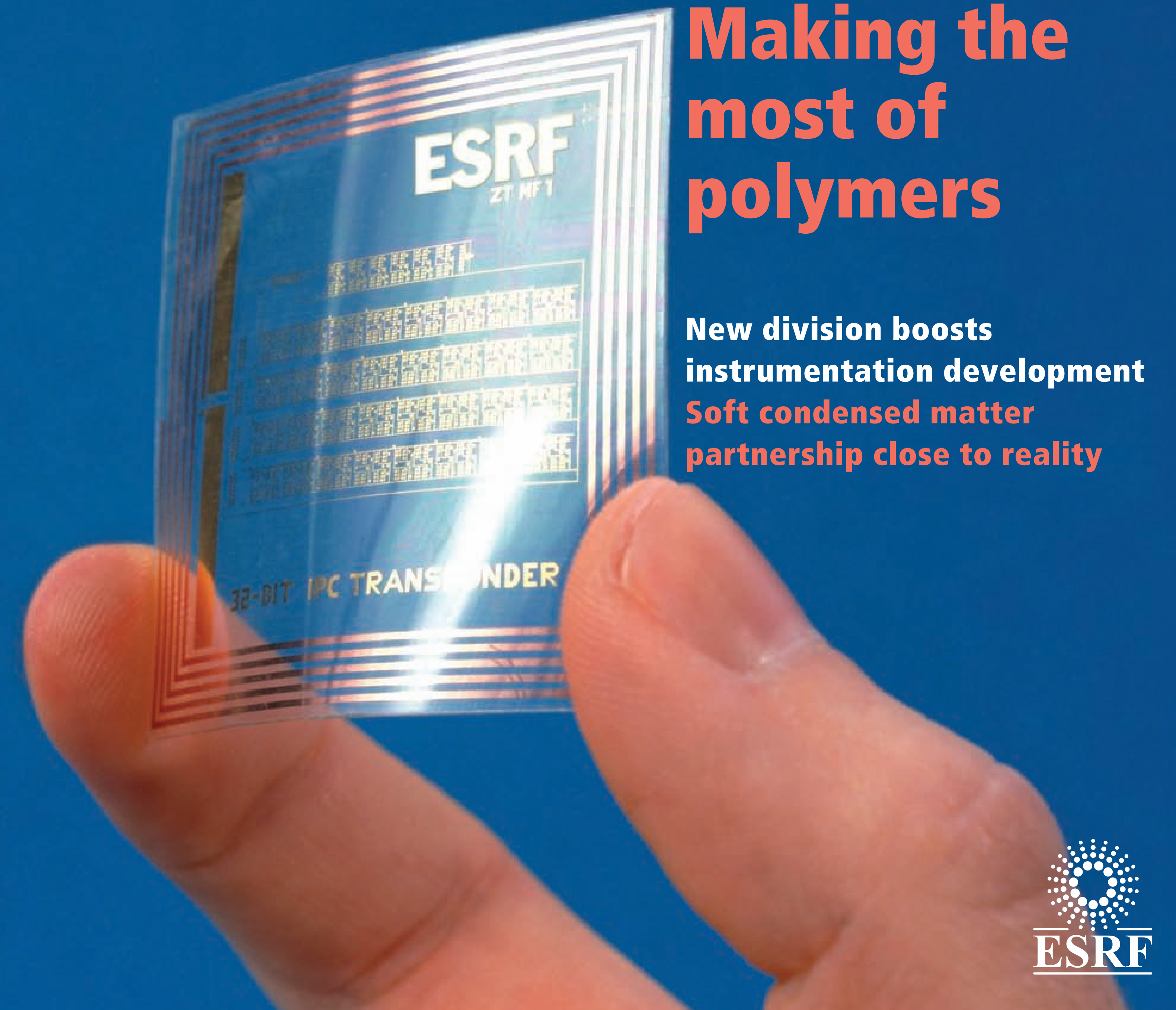
A LIGHT FOR SCIENCE

ESRF news

Number 50 June 2009



Making the most of polymers

New division boosts instrumentation development

Soft condensed matter partnership close to reality

ESRF

A light for science

Scientists monitor hydrogen bonds to make improvements to nylon. p9

Characterisation of composite materials takes place at the ESRF. p12

A step closer to the secrets of the most radiation-resistant bacteria. p15

On the cover: A polymer chip that could be used to identify merchandise or track products, in the same way that barcodes are used. Synthetic polymers are studied at the ESRF and are key in many technological developments.

VOLKER STEGER/SCIENCE PHOTO LIBRARY

ESRFnews Number 50 June 2009

Photonic Science

Affordable Turnkey X-ray Laue camera system replaces Polaroid film

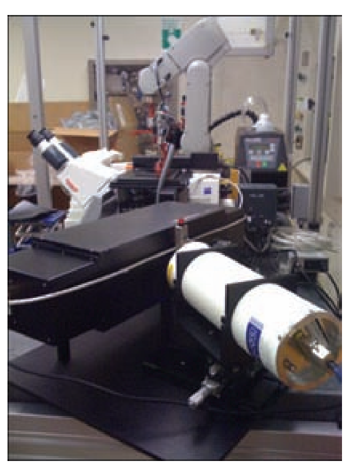
Digital Laue detectors – an alternative to high sensitivity films

for both laboratories and synchrotrons wishing to carry out systematic bulk crystal orientation and micro crystal characterisation.

The cameras allow unique back scattered geometry with collection time varying from near real time to a few minutes, depending on source, detector and crystal combination. Automated sample rotation, combined with shutterless acquisition brings simpler and more flexible data collection routines.

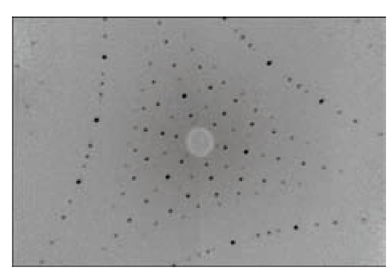
The acquisition software delivers ready to be indexed digital images from PC, to Linux remote controlled machines. Indexation of Laue patterns can be performed off line using dedicated software packages.

An existing Laue set up can be upgraded with turnkey solution including beam delivery: i.e. X-ray source, collimators, goniometer/sample holder up to system installation/integration. Very high resolution detectors allowing strain analysis studies are available on demand.



Microdiffraction installation with automatic sample changer

W111 pattern acquired with standard 04x08mm Cu source using 25kV, 25mA and 5 minutes exposure.



Images courtesy SPL, Netherlands

Daniel BRAU
Marketing Director – Photonic Science Limited
Tel: +33 (0) 4 76 93 57 20 Fax: +33 (0) 4 76 93 57 22
Email: Daniel@photonic-science.com
http://www.photonic-science.com

Advertising feature

ESRFnews

Editor
Montserrat Capellas Espuny
European Synchrotron Radiation Facility BP220
F-38043 Grenoble cedex
Tel +33 476 88 26 63
E-mail press@esrf.eu

Editorial committee
Nick Brookes
Dominique Cornuéjols
Pascal Elleaume
Axel Kaprolat
Sine Larsen
Joanne McCarthy
Sean McSweeney
Till Metzger
Manuel Rodríguez
Francesco Sette
Bill Stirling

With thanks for editorial advice for this issue
Wim Bras

Subscription
Chantal Argoud
To request a copy or make address changes, e-mail communication@esrf.eu.

ESRFnews is produced for the ESRF by
IOP Publishing
Dirac House
Temple Back
Bristol BS1 6BE, UK
Tel +44 (0)117 929 7481
www.iop.org

Publisher
Jo Nicholas
Art director
Andrew Giaquinto
Production
Alison Gardiner
Technical illustrator
Alison Tovey
Display-advertisement manager
Edward Jost
Advertisement production
Mark Trimnell
Marketing and Circulation
Anastasia Ireland

ISSN 1011-9310

The importance of studying polymers

When we think of polymers we tend to refer to water bottles or cheap packaging materials, such as polyethylene shopping bags. In fact, these materials are far more ubiquitous than most of us would imagine. Synthetic polymers can be found in food additives, composite materials, drug packaging, artificial organs and solar cells. However, way before man made the first synthetic polymer (Bakelite 1907), nature had already mastered this art. The natural polymer rubber was already being processed by ancient Mesoamerican societies by 1600 BC. And of course, biopolymers, such as DNA, actin, collagen and fibrin, play important roles in the body.

Aside from the widely used, cheap commodity polymers, there are more complicated and expensive plastics. For instance, technical polymers have been designed or processed with particular properties in mind, irrespective of their chemical composition. These include many familiar brand names such as the high-performance fibre Kevlar and the breathable membrane Gore-tex. Functional polymers, on the other hand, are usually selected based on specific chemical groups rather than physical properties. These tend to be exploited for novel optical and electronic applications, such as gas sensors.

Research into polymeric materials is carried out on many beamlines at the ESRF, whether this involves determining the structure of biopolymers or helping to improve synthetic polymers.To highlight some of this work, this issue of *ESRFnews* is dedicated to studies of synthetic polymers. You will find articles that address a range of different techniques used on a variety of beamlines – from ID2 and ID11 to ID13 and BM26 (DUBBLE). Results are presented on a diverse selection of materials, from commodity polymers, such as nylon (p9), to technical polymers in composite materials (pp12–13), as well as those that are designed to work in photovoltaic cells in the future (pp10–11).

“Research into polymeric materials is carried out on many beamlines at the ESRF”

The differences between synthetic and biological materials are fading rapidly because researchers have started to learn lessons from nature. As a result, many new materials are being synthesised from, or incorporate, natural building blocks, such as peptides. In addition, the creation of new nanomaterials, while based on synthetic materials, often involves self-assembly pathways that are inspired by nature.

You might get the impression that only novel plastics are interesting but that’s not the case. With better polymer processing methods come improvements to the material qualities of already widely used plastics. For example, a supermarket plastic bag, while much thinner today than it was 20 years ago, can be just as strong. This results in a reduction in oil consumption and less plastic ending up in landfills, while our eggs still make it back from the supermarket intact. For the time-resolved experiments that are necessary to understand how polymers behave under processing conditions, the well collimated and intense beams of storage rings are indispensable.

