THE EUROPEAN SYNCHROTRON

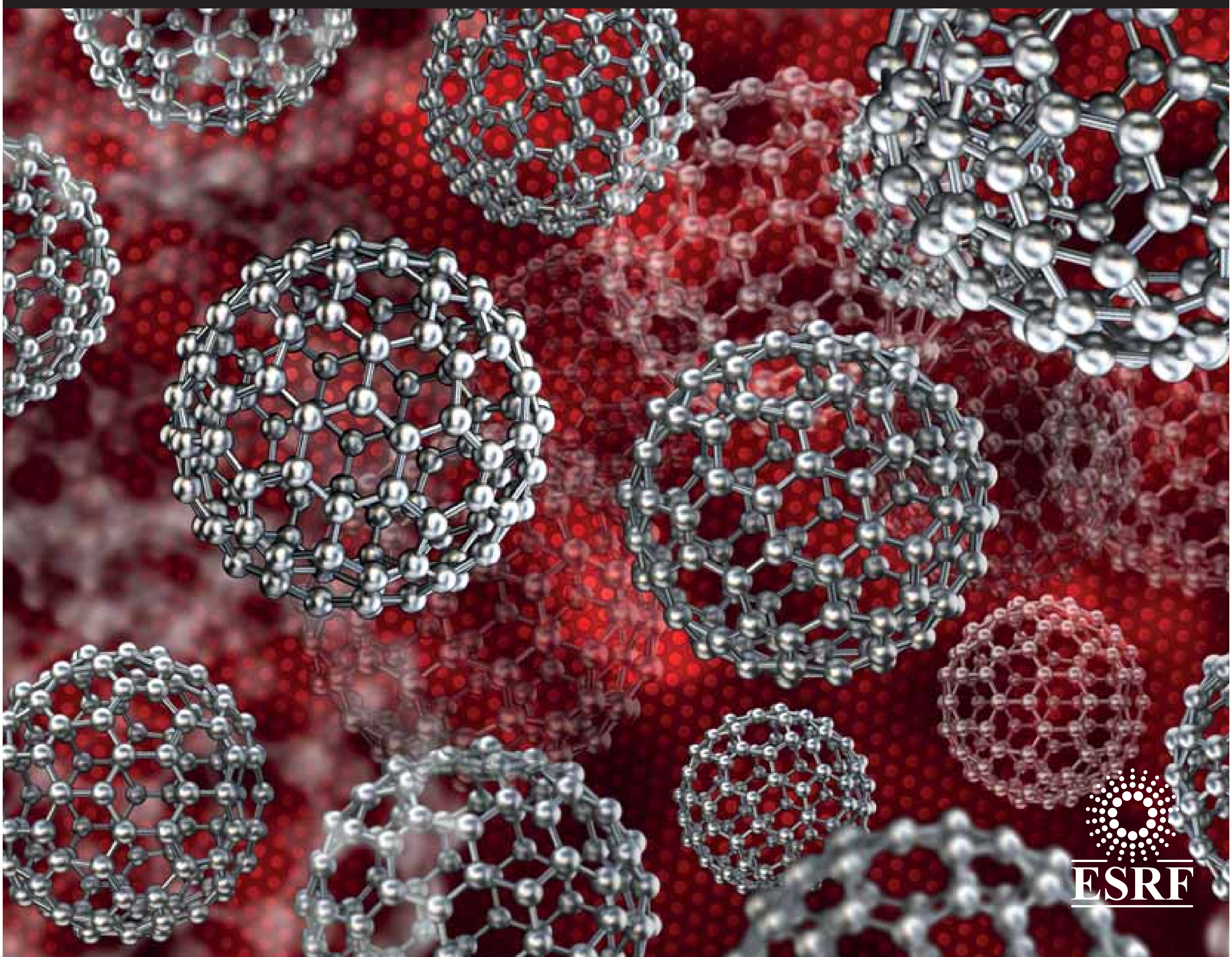
ESRFnews

Number 71 December 2015

Probing the nano world

MXCuBE enters third phase

Mystery at Earth's core



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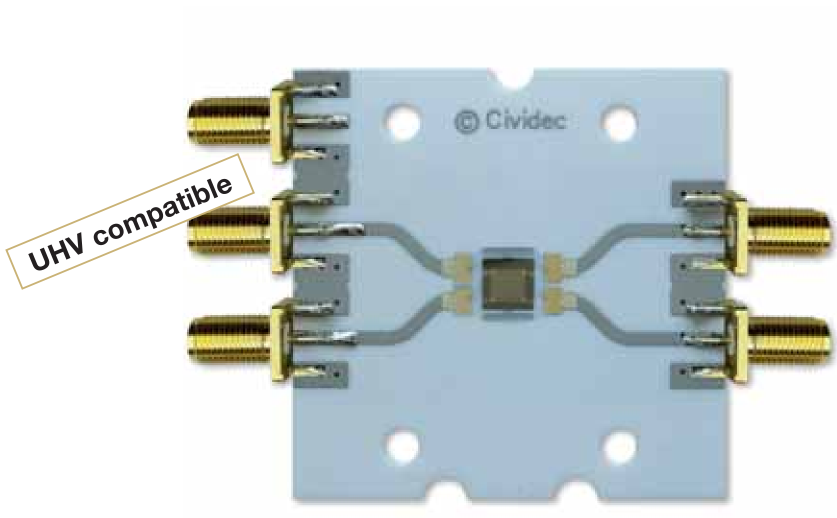