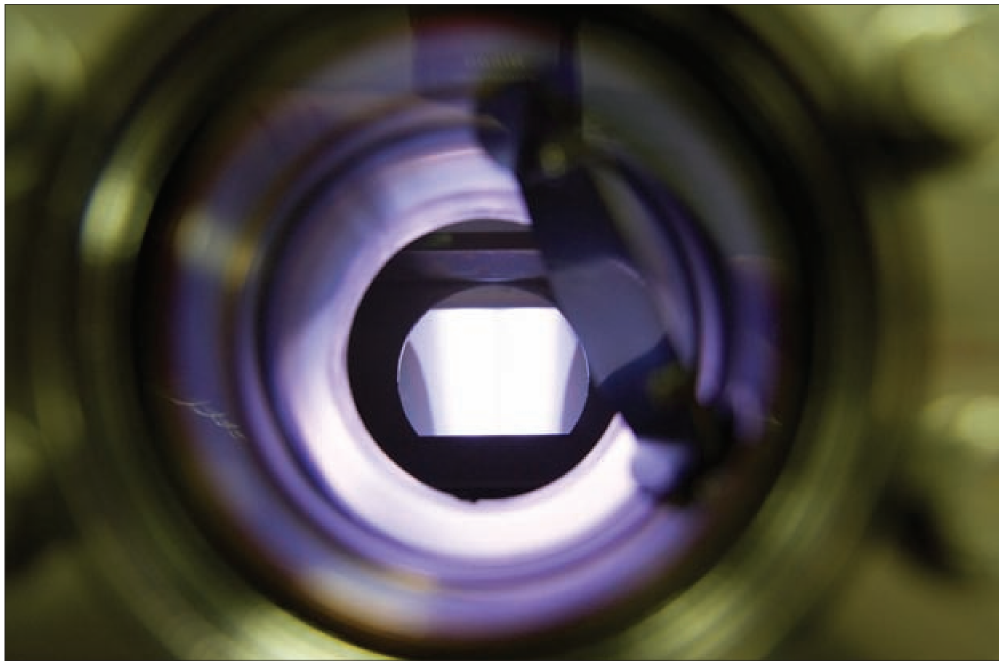
The polymer science experiments that are carried out at the ESRF are part of a much wider global effort to develop and improve these familiar materials. While partly motivated by economics, this work also has an important ecological aspect, the progress of which we can clearly witness for ourselves.

Harald Reichert, director of research

Graded multilayer reflectors are born

Focusing hard X-rays is a delicate affair and developing the custom optical set-ups that the beamlines require is the job of the ESRF X-ray Optics Group. One of the most prominent tools in its box of tricks is the use of curved and graded interference coatings (multilayers). After a major upgrade of its Multilayer Laboratory, the team can now deposit these coatings much faster and to a wider range of specifications.

The facility hit an important milestone in February when it finished the first graded, multilayered reflectors. These start life as a single crystal of silicon. After polishing, the substrates (which can weigh up to 40 kg) are loaded into the multilayer lab's new deposition plant. Equipped with four guns, the machine can lay down structures composed of up to four different materials – from metals and ferromagnetic materials to insulators – without breaking the high vacuum of the chamber. The thickness can be controlled with accuracy down to one part per thousand. With a deposition rate usually hovering around 0.1 nm/s, the machine is about four times as fast as the previous model.



ESRF

Looking down the viewport inside the new sputter deposition machine. The purple glow is a plasma of argon, which knocks atoms out of the target material (shown glowing white). The ejected atoms attach to the mirror's surface, forming a coating. Adjusting the deposition rate varies the thickness of the coating.

The finished graded multilayer reflector consists of hundreds of near-elliptical curved layers of alternating high and low refractive index materials. X-rays reflecting off any of the interfaces between the layers are directed towards the same point, via a path that differs by an integer number of wavelengths, leading to constructive reinforcement and a tight, brilliant beam at the focal point. By using two such reflectors at right angles to each other, the beam can be shrunk in both the horizontal and the vertical direction, giving a smaller spot with virtually no loss of photon flux. The first reflector pair constructed with the new coating lab will soon be in use at ID22, and it will regularly achieve a spot size of down to 1 µm at photon energies of up to 65 keV. Its relative, which is currently operational on the end station ID22NI, provides users with a focus of less than 100 nm.

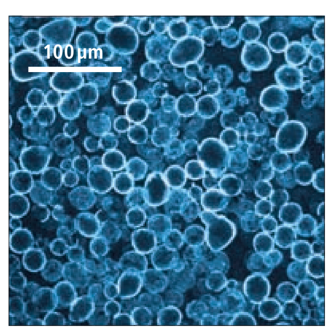
The Upgrade Programme's focus on nanoresolution will continue to shrink spot sizes. The programme calls for both new and existing beamlines with smaller beams, which will require new optical devices. "I am confident that we can get down to 20 or 30 nm," says Christian Morawe from the coating lab. As if that wasn't enough to keep the team busy, under certain circumstances the lab can produce tailored optical devices for other research institutes.

Contact the Industrial and Commercial Unit for more details (e-mail industry@esrf.fr).

X-rays reveal solid's intriguing behaviour

Scientists from the University of Edinburgh (UK), the University of Montpellier (France) and the ESRF have used X-rays to characterise an unusual soft solid that doesn't behave as previous models would predict. The material is an opaque emulsion of micrometre-sized drops of dodecane (the main hydrocarbon in diesel) suspended in water. Each drop is stabilised by a coating of nanosized silica particles that are trapped at the interface between the dodecane and the water. This layer prevents the drops from coalescing, but the low density of dodecane means that the drops float to the top of the mixture and rearrange themselves more densely there (a process known as creaming, as can also be seen in a pint of Guinness).

The behaviour of the cream differs depending on the age of the sample. In young samples the droplets move faster and undergo local rearrangements, while older emulsions move more slowly. The earlier dynamics can sometimes be regained simply by remounting the sample, no matter what its age. This suggests that the initial behaviour is due to loosely packed or disrupted droplets, and that the later-stage dynamics are occasional rearrangements of droplets jammed close together.



Confocal microscopy image of a densely packed emulsion of dodecane (outlined in white silica) suspended in water.

The soft solid is intriguing from a theoretical point of view because the droplets exist outside thermodynamic equilibrium. A large amount of energy would be needed to put the system into the lowest-energy state, and there is nowhere for this to come from, so the particles stay stuck on the surface of the droplets. This finding suggests that previous models created to describe these systems are still missing something – a result that has practical as well as theoretical importance. Understanding the motion of particle-stabilised droplets and bubbles has applications in mining, the recovery of oil from oil sands and paper recycling, among others.

Reference

E Herzig *et al.* 2009 *Physical Review E* **79** 011405.

Mirror checks become even more accurate

The mirrors used in X-ray optical devices at the ESRF are profiled in detail before they are installed on beamlines. After each of the many stages in device development, the results are assessed and precise measurements are used to locate and identify defects. These numerous checks help to ensure that the mirror quality is appropriate for the desired result.

To replace an aging instrument, the X-ray Optics Metrology Laboratory recently acquired a new Veeco optical profiler. This microinterferometer can measure the height profile of the X-ray mirrors' highly polished surfaces with an accuracy of more than 0.05 nm – on a vertical measurement that can be as large as 1 cm. The team is particularly happy with the high level of automation of its new device. The mirror to be measured can be positioned under the viewfinder using a joystick.

Once the measurement points have been defined, the Veeco automatically finds the optimum focus, moves the sample and measures up to 50 points spaced out along the surface, producing comprehensive information about the mirror's topography.

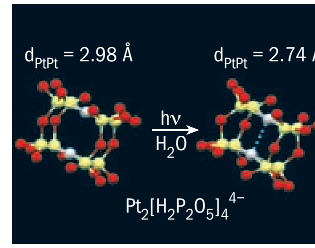
Not only does this give the scientists more time, but also the automation of sample positioning means that measurements can be repeated at exactly the same location on the surface using a range of magnifications, giving a detailed picture of the contours of the area at both small and large scales. Alternatively, the roughness measurer comes with software that can "stitch" together magnified images to form a larger surface map, which is high resolution and covers a large area. This is allowing the metrology lab to achieve things that it never has before, particularly on the larger mirrors that are needed for nanofocusing.

Excitement makes molecules shrink

A photoactive chemical called PtPoP (tetrakis-μ-pyrophosphitodiplatinate(II)) – one of the largest and most complex transient species yet investigated in solution – has recently been characterised in a highly elusive electronically excited state. Scientists at the Centre for Molecular Movies (Denmark), the ESRF and the Synchrotron SOLEIL have found that the bonding length between the two platinum atoms in the molecule, when excited, shrinks by 8%.

Taking such measurements is tricky because time is ticking away – excitations are necessarily transient. In addition, it is easiest to obtain data from a crystal of the intermediary molecule, but the shape of PtPoP in a crystal may not be representative of its configuration in solution, where reactions most often take place. The PtPOP measurements were therefore taken in solution, despite the weak signals from the very dilute PtPoP molecule.

The researchers think that functional molecules like this



The ground-state PtPOP molecule on the left has two platinum atoms, which are 2.98 Å apart. When it is excited by a photon, it changes into the configuration on the right and the platinum atoms move 0.24 Å closer.

could have potential as a "remote control" for atomic structure. One of the team, Michael Wulff, explains: "If we sent a molecule like this into a material and excited it with a beam of light, it would become charged and the atoms near it would rearrange. It could be a nice way to control the structure optically. First we need to know how it behaves when excited so that we know what we are doing to the material."

Reference

M Christensen *et al.* 2009 *J. Am. Chem. Soc.* **131** 502–508.

Users' corner

The next deadline for submission of standard proposals is 1 September for beamtime during the period of March to July 2010.