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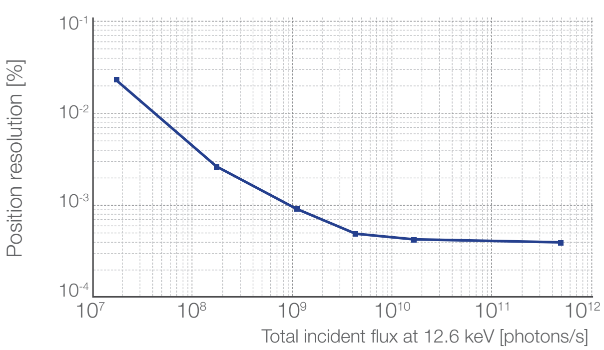

Figure: Measurements at Diamond Light Source Ltd., UK, show the measured position resolution at 1 kHz bandwidth for various beam intensities of the 12.6 keV photons. A position resolution of better than 0.1% of beamsize is obtained even for an incident flux as low as 10^9 photons/s.

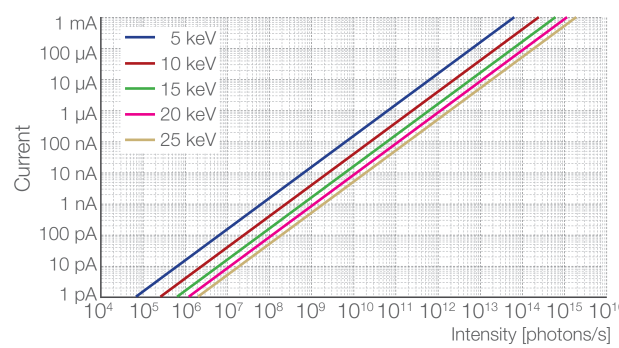

Figure: The detector response as a function of the photon energy and intensity demonstrates the wide dynamic range of the XBPM System in combination with the C8 Electrometer Amplifiers.

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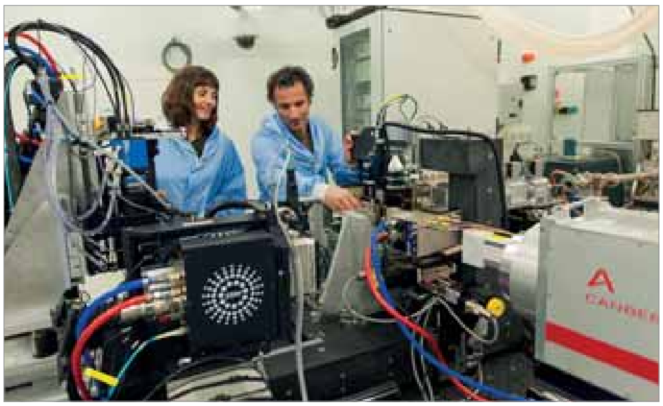
The European Synchrotron

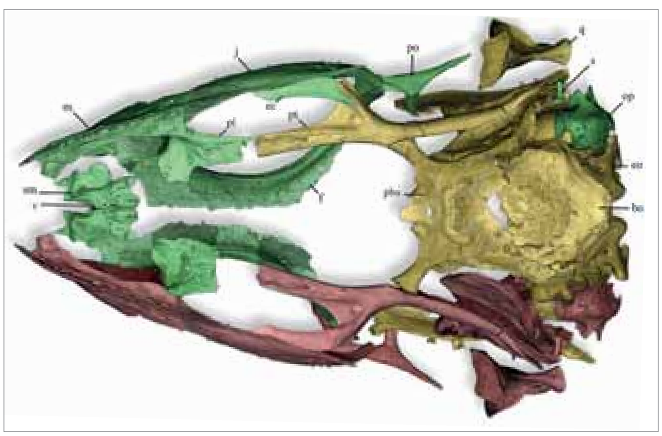
FRÉDÉRIC PATTOU (CDI)

Opening the box on the Archaeological Museum of Grenoble, p7.



PIERRE JAYET

X-ray nanoprobes at ESRF beamline ID16B, p19.



DOI:10.1371/JOURNAL.PONE.0128610

Ancient lizard eggs show their contents, p30.

On the cover: Nanoscience and techniques at the ESRF

ESRFnews Number 71 December 2015

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ESRFnews

Small beams, big science

ISSN 1011-9310

In the past few decades electron microscopy has allowed scientists to study matter with atomic resolution, while modern light microscopy offers sub-100 nm resolution imaging. Thanks to the ESRF and other leading third-generation synchrotrons, X-ray nanoprobes and techniques are now sufficiently advanced to fill the gap between these two imaging modalities – providing an invaluable tool for the structural study of nano-systems.

With Phase I of the ESRF Upgrade Programme drawing to a close, our portfolio now includes seven beamlines capable of providing nanobeams: ID01, ID11, ID13, ID16A and B, ID21 and ID31. These experimental stations offer a powerful suite of techniques including imaging, diffraction/scattering and spectroscopy, with routine focal spot sizes down to 50 nm or smaller. The ESRF's nanobeams, which range in energy from 2–100 keV, also allow *in situ* experiments in specific sample environments and the beamlines exploit the latest technologies in fast nano-positioning, focussing optics and 2D detectors.

The ESRF has a long tradition in exploring assemblies of nano-objects by looking at the average properties of a sample. Today, thanks to the dramatic progress in instrumentation and methods, we are focussing more on individual nano objects (see p19). On the other hand, progress in automation and throughput will allow users to produce statistics over a large number of objects, allowing conventional X-ray-based techniques to be used in combination with local probes. Such possibilities are changing the way X-ray-based techniques contribute to nanoscience.

"X-ray nanoprobes fill the gap between electron and light microscopy"

Nano focus

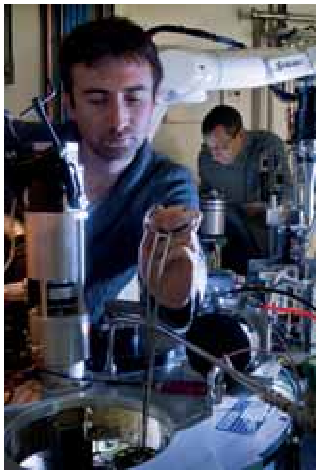
This edition of *ESRFnews* is dedicated to recent research in nanoscience and technology that has been undertaken on ESRF beamlines. Advanced synchrotron X-ray techniques are opening new dimensions in the emerging field of nanobiology (p16–17), and allowing researchers to better understand how nanoparticles enter biological cells (p21). ESRF users are also: identifying nanostructures for high-density data storage (p22); probing the chemistry of radioactive colloids for safe nuclear waste disposal (p24); and characterising nanowires for new device technologies (p25). Our industrial clients too are benefitting hugely from the ESRF's nano-capabilities, for instance to help design 3D integrated structures for next-generation semiconductor devices (p28).

We could have cited many further examples of research in this area, yet today we are still only using 5% of the X-ray beam when going to the smallest beam sizes. In the future, thanks to the ultra-low emittance of ESRF–EBS, we will be able to use most of the photons produced by the source and thus benefit from higher temporal and spatial resolution, throughput and sensitivity.

A further new dimension will open with the tremendous increase of the degree of coherence of the beam, in particular at higher energies. This will allow us to readily surpass the limit in resolution set by the beam size while reducing radiation damage and increasing penetration depth. We are therefore confident that X-ray nanoprobes and techniques will fill the gap between higher resolution electron microscopy and light microscopy, offering users even deeper exploration of matter at the nanoscale.

Harald Reichert and Jean Susini, *ESRF directors of research.*

ESRF/D MCBRIDE



Scientists in the experimental hutch at MASSIF-1.

MASSIF-1 cracks 10,000 crystals

In September, the ESRF's pioneering beamline for fully automatic macromolecular crystallography experiments, MASSIF-1, processed its 10,000th crystal. The beamline reached this milestone less than a year after it began full operations, and remarkably has since screened a further 4000 samples.

MASSIF-1 provides a groundbreaking tool for European structural biologists, allowing researchers to concentrate on complex data collections and interpreting results rather than performing more mundane operations such as sample mounting and centering. It is the first beamline of the Massively Automated Sample Selection Integrated Facility, and is operated jointly by the ESRF and EMBL Grenoble.

The 10,000th crystal was the "NtrX" protein from the bacterium *Brucella abortus* and was prepared by EMBL's High Throughput Crystallisation (HTX) laboratory, which is driving new technology for the automatic mounting of protein crystals. The study involved the screening of around 10,000 conditions to generate more than 100 crystals, from which the team characterised the protein's 3D structure. "To my knowledge, MASSIF-1 is the only beamline that can cope with the volume of crystals we generated, and screen them rapidly," explains Josan Márquez, group leader at EMBL Grenoble. "It was crucial to the success of this project."

Register now for 2016 User Meeting

The 26th ESRF user meeting will take place on 8–10 February 2016. Following last year's successful format, the User Organisation Committee and ESRF management aim to promote exchange among users and with local staff, give higher visibility to users and their science, and improve the interaction between users, beamline staff and facility directors.

C ARGOUD/ESRF

Participants enjoy scientific exchanges at last year's meeting.

The plenary session of the meeting on 9 February will include three keynote lectures from users covering aspects of the wide range of research carried out at the ESRF. There will also be a report from the facility directors and a talk from the winner of the prestigious Young Scientist Award. This session will be complemented by tutorials for users and several user-dedicated microsymposia.

A total of eight tutorials will address a range of user interests and activities, while microsymposia will cover three major scientific themes: nanoscience; dynamics of complex systems; and time-resolved room temperature protein X-ray crystallography.

Several poster clip sessions will give young users the opportunity to promote their work and encourage discussions during the evening's joint poster session, which will be followed by the User Meeting dinner. An additional social evening will be held on 8 February.

Registration is open until 22 January 2016, and more information can be found at www.esrf.fr/UM2016.

Reaching out across all audiences

ESRF/C ARGOUD

ESRF welcomes the public at the Mini Maker Faire in Grenoble.

M ALEXANDER

Swedish students align a sample for a diffraction experiment.

ILL/S CLAISSE

The 2015 ILL-ESRF International Student Summer Programme.

Partnering with the International Year of Light, the ESRF was a major presence at this year's French national science festival, Fête de la Science, held on 7–11 October. More than 10,000 people participated in the events where the ESRF was present, with hundreds of visitors building their own spectroscope to separate the colours contained in white light.