News from the beamlines

- **Manfred Burghammer** is the new beamline scientist in charge of the microfocus beamline, ID13, following the retirement of Christian Riekel.
- **Gema Martínez-Criado** is the new beamline scientist in charge of ID22 following the move of Jean Susini to the new Instrumentation Services and Development Division.
- **BM26B has a new Pilatus detector,** which will be available to users in the coming months.
- **A new nanodiffraction stage and an *in situ* atomic force microscope (AFM) are ready for users at ID01.** A new nanostage allowing combination of a focal spot (300*500 nm^2) with a positioning stage with nanometre precision has been developed. Focusing is done either by a Fresnel zone plate or by beryllium compact refractive lenses, and the flux in the spot is between 10^9 and 10^{10} photons per second. The nanopositioning stage is based on piezoelements with coarse and fine alignment capabilities, with a range of 5*5mm^2 and 30 μm in x and y, and 15 μm in z. The set-up can be used for nanodiffraction experiments with local resolution. The coherence and stability of the beam have been enhanced considerably, so the new set-up is also very well suited to carrying out coherent diffraction imaging in the forward direction and/or in Bragg diffraction, either from single nanostructures or from extended objects by ptychography.

  In addition, the new *in situ* AFM (developed by Small Infinity) has been commissioned. This is used not only for *in situ* imaging and finding nanosized objects (invisible in optical microscopy) and placing them in the nanofocused beam, but also for manipulating nanostructures. In a first proof-of-principle experiment the AFM tip has been used for nanoindentation on a single silicon germanium epitaxial island, and the corresponding lattice compression has been measured *in situ* by nanodiffraction. The results were published in T Scheler *et al.* 2009 *Applied Physics Letters* **94** 023109.
- **Coherent diffraction experiments are now possible on ID3**, although the technique is limited to reflections outside the specular plane. There are several important improvements to the experimental set-up:
- The flow reactor for catalysis studies is now connected to a new gas line that can be fully controlled by specification. The gas composition is controlled by the same procedure that is used for moving motors. The same applies to the sample temperature. The advantage of this set-up is that it is now possible to carry out macros giving more flexibility in exploring the thermodynamic volume where reactions might occur.
- In the UHV chamber of EH2, the phi and chi circles normally used for the surface-alignment procedure have been replaced with a hexapod. This makes the procedure much simpler and faster, and it eliminates all of the problems that are connected with the z movement of the sample. This also allows the sample surface to be centred at the centre of rotation of the diffractometer, allowing the study of samples with dimensions of less than 1 mm.
- ID03 can carry out the simultaneous measurement of surface diffraction and GISAXS. With this aim, new mask slits that will greatly reduce the background in the case of GISAXS measurements have been developed. These will be installed during the spring shutdown and debugged before the summer.
- A sample holder suitable for silicon samples has finally been developed. It is now possible to flash silicon wafers with the pressure remaining at 10^{-10} mbar.

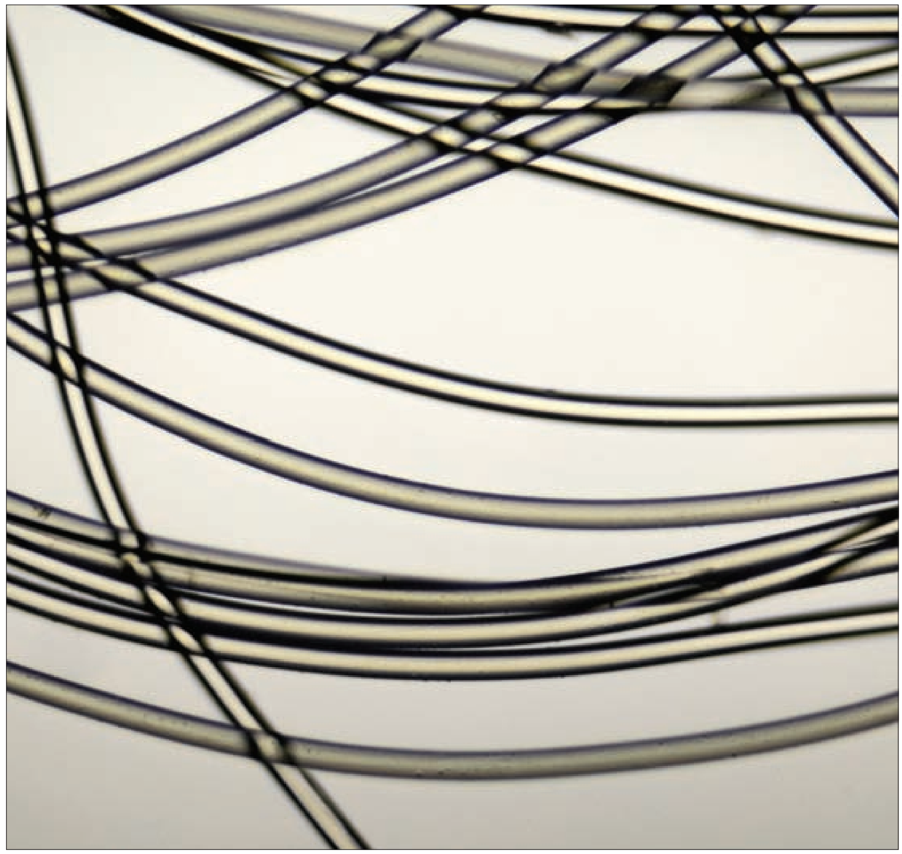
Hydrogen bonds prove key to improved future nylons

A team is using advanced characterisation tools to control crystallisation and eventually develop a class of polyamides with enhanced mechanical properties.

Nylon was first produced by Dupont in 1935 as a synthetic alternative to silk, and it has gone on to become one of the most familiar polymers. Like other polyamides, its properties largely depend on hydrogen bonds between amide groups in adjacent molecular chains. One of the principal problems when attempting to make high-modulus, high-strength polyamides such as nylon is premature crystallisation, which occurs before the molecules have reached their optimum orientation. This reduces the material's strength and stiffness and, once the crystals have formed, they cannot be unfolded. If hydrogen bonding (i.e. crystallisation) could somehow be halted until the molecules have reached their optimal alignment, a material with significantly enhanced mechanical properties should result.

An international team of researchers led by Sanjay Rastogi of the University of Loughborough (UK), and Jules Harings of Eindhoven University of Technology (the Netherlands), is currently investigating this problem at the ESRF. The goal is to control hydrogen bonding in materials such as nylon without changing its crystal structure. Appropriately, the approach that they have adopted is based on natural silk production. In the glands of spiders and silkworms, the hydrogen-bonded moieties along the protein chain are shielded and mediated by water molecules, salts (ions) and the pH. Using the same principle of shielding hydrogen bonds during the processing of polyamides, crystallisation can be prevented during spinning and drawing. When the polymer chains are ideally aligned and extended, the hydrogen-bonded network can be restored.

Researchers have been able to mimic the shielding phenomenon found in natural silk production using superheated water, which acts as a solvent.The development work is being carried out on a model compound called N,N'-1,2-ethanediyl-bis(6-hydroxy-hexanamide) instead of a polyamide. This approach allows hydrogen bonding to be studied in isolated crystals without the complications of an additional amorphous phase. Time-resolved wide- and small-angle X-ray experiments on beamlines ID11, ID2 and BM26 have allowed the team to monitor the state of molecular chains and hydrogen bonding in the polymer.


ISTOCKPHOTO.COM

Nylon fibres. Superheated water can control crystallisation and lead to a more robust material.

"The results obtained so far are very encouraging"

The initial work has shown that crystallisation from superheated water results in the formation of thermodynamically metastable crystals, where water molecules in the vicinity of the amide moieties shield the interchain hydrogen bonds. On heating, the evaporation of water molecules leads to a change in molecular movements and hydrogen-bonding efficiency. This restores interchain hydrogen bonding, corresponding to an irreversible stabilisation of the crystals.

The team has also discovered that water molecules near amide moieties help to mediate the formation of stabilising hydrogen bonds. Taking inspiration from the production of natural silk one step further, the scientists are currently studying the use of ions for shielding the hydrogen bonds more effectively. The results that they have obtained so far are very encouraging. Rastogi explains: "Phenomena such as ionic interactions and hydrophobic hydration introduce ample opportunities in polyamide processing."
M Capellas

References

J A W Harings *et al.* 2008 *Cryst. Growth Des.* **8** 2469–2477.
J A W Harings *et al.* 2008 *Cryst. Growth Des.* **8** 3323–3334.
J A W Harings *et al.* 2009 *Langmuir* online **doi:10.1021/1a900318n.**
B Hess *et al.* 2009 *J. Phys. Chem. B.* **13** 627–631.
E Vinken *et al.* 2008 *Langmuir* **24** 6313–6326.

Polymer potential. Buildings are an ideal place to deploy organic solar cells, but the challenge is to find a means of improving their performance.

Polymers could set the pace for broader use of photovoltaics

The next generation of solar cells needs to be flexible, available in many different shapes, efficient and cheap. An alternative material to silicon is required to achieve this. Polymer semiconductors can save energy through self-assembly, as well as being an energy provider.

The differences between insulators and conductors aren't as clear-cut as you were taught in school. Some polymers can display the same kind of semiconductive behaviour as traditional silicon, and work is ongoing to make polymer and organic equivalents of the silicon semiconductor devices that we use every day. Although silicon is highly efficient as a semiconductor, it's very expensive to process because it requires many stages (some in vacuum) and the finished product is brittle – hence the limited use of silicon photovoltaics.

Plastics are robust, flexible and cheap, so these would be more affordable for covering large, odd-shaped areas, such as roofs, with organic solar cells. Polymer LEDs, transistors and photovoltaic cells are now available, but the challenge is to optimise their performance so that they can compete with silicon.

All photovoltaic systems use the energy of a photon to excite an electron-hole pair, before splitting them up quickly and chaperoning them to different electrodes before they have a chance to recombine. The result is that a photon is turned into charge. For this process to work well, regions attractive to both holes and electrons need to be well mixed so that neither particle has far to go to find a niche. Once the charged particles reach these areas, they must be able to travel rapidly to their respective electrodes without having a chance to recombine.

One way of doing this is to mix electron- and hole-friendly polymers in the same device. This can be effective, but over time the two separate. It was hoped that by joining together an electron-donor chain with an electron-acceptor group in the same polymer chain, a device could be made that would be both stable and efficient. A team of scientists, including Dimitri Ivanov of the Institut de Sciences des Matériaux de Mulhouse, CNRS, used a block copolymer containing an electron-donor "rod" block (which, as the name suggests, forms regular, straight lamellae) and a flexible "coil" block bearing electron-acceptor groups (fullerenes).