Earlier this year, the ESRF welcomed 12 female high-school students from Sweden for a two-day visit as part of the outreach programme Synchrotron@School. They were selected via a competition organised by the University of Uppsala that encourages girls to pursue a science career. They toured the beamlines and met some of the ESRF's female scientists.

Finally, September saw the completion of the second joint International Student Summer Programme organised by the ESRF and ILL. Open to undergraduates from all over Europe, the event offers students a four-week long placement in the world of X-ray and neutron science. This year's event involved 15 students from a total of 120 applications.

Diamond acquires ESRF knowhow

An ESRF-developed CCD camera optimised for synchrotron experiments, the FReLoN camera, has been installed at the Diamond Light Source in the UK.

The €200k device, which was first developed in 1996 and is installed on more than 20 ESRF beamlines, combines speed and sensitivity with an emphasis on linearity and stability. The new system (right) is a clone of a FReLoN setup at ESRF beamline ID24 and will be installed at Diamond's spectroscopy beamline.

The ESRF is keen to share its technologies, says Ed Mitchell, head of the Business Development Office. "Manufacturing unique equipment, as well as technology licensing, are parts of a growing programme to leverage the ESRF's expertise in instrumentation."

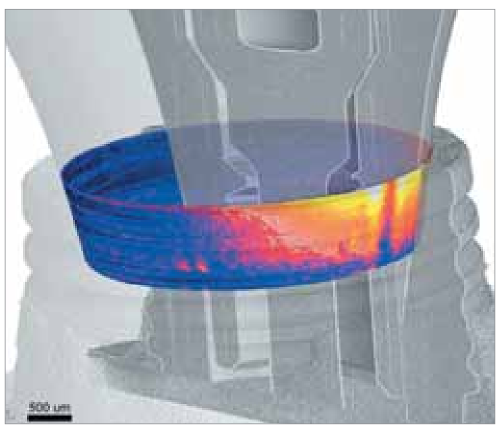
ESRF takes part in major European projects

As part of the European Union's research and innovation programme, Horizon2020, the ESRF is set to play a significant role in two major projects that were launched in October.

The European Cluster of Advanced Laser Light Sources (EUCALL) is a three-year long €7 m project designed to foster closer collaboration between major X-ray sources and advanced laser facilities for the benefit of users. The project will be managed by the European XFEL, the X-ray free-electron laser in Germany that is due to switch on in 2017, with the ESRF and the Extreme Light Infrastructure in the Czech Republic, Hungary and Romania playing key roles.

The second project is a four-year long, €4.5 m effort to develop high-power diamond electronic devices, which could help to reduce the huge energy losses associated with electrical power transmission and transport. The ESRF is one of 14 institutes involved in the "Green Diamond" project, and will play a vital role in characterising the diamond material that will be used by the other partners (www.greendiamond-project.eu).

Closing the gap on dental implants



3D visualisation of an IAC microgap map superimposed on the CT scan of the dental implant: yellow and blue correspond to large and small gaps, respectively.

Dental implants are a common way to replace missing teeth and typically involve an abutment, which is fixed to the jawbone, and an implant body. It is vital that the gap between the implant and the abutment is as small as possible – otherwise microgaps can allow microbes to enter, possibly resulting in infection or peri-implantitis. Microscale deformations along the implant–abutment connection (IAC) can even cause an implant to loosen or fracture.

A recent study at ESRF beamline ID19 led by Wolfram Wiest of the University of Würzburg and co-workers reports a new technique to study cyclic deformation in dental implants (*J. Synchrotron Rad.* **22** in press). Using an optimised apparatus that allowed different chewing scenarios to be simulated, the team was able to visualise fatigue loading of dental implants in real-time. "Synchrotron real-time radioscopy and *in situ* microtomography are the only techniques providing direct visible information on a micrometre scale of local deformation in the IAC during and after cyclic loading," says co-author Alexander Rack of the ESRF.

Imaging opens ancient box

P TAFFOREAU/ESRF

The damaged box contains a medal depicting Christ's crucifixion and resurrection.

The inner secrets of a small 17th-century metallic box have been revealed thanks to X-ray microtomography at ESRF beamline BM05. Discovered buried alongside a corpse on the archaeological site of the Saint-Laurent church, now the archaeological museum of Grenoble (MAG), researchers have previously been limited to preserving the badly damaged and fragile box without gaining any insight into its contents. Thanks to the non-destructive imaging techniques at the ESRF, in particular synchrotron X-ray phase contrast microtomography, scientists from MAG and the ESRF were able to virtually reconstitute the inaccessible contents of the box in 3D with astounding resolution – showing the presence of three medals.

"It was only supposed to be a small feasibility study to produce an image for an exhibition," says Paul Tafforeau of ID19. "However, the results were so astounding that it turned into a full-scale research project."

THE BARNES FOUNDATION

Henri Matisse's The Joy of Life.

X-rays reveal why yellow loses its shine

For more than a decade, museum scientists have puzzled over the deterioration of a bright yellow pigment used by famous artists.

Using beamline ID21, Jennifer Mass of the Winterthur Museum in the US and co-workers used a combination of X-ray techniques to study samples of damaged paint removed from masterpieces by Matisse. They then compared the results with those obtained using similar techniques from paintings by Van Gogh and Ensor. The team found that the original chemical compound, cadmium sulphide, which is highly water insoluble and bright yellow, is subject to a light-induced oxidation process that transforms it into the colourless and highly water soluble compound cadmium sulphate.

Closer management of lighting conditions and relative humidity levels could therefore help to mitigate further damage (*Applied Physics A*, DOI:10.1007/s00339-015-9239-4).

Record pressure leaves osmium intact

An international team led by researchers at the University of Bayreuth in Germany and with participation of the ESRF and DESY has created the highest static pressure ever achieved in a lab. Using a novel double-stage diamond anvil cell, the researchers investigated the behaviour of the metal osmium at pressures of up to 770 GPa – more than twice the pressure in the inner core of the Earth, and about 130 GPa higher than the previous world record set by members of the same team.

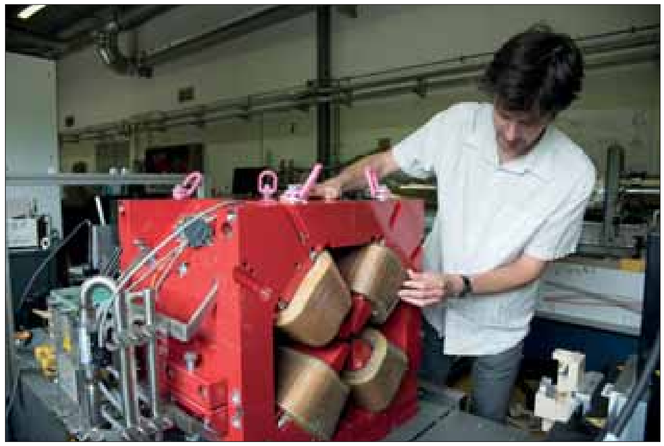
Surprisingly, osmium does not change its crystal structure at such pressures, but its core electrons come so close to each other that they can interact. The team used high-brilliance synchrotron X-rays at ESRF beamline ID09, the PETRA III source at DESY and the APS in the US to probe samples under such extreme conditions (*Nature* **525** 226).

New magnets pass crucial tests

High-precision tests have been conducted on the first prototype quadrupole for the ESRF's new storage ring, ESRF–EBS, which is due to be implemented towards the end of the decade during Phase II of the ESRF Upgrade Programme (see right).

Quadrupole magnets, which comprise four magnetic poles arranged around a central aperture, ensure that electrons are densely packed together as they pass through the storage ring and therefore result in more brilliant photon beams. The new ESRF storage ring will see electrons pass through two families of quadrupoles: first through large-aperture, moderate-gradient quadrupoles, and then through smaller-aperture, high-gradient quadrupoles in order to maximise the electron concentration.

Designed in-house by Gaël Le Bec of the ESRF Insertion Device and Magnets Group, the 955 kg prototype iron magnet is five times stronger than those in the present machine, with a magnetic gradient of 90 T/m, and uses much less energy due to a more optimised design. Narrow apertures were key to the design of the prototype, since the smaller the aperture the greater the gradient and therefore focusing power of the magnet.


C ARGOUD/ESRF

Gaël Le Bec during tests of the first prototype magnet for the ESRF's new storage ring, ESRF–EBS.

Le Bec's tests, which were conducted over a period of three months, have concentrated on measuring the centre and defining the axis of the aperture by moving a 100 µm titanium wire through the aperture while analysing its position and induced voltage. This will make sure the magnets are correctly aligned, which prevents the electrons from being kicked off course. The quality of the magnetic field and its gradient were also measured in detail to check for imperfections.

The tests were successful and a call for tender is now being prepared for producing the final magnets. A total of 512 quadrupoles will need to be produced for the new storage ring, which will produce X-ray beams a factor 100 brighter than at present and with a much higher degree of coherence.

User firsts at beamlines ID30B and ID32

The ESRF's state-of-the-art beamline for protein crystallography, ID30B/MAD, welcomed its first users this summer. The team from Leiden University in the Netherlands used the beamline to study crystals of Cockayne Syndrome Protein B (CSB), which is a key element in repairing UV-damaged DNA implicated in the onset of Cockayne syndrome.

Solving the structure of CSB opens up a path to finding a cure for this rare neurodegenerative disorder, which is characterised by short stature and an appearance of premature aging. After just three shifts at the ESRF, team leader Navraj Pannu was confident that the data obtained will allow a full solution of the protein structure. "The level of automation and the technological developments pioneered at the ESRF were crucial in collecting high-quality data from such a fragile sample," he says.


C ARGOUD/ESRF

ID30B scientist Andrew McCarthy and ESRF users Claudia Temperini and Navraj Pannu from Leiden University.

Meanwhile, in July, the high-resolution soft X-ray resonant inelastic X-ray scattering (RIXS) branch of beamline ID32 also welcomed its first users. A team from the Politecnico di Milano and CNR in Napoli, Italy, and the Max Planck Institute for Solid State Research in Stuttgart, Germany, performed studies of spin excitations in layered cuprates, which are promising high-temperature superconductors, and were able to measure the 3D spin-wave dispersion of $CaCuO_2$ for the first time.

The other branch of beamline ID32, devoted to soft X-ray dichroism (XMCD) studies, hosted its first users in November last year.

Phase II upgrade renamed ESRF–EBS

The ESRF is now entering the second and final phase of its upgrade programme, which is centred on the design and implementation of a pioneering low-emittance storage ring. To mark the characteristics of this world-leading project, ESRF management has decided to rename the project "ESRF–EBS", where EBS stands for Extremely Brilliant Source.