To investigate thoroughly how this polymer behaves, scientists characterised it in thin films and in bulk by using spectrometry, atomic-force microscopy and wide- and small-angle X-ray scattering at the ESRF's DUBBLE beamline. These analyses showed three separate forces acting on the polymer layer. The rod polymers have a tendency to form crystalline sheets, which give the film order. When combined with coil polymer blocks the two have a tendency to separate. For small amounts of coiled polymer this can create regular lamellae with both internal and intersheet order. Alternatively, the fullerene moieties tend to group into fullerene nanocrystals that "pin down the coils", preventing the rest of the polymer from forming into its optimum shape. Depending on the proportions of the mixture, different effects can dominate, and further adjustment is necessary to produce a suitable nanoscale network of well defined regions of rods interspersed with regions of coils. Although the films were not as efficient as researchers had hoped, they did absorb photons well, suggesting that the acceptor–donor interface is doing a good job of splitting up holes and electrons. These results can be used as guidelines to develop the promising idea of self-assembled polymer photovoltaics.

To optimise the next stage – transporting the electrons quickly to the electrodes – it is important to have a well ordered film. The team obtained promising results by using the self-organising properties of disc-like organic molecules, which assemble themselves into columnar stacks. The electron-receptive areas at the centre of each molecule combine as they overlap, making a conductive channel and turning this into a straw that the electrons can travel down. The repeat units are held together with only a weak force, so the columns are not technically polymers. Instead they are classed as supramolecular polymers, but they still carry all of the advantages of polymer electronics mentioned earlier, including being easy to assemble. For optimum effect, all of the columns should be aligned in parallel and should run directly between the electrodes.

"To get better photovoltaic performance we need to tune the fine nanostructure"

Ivanov and scientists from DUBBLE and the Center of Molecular and Macromolecular Studies (Sienkiewicza, Poland) prepared films of disc-like molecules in two ways: first by passing a "conveyor belt" of substrate under a stream of organic solution and leaving it to dry (the zone casting method), and second by exercising stress on the material to "comb" the molecules into columns (the mechanical shear method). At the DUBBLE beamline they measured the samples using grazing incidence X-ray diffraction. They found that, for shearing effects, the columns were not strictly collinear and tended to point in the direction of the shear force. On the other hand, films formed by zone casting showed columns perpendicular to the casting direction, and so parallel to the substrate. In addition, the resulting film was regular and smooth, with long-range order in the lateral columnar arrangement. Letting the molecules arrange themselves therefore gives the best result.

To make polymer photovoltaics viable, their efficiency must be improved. At the heart of this is the arrangement of the polymers inside. Ivanov explains this connection between big and small: "We think that to get better photovoltaic performance we need to tune the fine nanostructure, and the only way of doing that is by self-assembly. By using polymers of different length, tuning them using chemistry and processing them in novel ways, we can encourage them to assemble into the 3D morphology that we want."

K Oliver

References

D Anokhin *et al.* 2008 *Thin Solid Films* **517** 982–985.
S Barrau *et al.* 2008 *Macromolecules* **41** 2701–2710.

A new look into fibre-reinf

Researchers have been discovering new ways to investigate fibre-reinforced composites using microfocus X-ray microbeams to probe and understand their internal microstructure.

ERIC W

Felipe Massa driving for Scuderia Ferrari at the 2007 United States Grand Prix. The use of advanced materials has resulted in fewer F1 fatalities.

Modern Formula One (F1) cars can reach speeds of up to 360 km/h. Yet F1 fans have become used to witnessing dramatic accidents where the drivers emerge from the mangled wreck virtually unscathed. There hasn't been a single fatality in F1 during the last decade. There were nine driver deaths during the 1960s, by comparison, even though average speeds were 30 km/h slower than they are today. The reason for this is partly down to the widespread use of advanced materials in the construction of modern F1 cars, such as fibre-reinforced composites.

The chassis of an F1 car is made up almost entirely of woven carbon-fibre composites. This allows the vehicle to keep its shape rather than deform during the impact of a crash. These so-called fibre-reinforced composites typically consist of two components. The material's strength and stiffness is imparted by fibres, held in place by an adhesive binder, or matrix. This binder also transfers stresses between the individual fibres. The composites offer a range of properties that traditional materials cannot easily match. They are incredibly lightweight yet have tremendous durability and high specific strength. They can also have directionally dependent properties and can be formed into elaborate shapes that would otherwise be difficult to manufacture.

Researchers from the University of Manchester (UK) and the ESRF have recently demonstrated an entirely new method of investigating the structure and performance of fibre-reinforced composites. This exploits the crystallographic information obtained during microfocus X-ray diffraction to derive a range of information from the fibres buried in the composite material. The technique uses a small X-ray beam to collect diffraction data in a scanning data-acquisition mode as the composite material is being deformed *in situ*. By combining this real- and reciprocal-space information, an image can be reconstructed showing how local stresses and microstructural parameters evolve as a function of macroscopic strain.

The technique can reveal, for example, how stress fields evolve around drilled holes in a composite material via stress transfer through the matrix. This kind of information is relevant

orced composite materials

THE BOEING COMPANY

Where are they used?

- As much as 50% of the primary structure of the new Boeing 787 Dreamliner (right) will be made of composite materials. This will include the fuselage and wings.
- More than 70% of the new Eurofighter's shell is made of carbon-fibre composites.
- In the wake of natural disasters, such as hurricanes and flooding, construction companies are attracted to composite materials because they could increase the resistance of buildings to extreme wind and high water.
- The WhiteKnightTwo jet-propelled carrier aircraft was built with composites for Virgin Galactic to ferry the eight-passenger SpaceShipTwo commercial space vehicle to launch altitude, where it will propel space tourists into suborbital flight.
- The massive blades of modern windmills are made from composites because these materials are both light and rigid.

Dream machine under construction. This one-piece composite fuselage section (right) belongs to one of the new Boeing 787 Dreamliner aeroplanes. By building these sections as full barrels containing integrated struts, the company will reduce the number of parts that are on the aeroplane, improve the overall aerodynamic performance and help to make the aircraft more fuel-efficient than any other aeroplane in the same class.

High-performance fibres on ID13

ID13 has been performing experiments on high-performance fibres, such as Kevlar, for more than a decade.

Even today, its microfocus X-ray beams are routinely employed for new studies of these remarkable materials, for both academic and industrial research. This is because there are no other techniques that can provide similar information without sectioning the fibre – a process that risks altering its internal microstructure.

A great deal of the work on high-performance fibres at ID13 is related to investigating their so-called skin-core morphologies. This refers to the difference in structure between the outer layers of the fibre compared with its centre.

Skin-core variations can influence the fibre's mechanical properties, and they may provide a route to tailoring their properties during the manufacturing process at very little additional cost. They can also alter the performance of fibre-reinforced composite materials, because it is a breakdown in adhesion between the fibre and the matrix that often causes composite failure. If the skin-core microstructure can be adjusted to promote better adhesion and more effective stress transfer, the performance of composites could be improved.

to engineering applications where rivet holes are often used to attach composite panels. It also shows in detail how the deformation of a composite material influences the orientation of yarns embedded within the matrix. This includes fibre rotations due to emerging shear stresses and crimping in woven composites caused by a contraction perpendicular to the deformation axis.

A key feature of the microfocus X-ray diffraction technique for studying composite deformation is its applicability to engineering composites. Unlike many other techniques, it is not constrained to model systems and could easily be adapted for more complex sample geometries. It also stands apart from other test methods in terms of the unique information that it can provide. Most existing methods of probing composite materials cannot offer any information whatsoever from the buried fibres. They also tend to be limited to translucent matrix materials or only provide surface information.

Robert Young, head of the School of Materials at the University of Manchester, who initiated this project, sees microfocus X-ray diffraction as a crucial step forward in composites research. He says: "Despite the widespread use of composites, until now it has not been possible to analyse certain characteristics of the material, such as the propagation of stresses in particular composites. Using this technique we now have the tools to overcome these limitations".
M Capellas

References

R J Davies *et al.* 2007 *Applied Physics Letters* **91** 044102.
R J Davies *et al.* 2008 *J. Materials. Science* **43** 6724–6733.
R J Davies *et al.* 2009 *Composites Science and Technology* **69** 567–574.

ESRF meets ILL. Theyencheri Narayanan (left) and Giovanna Fragneto are hoping to bring together competences in soft condensed matter research.

Labs unify in soft condensed matter

About six out of ten soft matter users at the ESRF also use the ILL, since neutron scattering is complementary to X-ray studies. Now a partnership will make it easier to access both.

As the topics and systems of soft condensed matter research become increasingly complex, the ESRF and the Institut Laue-Langevin (ILL) are looking into forming a Partnership for Soft Condensed Matter (PSCM) to undertake the increasing number of ambitious projects initiated by this diverse community.

Soft condensed matter covers many everyday materials – including polymers, nanomaterials, detergents, emulsions, food products and a large fraction of biological materials. This kind of matter is characterised by a microstructure, the slow dynamics of its constituents and weak elastic moduli, or its "softness", all of which are easily accessible to both neutron and X-ray scattering techniques. Soft matter systems pose many theoretical challenges and offer novel synthetic routes. A better understanding of their structure and dynamics could make a timely contribution to the sustainable development of consumer products that require smaller amounts of raw material, with lower processing costs and better efficiency.

Both the ESRF and the ILL provide powerful tools for soft condensed matter research, but they must continually offer new features.

Theyencheri Narayanan, head of the Soft Condensed Matter Group at the ESRF, explains his half of the match: "X-rays cannot always provide the complete picture. Neutron scattering has a rich tradition in soft condensed matter studies, and the two techniques are often very complementary." The goal is to unify the efforts of the Soft Condensed Matter Group at the ESRF and the soft condensed matter scientists at the ILL (mainly from the Large Scale Structures and Time-of-Flight groups), to bridge the gap between different techniques and provide access to common resources that would not be available to either group alone.

"Recent progress on the PSCM is of the greatest importance, as the on-site availability of sample preparation and precharacterisation laboratories is vital for the success of many experiments in soft matter areas. The instruments we already have available are in heavy demand, by both users and ILL/ESRF members of staff," says Giovanna Fragneto, senior scientist in soft matter and responsible for the PSCM initiative at the ILL. In addition, the partnership will invite outside collaboration and contributions.

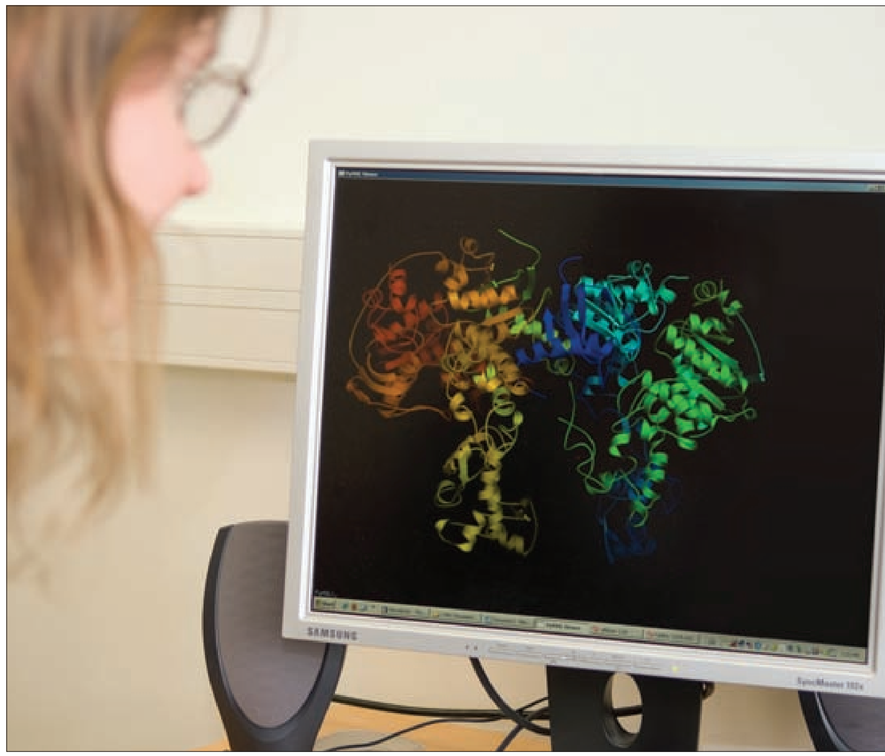
As part of the Contrat de Projets Etat-Région, a funding programme set up by the local authorities, the PSCM hopes to obtain its own science building to house visiting research groups and common lab facilities. Its new home will host an atomic force microscope, a Brewster angle microscope, rheometers, microfluidics, UV-visible light spectrometers and micromanipulation techniques, including optical tweezers.

Elsewhere on the joint site, the Partnership for Structural Biology provides a permanent reminder of the success of such a concept. The introduction of this facility has made it much easier for scientists to prepare samples on site and to find collaborators. Soft condensed matter researchers hope that they will experience similar benefits. They may not have long to wait. Narayanan says: "We're hoping that the memorandum of understanding will be approved at the Council meeting in June. If we get the go-ahead, work on the project could begin in the autumn."

K Oliver

Rewriting textbooks on world-record bacterium

A team from the MX Group has published novel details about the resilient nature of the world's most radiation-resistant bacteria.



C ARGOUD

MX Group scientist Joanna Timmins observes the structure of UvrA2 that her team has solved.

Facts about *Deinococcus radiodurans*

- *Deinococcus radiodurans* was discovered in 1956 in the US while scientists were trying to determine if canned food could be sterilised using high doses of radiation. A tin of meat was exposed to a dose of radiation that was thought to kill all known forms of life, but the meat subsequently spoiled, and *Deinococcus radiodurans* was discovered.
- It has appeared in many different environments, such as elephant dung and granite in the dry valleys of the Antarctic. However, according to *Genome News Network,* it is not clear what its natural habitat is.
- It can resist an instantaneous dose of up to 5000 Gy of ionising radiation. Only 10 Gy is needed to kill a human.
- In its stationary phase, each bacterium contains four copies of the genome; when rapidly multiplying, each contains 8–10 copies.

It has been nicknamed "Conan the bacterium" and *Guinness World Records* has listed it as the world's toughest bacterium. Its name, *Deinococcus radiodurans*, speaks for itself: in Greek the first part means "strange berry" and in Latin the second part means"radiation surviving".

The microbe can survive conditions ranging from drought to cold, lack of nutrients and a thousand times as much radiation as a person can. All systems for DNA repair, DNA damage export, desiccation and starvation recovery, and genetic redundancy are present in one cell. Its ability to repair its DNA after being damaged has made it the subject of study for many scientists around the world. "We have tried to kill it several times with an X-ray beam, but two or three hours later it is as good as new again," explains Sean McSweeney, head of the Macromolecular Crystallography (MX) Group at the ESRF.

Despite the multiple applications that this microbe could have, such as DNA repair for medical applications or the cleaning of contaminated environments, researchers worldwide still don't know enough about it to put any of these into practice.

"The *Deinococcus radiodurans* genome was discovered a decade ago, but it doesn't present any answer as to why this bacterium is so resistant to radiation compared with others. So we basically still don't know how it fixes itself after radiation," says Joanna Timmins, a scientist in the MX Group.

In a recent paper (Timmins *et al.* 2009) the team has unveiled the structure of one of four proteins that become active when the bacterium is damaged by ultraviolet light. The so-called UvrA proteins are key players in recognising lesions in DNA and repairing them. The other Uvrs have different roles. Together with UvrA, UvrB is responsible for damage recognition. After the lesion has been located, UvrA dissociates from the DNA, while UvrB forms a complex on the DNA damage sites. UvrC binds to the UvrB–DNA complex and incises the DNA lesion. UvrD extracts a fragment of 12–13 nucleotides containing the damaged DNA and finally the gap is filled by DNA polymerase and ligase, which repair the DNA. Uvrs are present in many bacteria.

The scientists say that despite previous studies on similar proteins, the architecture of UvrA is "largely unexpected". They have identified the different areas in the protein that bind to the DNA and compared the structure to that of another UvrA from a different bacterium. They found that the insertion domains of the two proteins have a role in the DNA-binding and damage-recognition processes.

The information about the two proteins allowed the researchers to design a model for how UvrA functions. "We are basically rewriting the textbooks," explains McSweeney. "Until now, what was known was a sketch of the interactions of the proteins within the bacterium, but after this paper we have a better idea of how UvrA2 contributes to the repair of the damage. It is a big step forward, although there is still a lot of work ahead," he concludes.

M Capellas

References

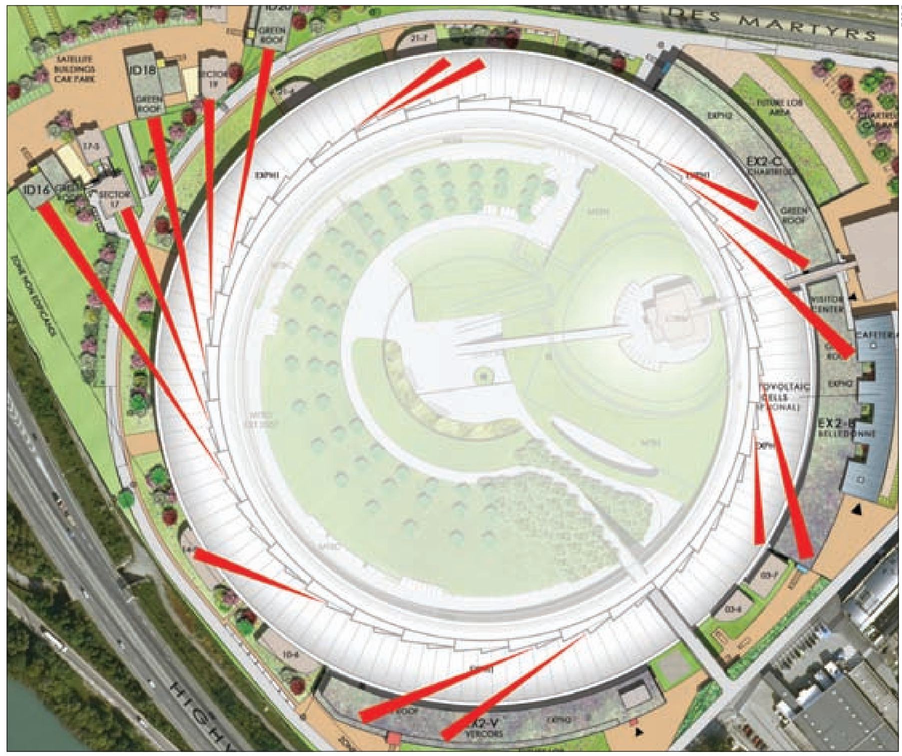
J Timmins *et al.* 2009 *Structure* **17** 547–558.
O White *et al.* 1999 *Science* **286** 1571–1577.

Brainstorms define new beamline candidates

Following 11 meetings with users and experts, only 8 of the proposed new beamlines are set to become a reality.

Foreseeing the future of science is not straightforward. However, scientists at the ESRF are trying to do precisely that as they come up with proposals for state-of-the-art beamlines where the experiments of the next two decades will take place. After the Upgrade Programme, the ESRF's world-class beamline portfolio will contain eight unique new beamlines. There are 11 hopefuls (some include several beamlines) and the competition between them is strong.

To come up with the best beamline proposal, experts from other facilities, users and ESRF staff gathered for brainstorming sessions at the beginning of the year to talk about their requirements and hopes for the Upgrade Programme. The March issue of *ESRFnews* (p14) covered the early meetings, which were dedicated to UPBL7, UPBL10 and UPBL11, while the reports from the remaining UPBL sessions are covered here.



ESRF

Future beamlines. The location of the potential new projects for beamlines are marked in red.