Whilst the first phase of the upgrade programme focused on the implementation of a new generation of beamlines, ESRF–EBS includes the delivery of the first of a new kind of synchrotron source with a normalised horizontal emittance a factor 10 better than any existing facility. Launched in May, ESRF–EBS represents an investment of €150 m for the period 2015–2022.

ESRF–EBS: call for expressions of interest

ESRF–EBS, which is due to be operational by 2022, will allow users to benefit from a factor 100 gain in brilliance and transverse coherence of the X-ray source compared to today's performance. In order to maximise scientific exploitation of the new machine, the ESRF management – mandated by the ESRF Council and Science Advisory Committee (SAC), and in conjunction with the ESRF user community – aims to identify new and challenging experimental programmes and beamlines by the end of 2017.

The ESRF is therefore seeking expressions of interest for the identification and definition of science cases for new beamlines, end-stations and instruments that will complete and strengthen present capabilities. The science case and conceptual design of new projects will be submitted to the ESRF SAC after which advice will be given to Council on the final choice and implementation.

The deadline for submission of expressions of interest is 11 March 2016, and a template for submissions can be found at: www.esrf.eu/home/about/upgrade/ESRF-EBS-call-expressions-of-interest.html.

News from the User Office

An impressive 1135 proposals were received for the autumn proposal deadline, which was changed to 10 September this year in order to give users more time to prepare proposals following the summer vacation and conference season. This is the second highest number of proposals ever received for an ESRF submission deadline and the highest ever for an autumn proposal round, demonstrating the benefits of the later submission deadline. The proposals were reviewed during the Beam Time Allocation Panel meetings held on 22 and 23 October.

The next deadline for submission of standard proposals is 1 March 2016. Proposers are reminded of the importance of submitting Experiment Reports for all beamtime allocations previously used, which are considered essential by the Panels before further beamtime allocations can be considered. The next deadline for submission of Long Term Proposals (LTPs) is 15 January 2016, and proposers with LTPs ongoing must submit progress or final reports by 31 January 2016.

The 26th ESRF User Meeting will take place on 8–10 February 2016, with a format following that of last year's highly successful event (see p6).

News from the User Organisation Committee

The ESRF User Organisation provides an organised framework for discussion within the user community and a direct link between users and ESRF management.

The structure of the ESRF User Organisation Committee (UOC) closely resembles the ESRF beamline group structure, with one representative per beamline group and a seventh member representing the surfaces and interfaces community. With the ESRF beamline group structure having recently been modified (see p28), the UOC structure will evolve to reflect those changes. More information about your UOC representatives and the role of the organisation can be found here: www.esrf.fr/UsersAndScience/users_org.

In order to strengthen contact between UOC representatives and the relevant ESRF users, it is important for the committee to have an updated list of which users work in each of the different fields we represent. A recent update in the ESRF User Portal allows you to indicate the fields of interest appropriate for your research, allowing more targeted communication.

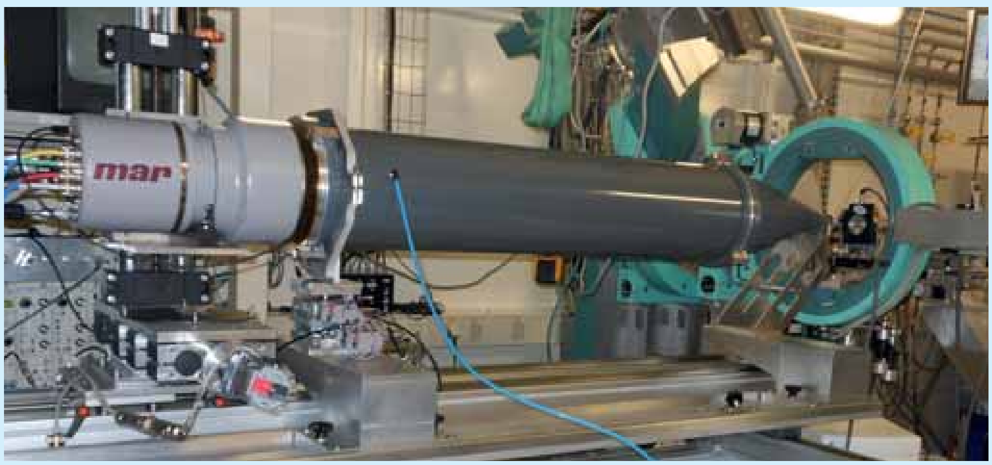
Paola Coan, Chair of the UOC

News from the beamlines

- **ID01** has begun commissioning of dark-field diffraction microscopy, which has a demonstrated resolution as low as 400 nm, and will be open to users as of 1 March 2016. A 1M Eiger pixel detector will also be commissioned and be made available to users in the new year.

- The refurbishment of **ID15** is going ahead as planned and on schedule. As previously reported, the new beamline will be on a canted section with **ID15A** being dedicated to materials chemistry and engineering and **ID15B** dedicated to the high-pressure science programme currently located at **ID09A**.