The rest of the proposed beamlines and their objectives

UPBL1's main field of application is material science (hard condensed matter) at the nanoscale. In particular, the study of shape, strain and composition of single nanoscale objects is the main scientific objective of UPBL1, followed, in the future, by studies oriented towards real functional materials and applications. The techniques that UPBL1 will develop and use will mainly be micro- and nanodiffraction in combination with anomalous scattering on single nano-objects; use of intense coherent (nano) beam for the investigation of the strain and shape of mesostructures using coherent diffraction imaging (CDI) and phase-retrieval algorithms; and the combination of m-XRD and/or CDI with *in situ* atomic force microscopy and other *in situ* techniques. Therefore, the technical capabilities and the scientific research direction of UPBL1 should concentrate on making the beamline fully capable of exploiting these techniques (e.g. with routine alignment, sample manipulation and data-handling capabilities). The development of sample nanopositioning and nanomanipulation has been indicated as a long-term project of UPBL1, which will strengthen its research field in combined techniques for the study of single-object properties.

Europe's high-energy beamlines are in demand for research into new materials, surface and interface science, and applied engineering problems. **UPBL2** seeks to provide even higher-energy X-rays, up to 150 keV, in combination with a reduced beam size to apply to these issues. Using submicrometre beams for grazing incidence diffraction, detectors optimised for high energies and time-resolved reflectivity measurements, scientists could study buried interfaces far from equilibrium and in non-ideal conditions. This is frequently the case for energy applications, such as where electrode, electrolyte and gas meet in a fuel cell. UPBL2 would allow the study of these interfaces in working conditions. For tomographic imaging applications, *in situ* techniques would also be valuable in studies of chemical or material processing, maximising the impact of structural measurements on real working devices.

UPBL3 would be an advanced nuclear resonance beamline. In the brainstorm, scientists identified two major areas that are necessary to take nuclear resonance (NR) further: nanofocus and ultra-high energy resolutions. Since NR measurements are very "flux hungry", it is impossible to use a nanofocus beamline for NR if the decreased spot size is accompanied by a drop in intensity. However, if the flux level could be maintained, the combination of NR techniques and nanofocus would make important contributions to the fields of nanotechnology and science at extreme conditions – two of the five scientific subjects that the Upgrade Programme is focusing on. Meanwhile, the availability of ultra-high energy resolution (with a bandwidth of <0.5 meV) would enable nuclear inelastic scattering techniques to achieve greater precision.

UPBL4 is targeted at making nanoimaging and nanoanalysis routine with a much higher spatial resolution than is currently available for hard X-ray microscopy and microanalysis. Three key scientific fields are driving the new beamline: biomedical research; environmental and Earth sciences; and materials sciences at the nanoscale. The beamline would consist of two branches providing state-of-the-art nanofocused beams optimised for ultramicroscopy and nanospectroscopy, respectively, but users at the brainstorm emphasised their wish to maintain the ability to conduct microscale *in situ* studies. This gain in spatial resolution would enable work on biomedical topics (e.g. the examination of individual cells). To reduce the effects of radiation damage during this line of research, a permanent cryogenic facility is essential, and detector technology would need to be improved to collect data before radiation could destroy the samples. Combining the new facilities with new techniques, such as coherent scanning X-ray microscopy, would benefit the rapidly increasing user community enormously.

The ESRF's high-energy X-rays, combined with long beamlines, offer the chance to develop microimaging applications with parallel and coherent beams. **UPBL5** is the prospective successor to ID19 and would have an outstation at ID17, the biomedical beamline. It would offer full 3D data for the internal structure and, increasingly, the characteristics of macroscopic samples on length scales of less than 1 μm to many centimetres. Such techniques are in use in materials science, environmental and biomedical studies, and a range of cultural heritage projects and collaborations with palaeontological researchers. UPBL5 would expand on these areas, increasing the chance of fast, real-time imaging and adding the ability to perform multiscale experiments. For these purposes the combination of an enhanced ID19 beamline (with novel concepts for collimating X-ray optics providing a small but intense beam) and a wide, coherent beam for phase-contrast imaging of large objects, at ID17, is essential. Novel X-ray phase-contrast methods, such as interferometric imaging, can reveal details with unprecedented sensitivity. These are under development by the X-ray Imaging Group and will be implemented in the Upgrade Programme.

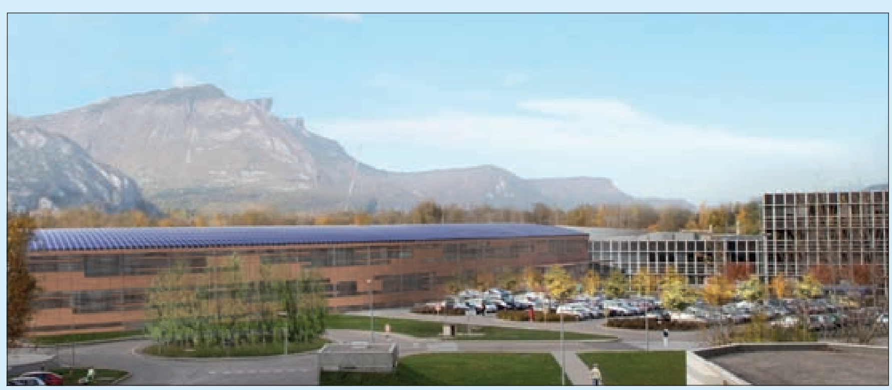
UPBL6 is dedicated to exploring electronic excitations using both resonant and non-resonant inelastic X-ray spectroscopy (IXS). This technique is used across disciplines, touching on chemistry, materials science and physics, for research into fundamental matters and for practical applications. To serve these communities in the future, scientists envisage a beam with a spot size of just a few micrometres, which must be kept extremely stable for the duration of an IXS scan – typically several hours. This capability would enable high-pressure, and high-temperature experiments to be conducted, and open up the possibility of obtaining tomographical measurements simultaneously with IXS measurements.

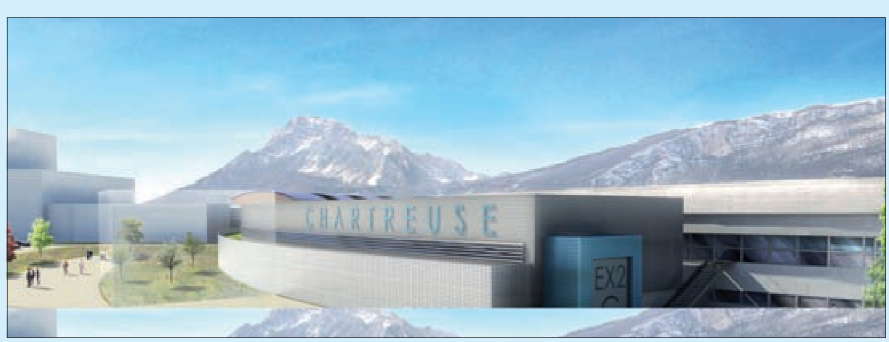
The brainstorm expressed interest in a higher-energy beam, pushing towards 20 keV, and a smaller spot size. This would enable the study of samples containing higher-Z elements, buried samples and those under *in situ* conditions.

UPBL8 would be the next evolution of ID13, which is already known to its users for its high degree of flexibility in the use of micro- and nanosized X-ray beams. It would add the ability to build and test specialised set-ups offline, such as microfluidic cells and *in situ* devices. The control of parameters such as temperature and humidity would open up many options for science that are unavailable today, particularly for the X-ray nanobeams in the new experimental hutch. The upgrade would also provide a substantial increase in terms of sensitivity and data acquisition speed for nanodiffraction experiments. This would allow *in situ* or *in vivo* studies of radiation-sensitive specimens, such as hydrated biological fibres and tissues.

UPBL9 would combine ultra-small, small- and wide-angle X-ray scattering – a combination that isn't readily available at other synchrotron sources. Although technical constraints imply that its two end-stations (UPBL9A and UPBL9B) must remain physically separate, a synergistic interaction between them would bridge the relatively unexplored field of soft condensed matter in the submillisecond time range, with UPBL9A handling soft condensed matter studies and UPBL9B focusing on chemistry and life sciences. A range of 10–30 keV X-ray energy would serve most experiments, but a high-energy option is very attractive for research on small molecules, with the lower limit proving interesting for anomalous scattering and spectroscopy. The ability to combine time-resolved work with higher X-ray energies would be unique in Europe, and superior to other existing facilities in terms of momentum transfer and time resolution, flux and energy tunability.

SUD ARCHITECTES

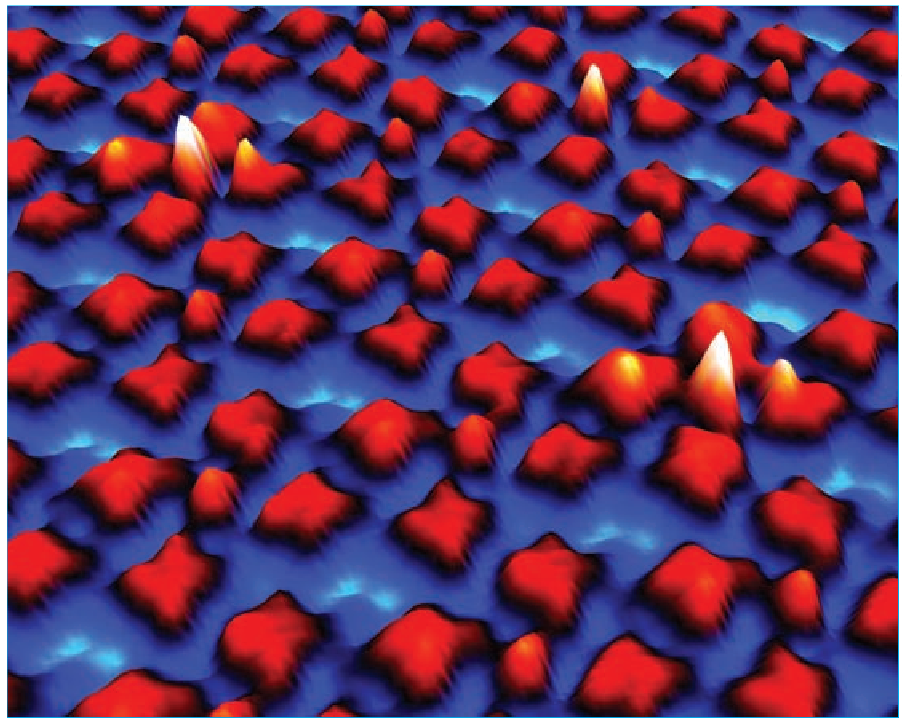




An artist's impression of the facility following the Upgrade Programme from different views.

Grid allows manipulation of magnetic moments

By combining organic molecules and iron atoms in a network, a team of European researchers has created a useful model for the study, or maybe even the use, of individual atoms' magnetic moments.



P GAMBARDELLA

Magic moments. A scanning tunnelling microscope image that was captured at the Institut Català de Nanotecnologia (Spain) of the 2D metal-organic iron network self-assembled on copper. This appeared on the cover of the March 2009 issue of *Nature Materials*.

It's not only consumers who demand smaller and smaller gadgets – miniaturised electronic and magnetic devices have applications in fields that include material science research, medical physics, space travel and environmentally friendly technology. At the same time as these devices shrink, the drive to develop novel, artificial materials with properties that can be manipulated on a subnanometre scale only increases.

In the last 20 years we have witnessed great progress in the performance of magnetic memories and sensors, which originated from basic investigations of the magnetic behaviour of nanometre-thick metal films. For example, the 2007 Nobel Prize in Physics was awarded for the discovery of giant magnetoresistance, whereby a very weak magnetic field can change the electric resistance of a sample radically. This later became the basis for a new standard of hard-drive memory.

Recently the research focus has shifted towards hybrid materials, which are composed of two very dissimilar species, such as metallic and organic molecular layers. It is hoped that, by combining the vast library of organic molecules available with the very specific magnetic properties of metals, new methods and phenomena will be discovered to control the magnetoelectronic behaviour of very small objects. There are two challenging problems that researchers working in this field face. The first is how to assemble millions of tiny molecules in an ordered way. The second is how the properties of such molecules change when in contact with a metallic layer.

The work performed at the ESRF by scientists from the Centre d'Investigacions en Nanociència i Nanotecnologia in Barcelona (Spain), the Max-Planck-Institut für Festkörperforschung (Stuttgart, Germany), and collaborators from across Europe shows a way to meet these challenges. Iron atoms and a molecule called terephthalic acid have been found to assemble themselves spontaneously into a regular pattern on a copper substrate. They form a 2D network (shown in the image, coloured according to the height of the surface) where the iron atoms are held in a square grid pattern, 1.5 nm on a side, by the organic molecules. As well as providing organisation, the ligands free the iron atoms from the dominant influence of the substrate, making their magnetic moments almost independent of it.

Directing magnetic moments

This research necessitated detailed observations of both the surface morphology and its magnetic characteristics. This was made possible by the combination of microscopy and spectroscopy techniques available on beamline ID08 at the ESRF, where users have simultaneous access to scanning tunnelling electron microscopy and X-ray magnetic dichroism techniques.

By changing the ligands that surround each iron atom – for example, by allowing them to react with oxygen – the strength and direction of the magnetic moment of the iron atoms can be altered. This allows selected atoms to be singled out and "marked" by the different orientation of their moment – a useful property for storage media, although the work reported in a recent paper (Gambardella *et al.* 2009) has no direct application currently. Rather, this fundamental research adds another element to our knowledge of magnetic behaviour.

The principal author of the paper, Pietro Gambardella, explains: "The parameters that control the direction and strength of the magnetisation are quite well understood in metals and molecules. But things get more complicated in hybrid systems because of the lack of models and measurements in such poorly defined compounds. In our case it was even worse as hybrid molecular complexes are difficult to synthesise by standard chemistry methods and they had to be self-assembled *in situ* at the ESRF." This organic-metallic system can be thought of as a prototype for studying the interaction of molecules and metals in self-assembled structures. And if hybrid materials are as promising as some think, this could be a first step towards the exploitation of molecular magnetic phenomena.

K Oliver

Reference

P Gambardella *et al.* 2009 *Nature Materials* **8** 189–193.

Gergely Katona: the biologist adapts

Biologist and 'molecular-film director' Gergely Katona, winner of the ESRF Young Scientist Award, has started a research group in Sweden but hopes to keep his links with the ESRF.

DOMINIQUE BOURGEOIS

Gergely Katona on the mountains around Grenoble during his time at the Institut de Biologie Structurale.

He has always been good at adapting himself to new situations. Where he lives, for example, has never been an issue. In fact, travelling around the world was his aim as a child. In those days, he thought that a job as a reporter would give him the greatest chance of pursuing his goal. Progressively, his path led him to science, and his research career has since taken him around Europe. Wherever he finds himself, his easy-going personality helps him to make himself at home.

Gergely Katona's studies started in his home town of Budapest (Hungary), but he was soon offered the chance to spend three months in Sweden with the Erasmus programme, and he liked it so much that he completed his PhD there. Afterwards, he went on to spend time as a researcher at the University of Leicester (UK) and the Institut de Biologie Structurale (IBS) in Grenoble (France). No matter where he is, Katona makes an effort to learn the language, enjoy the food and make the most of the advantages that each place offers.

He has now started his own research group in the coastal city of Gothenburg (Sweden) but he will still come back and use the ESRF from time to time.

This 33-year-old, mild-mannered protein crystallographer made his name in the kinetic crystallography group of Dominique Bourgeois of the IBS. Among other things this team maintains and develops the cryobench laboratory at the ESRF, which enables researchers to freeze a reaction and to study transient stages. Katona helped to introduce the technique of Raman spectrometry to the cryobench, allowing the energy of the frozen intermediaries to be read without damaging them with radiation. The equipment that he helped to install is now available to all users, and a paper that he published is given to new users to illustrate what can be done with Raman spectroscopy.

By combining these complementary methods, the IBS–ESRF group was able to produce a "video" of molecular interactions as they happened. Although unlikely to be presented at Cannes, this represented the reaction documented in Katona's most successful yet – "Raman-assisted crystallography reveals end-on peroxide intermediates in a nonheme iron enzyme".

Research brings rewards

This research was recognised by the Académie des Sciences in France as one of six "Great French advances in biology, 2007–2008".

While the Young Scientist of the Year Award took Katona's entire research history into account, this paper was definitely significant for him. He describes his prizes as a "nice surprise" and sums up his research modestly: "I was lucky in many respects. The group was well prepared, the crystals were 'well behaved' – things went smoothly."

After his contract at the IBS finished, Katona returned to Gothenburg as an assistant professor to start his own research group, so his life is currently quite hectic. When working he likes to listen to classical music, while in his free time he turns to French ska and reggae. His current work – perhaps conducted to the strains of Vivaldi's *Spring* concerto – investigates how photosynthesising bacteria harvest sunlight.

Although his work is still in the field of structural biology, Katona is moving away from the Raman spectroscopy techniques that won him his first prizes. With his research group he has taken a step up in management, and he has settled into his new role without any problems.

In the future he hopes to broaden his research further and return to more general studies, because he still sees himself as a biologist first and foremost.

The photosynthesis studies will be conducted at many synchrotrons around Europe, but Katona hopes that another project on how light-sensitive proteins change structure in solutions may bring him back to the ESRF. He has fond memories of the mountains, where he enjoys hiking, and where Bourgeois would occassionally take the research group on trips.

Recalling their time together in the snow and in the lab, Bourgeois describes Katona as "a quiet but extremely talented chap and a nice person to work with. He was brilliant to have in the group. Although he prefers to stay in the background, he has great scientific initiative. He has only spent a few months in his new position in Sweden, but he's already been very successful."

And for those who fear that Katona may have forgotten his Hungarian roots, Bourgeois adds thoughtfully: "He makes a great goulash as well."

K Oliver

Reference

G Katona 2007 *Science* **316** 449–453.

Boosting instrumentation development

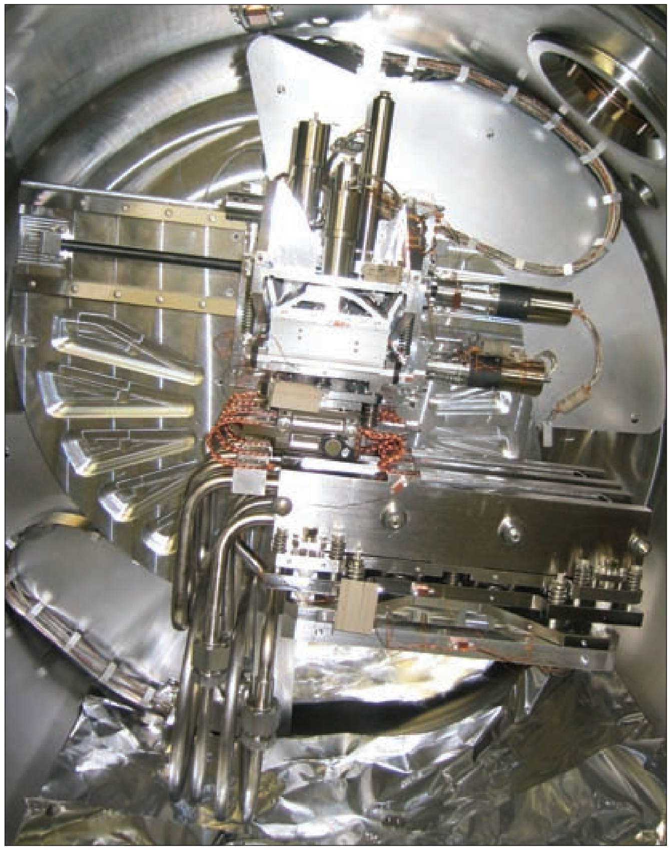
Staff from computing, technical services and experiments make up the new ISDD division.

This spring a new division emerged at the ESRF. It brings together more than 120 people from the experiments, computing and technical services divisions. This reorganisation of staff aims to optimise the capabilities of different groups involved in instrumentation at the ESRF. The ultimate goal is to create a new critical mass of competences to support and monitor instrument development from its design stage to its final implementation.

The Instrumentation Services and Development Division (ISDD) will be driven by a project-management structure. This means that every project will need to be approved and will have a precise timeline and resource allocation.

"With this division we want to capitalise on the knowledge. It is important that one development helps the ESRF as a whole and not only one individual or a small group," explains Jean Susini, head of the ISDD. In this sense "coordination" is a key word that is repeated in the mission statement of the different groups that make up the division.

To fulfill its mission, the ISDD will primarily cover areas such as detectors, control software, data analysis, optics, mechanical engineering and the integration of technology on beamlines.