- The investigation of heterogeneous catalysts *in operando* is one of the main areas of research at the XAS beamlines ID24 and BM23, which are devoted to time-resolved and extreme-conditions research. The beamlines have particular scientific impact in investigations of supported metal nanoparticles used as active catalysts in the automotive industry, or of toxic metals in soils and water, catalysts involved in water splitting reactions, and the production of a variety of synthetic "green" hydrocarbons from biomass. A new combined DRIFTS/XAS facility for structure/function studies of catalysts is now available on **ID24** and **BM23**. The DRIFTS spectrometer is used in synchrony with time-resolved EXAFS for *in situ* characterisation of structure-function relationships in heterogeneous catalysts and other functional materials. Time resolution typically ranges between 0.1–10 s per spectrum and the setup is mounted inside a Plexiglas box to avoid IR signals from water and carbon dioxide. The operational temperature range is 300– 970K and the cell can be operated under pressures of up to 10 bar.



The UK operated CRG beamline "XMaS" has a new setup for GISAXS and reflectivity XRR measurements.

- Several recent modifications to the Spanish CRG beamline SpLine (**BM25A/B**) have boosted the beamline's performance and capabilities. On **BM25A**, both stations have been upgraded. The high-resolution powder diffraction station has been completely refurbished including: new control and detection electronics, a new diffractometer, a new set-up for detectors, and improved sample environments including a new set-up to study solid-gas reactions at isobaric and isothermal environments as well as a continuous liquid He flow cryostat. The XAS station has received a set of three custom built low-noise ionisation chambers, and the sample set-up and detectors are placed inside an isolation box that can be filled with He gas in order to decrease air absorption. On the six-circle multi-purpose diffractometer of **BM25B**, a new multi-purpose portable UHV-high pressure chamber including a continuous liquid He flow cryostat (25–1000 K) and background/diffuse scattering rejection slits has been developed and installed. On the HAXPES-GI-XRD station a continuous liquid He flow cryostat and a 2D MAXIPIX detector have been installed.

- The UK CRG beamline XMaS (**BM28**) has installed a new set-up especially suited for combined grazing incidence small angle (GISAXS) and reflectivity (XRR) experiments. This new set-up, which was designed in collaboration with Nominal Ingénierie, improves the capabilities for standard SAXS and WAXS measurements and also for measurements under applied magnetic fields.

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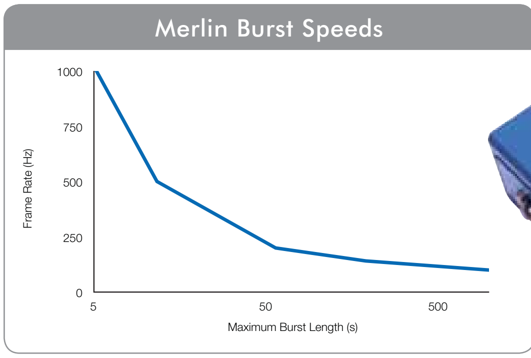

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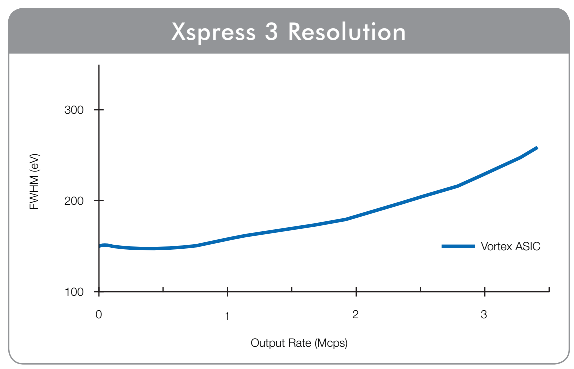

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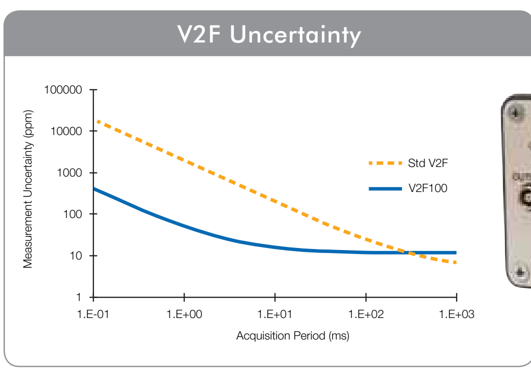

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XAS tackles mystery at Earth's core

X-ray absorption spectroscopy at elevated pressures opens a new chapter in the quest to map the temperature profile of the Earth.

We understand precious little about the world beneath our feet. Although the interior of the Earth cannot be observed directly, seismic waves reveal that its core is made of iron and allow researchers to estimate the density profile of the Earth very precisely. But the temperature profile, also called the geotherm, is much less well understood. Knowledge of the melting temperature of iron at the border between the solid inner and liquid outer core would provide an important constraint on the geotherm, revealing the temperature, thermal history and dynamics of our planet.

Efforts to measure this temperature date back to 1993 when Reinhard Boehler, now at the Carnegie Institution of Washington in the US, used optical microscopy to study iron under high-pressure conditions. Since then, X-ray measurements have allowed more detailed structural studies of iron under pressure, yet there has been a long-standing debate over the temperature determined by early static laser-heated diamond anvil cells (DACs) compared to that from dynamic compression studies using high-power lasers and also more recent static laser-heated DAC studies.