C DETLEFS

Monochromator on ID6. The Instrumentation Services and Development Division is in charge of defining the specifications of these instruments.

To put this strategy into practice it will be structured around five groups: advanced analysis and modelling; detectors and electronics; software; optics; and mechanical engineering.

Susini explains that there are short-, medium- and long-term goals: the daily support to ESRF staff and the users, the mid-term projects and the R&D innovation, respectively. "Ideally, everyone will contribute to these three activities," he adds.

It is not a coincidence that the ISDD has been created at the time when the Upgrade Programme is starting up. The programme will require a considerable amount of development of instrumentation to achieve the beamlines of the future. The ISDD will carry out research and development of new X-ray optical elements and systems, create a software roadmap for the ESRF and provide a new push for X-ray detection technologies, among other duties.

M Capellas

Movers and shakers

Head of Instrumentation Services and Development
Jean Susini

Jean Susini describes himself as having a "hybrid profile". He has always combined instrumentation development with scientific research and likes to see how these two elements, which are key at synchrotron facilities, relate to each other. This is exactly the aim of the newly created Instrumentation Services and Development Division (ISDD), which he leads. The group will combine instrumentation development as well as a service to the researchers. "This job is a logical continuation of what I started to do at the ESRF," he says.

When Susini arrived at the ESRF 20 years ago with a degree in biology and a PhD in chemistry and physics, he hardly knew what the ESRF acronym stood for. Andreas Freund, the first head of the Optics Group, now retired, met him at a conference and hired him quite soon afterwards. Years later the directors of research assigned him the task of constructing ID21, a beamline optimised for soft-X-ray microscopy applications. "They believed that my background in biology and the expertise that I had in X-ray optics would be an ideal combination, although I didn't know much about microscopy," Susini says.

C ARGOUD

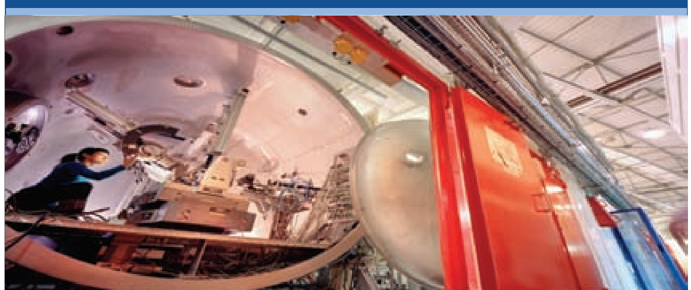
Despite this lack of knowledge, the beamline has proved to be successful and is highly oversubscribed. He believes that his naive and pure approach to the design of the beamline was an advantage more than it was a disadvantage, because he didn´t have any preconceptions or influences. As well as ID21, he built the infrared end-station and took charge of ID22, the hard-X-ray microprobe beamline. These three instruments are functioning today as a microanalytical platform.

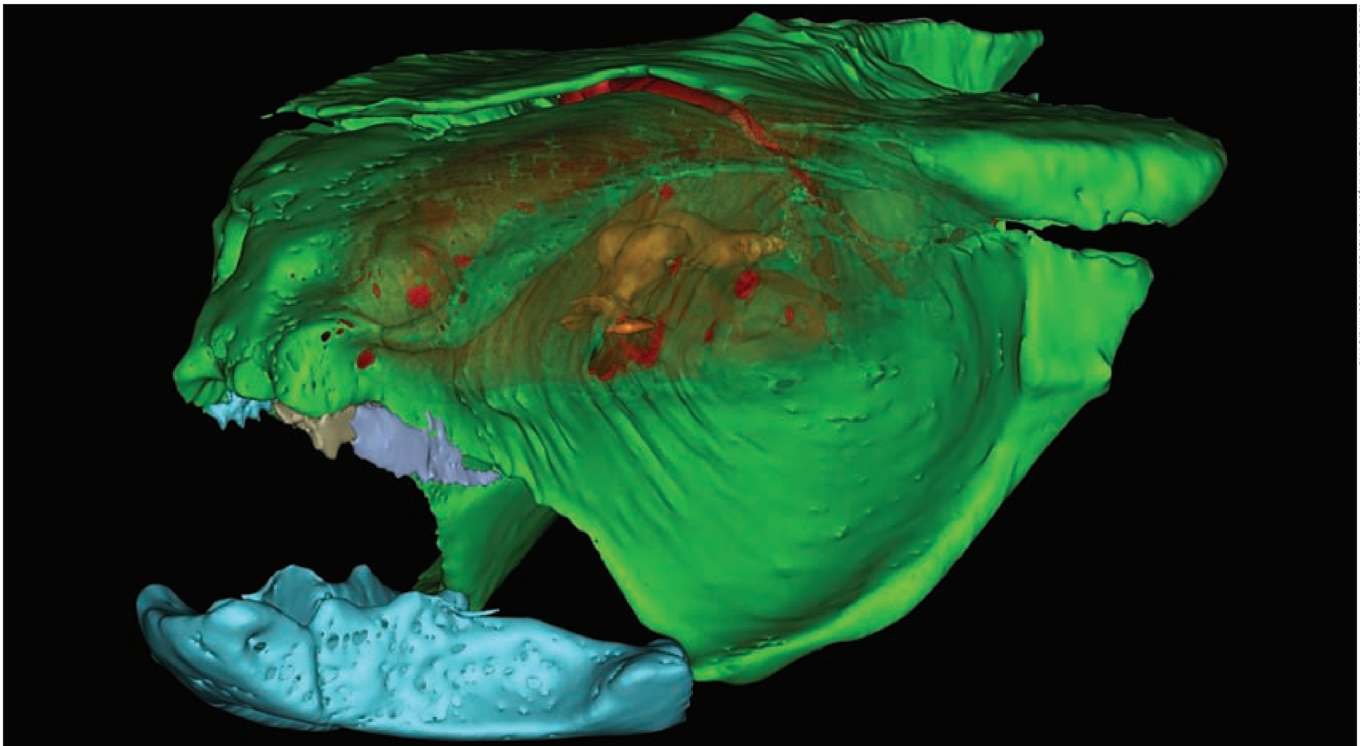
With two beamlines in his control as deputy head of the Imaging Group, Susini started taking on more managerial and coordination duties. He was in charge of the Nanotechnology Platform, which comprised working groups dealing with key issues for the Upgrade Programme, in particular nanobeams. "This platform could be taken as a precursor to the instrumentation development of the Upgrade Programme. It is a model of the spirit of the ISDD," Susini comments.

His main challenges for the next few months are to assemble more than 120 people in the new group and to implement a new culture. "The support provided to the beamlines is a real asset of the ESRF. However, this is sometimes at the expense of long-term development and innovation. We need to find a good balance between the two in the future," explains Susini.

He acknowledges that the task might be laborious, but he hopes that the experience that he brings as a beamline scientist, and his longstanding interactions with scientists and technical staff, will pave the way. He exudes a serene enthusiasm, as he asserts, with a paused smile: "I am looking forward to it."

M Capellas





PNAS/PHILIPPE JANVIER (CNRS, MUSÉUM NATIONAL D'HISTOIRE NATURELLE)

First fossil brain ever found. Scientists from the Muséum National d'Histoire Naturelle, the American Museum of Natural History and the ESRF have elucidated the structure of the skull (foreground) of a 300-million-year-old iniopterygian fish from Kansas, which is remotely related to the ratfish, using the ESRF X-rays on ID19. Thanks to holotomography, a technique based on synchrotron X-ray phase contrast imaging, the results yield the first hint at an exceptional mineralisation of the brain (orange). **Reference** A Pradel *et al.* 2009 *PNAS* **106(13)** 5224–5228.

In the corridors

Do acupuncture points really exist?

Double-blind tests have shown acupuncture to be effective for some ailments but have offered no explanation for how it works (if we discard "blocking the flow of the body's energy" as unlikely).

There are 361 acupuncture points on the body, situated along meridians – lines that acupuncturists believe mark the flow of the body's energy. Although their location is well defined, the existence and function of acupuncture points are a matter of controversy. To discover if their positioning has a biological basis, scientists from Fudan University (China) have examined tissue samples taken from four acupuncture points at the Beijing Synchrotron Radiation Facility.

Using X-ray fluorescence they found that three of the points that were tested showed a significantly higher concentration of calcium, zinc, iron and copper – up to 20 times as much as the surrounding tissues. Samples taken along the meridians also showed a slightly higher level of the metals, peaking at the acupuncture points. No one currently knows what effect high metal concentrations have during acupuncture, but this study seems to support the idea that the practice has some physical aspects rather than just creating a placebo effect.

WELLCOME LIBRARY, LONDON

An acupuncture chart that show some of the energy points.

Reference
X Yan 2009 *Phys. Med. Biol.* **54** N143–N150.

Biometric ID turns to knobbly knees

In high-security environments, recognising and authenticating people often involves identifying them by parts of the body. In a recent paper, researchers say that internal body parts can be just as distinctive. They suggest that matching X-rays of joints could be an alternative method of identification, and much harder to fake – it's more difficult to resculpt a knee than it is to put in contact lenses.

Using algorithms already developed to identify medical joint problems, researchers matched knees to names more than 50% of the time, even if old X-rays were used. This success rate doesn't yet compare with the results from iris scanning or fingerprinting, but with refinements, and possibly the addition of terahertz imaging, accuracy should be improved.

Reference
L Shamir *et al.* 2009 *International Journal of Biometrics* **1(3)** 365–370.

Robots are to be more interactive

Einstein lives again, and he could soon be teaching in a US high school. Scientists at UC San Diego's California Institute for Telecommunications and Information Technology have created a head-and-shoulders model of the world's most famous physicist, backed by software that takes both facts and emotions into account, to build a robot capable of interacting with humans on a deeper level than before.

The Einstein Robot, complete with unruly white hair and a bushy moustache, can recognise and mimic facial expressions, hold a reasonably fluent conversation and, of course, it has the computational ability of a computer. The group chose to recreate Einstein for his iconic status in science, his "emotional accessibility" and his "lovability". These qualities will be put to the test in a real-life environment. If all goes well the robot will act as an assistant teacher in a California high school in September.