In 2013, for instance, X-ray diffraction carried out at the ESRF by Simone Anzellini of the CEA and co-workers using static laser-heated DACs suggested that the temperature of Earth's inner core boundary is around 6200K – more than 1000° hotter than previously thought (*Science* **340** 464).

New angle

Boehler, along with ESRF staff and an international team of users led by Giuliana Aquilanti of Elettra-Sincrotrone Trieste in Italy, has now used an alternative method: X-ray absorption spectroscopy (XAS), which provides structural information within a few angstroms around the photo-absorbing atom. Thanks to a major upgrade of ESRF beamline ID24, the first *in situ* laser heating facility for a DAC compatible with XAS has recently been developed.

ESRF scientist Innokenty Kantor setting up a laser-heating experiment at beamline ID24.

"There has been a long-standing debate over the core temperature."

The team used modifications of the onset of the absorption spectra as a melting criterion, and the results showed a melting temperature of iron of 3090 K at 103 GPa (10.1073/pnas.1502363112). This is in agreement with most previous studies up to such pressures but differs significantly from the value obtained by Anzellini and colleagues in 2013 using XRD, which reports a much steeper melting curve in agreement with dynamic compression estimates and theory. Although an accurate extrapolation of the data to Earth's core conditions is difficult, the XAS results suggest a melting temperature of iron below 5000 K when extrapolated to the Earth inner-core-boundary conditions.

The study presents a new technique to measure melting in DACs that complements other methods, explains ESRF co-author Sakura Pascarelli. "Since XAS is sensitive to other aspects of melting such as changes in the electronic structure, it can potentially help scientists understand the observed discrepancies in the literature," she says. "These differences have significant implications for estimating the temperature of the Earth's interior, so further studies are needed."

Matthew Chalmers

Extreme science goes further

Science at extreme conditions is one of the scientific pillars of the ESRF Upgrade Programme. Phase I of this project has seen the construction of two new beamlines with unprecedented performance: ID20, for inelastic and X-ray Raman scattering, and ID24 for X-ray absorption spectroscopy (XAS). On ID24 X-rays are focused to spot sizes of a few microns and the beamline is capable of reaching pressures of 2.7 Mbar using diamond-anvil cells and 5 Mbar using laser-shock compression methods. In addition, ID24 offers the only *in situ* laser heating facility in the world for XAS, allowing users to study the local structure in melts at conditions present in the Earth's outer (liquid) core.

For Phase II of the ESRF Upgrade Programme, which has been renamed ESRF–EBS (see p9), the Matter at extremes group seeks new projects to enhance the ESRF's capabilities. One of our priorities will be to propose an upgrade of the high-pressure X-ray diffraction (XRD) beamline ID27 to take full advantage of the increased brightness and coherence of the new storage ring, which will enable XRD on light elements at pressures and temperatures up to those in the Earth's core and beyond.

In parallel, the Matter at extremes group will propose a facility that allows high power laser shock dynamic compression experiments using several X-ray techniques. This new facility would enable users to probe states of matter that go beyond the Earth's core, perhaps reaching pressures as high as 10 Mbar and temperatures of 20,000 K. This is important for many reasons, for example understanding the interiors of exoplanets and whether such objects can host life.

Sakura Pascarelli, group leader for Matter at extremes


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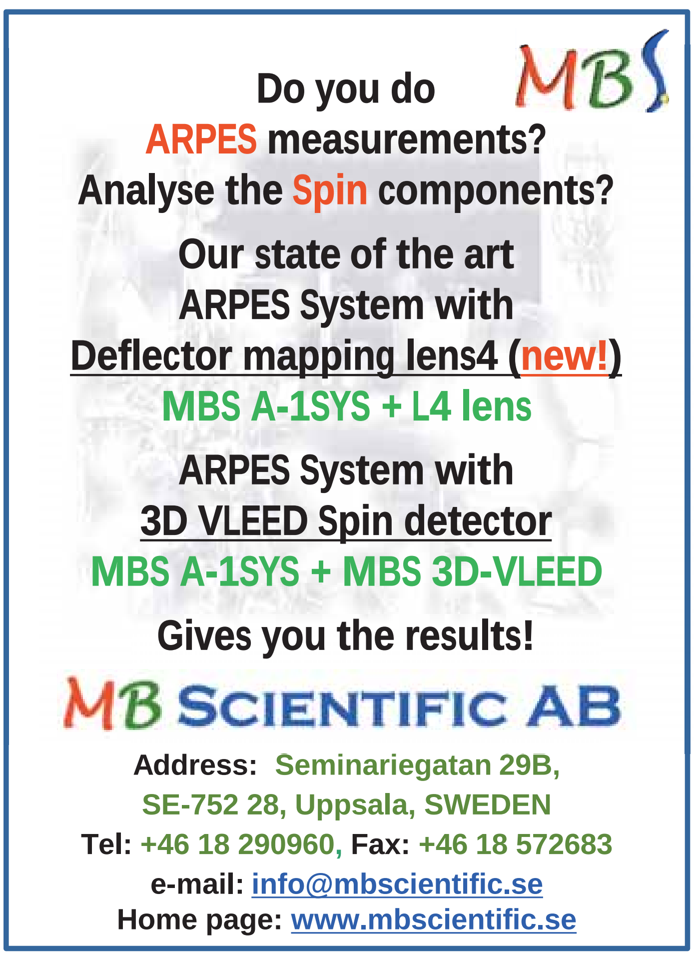
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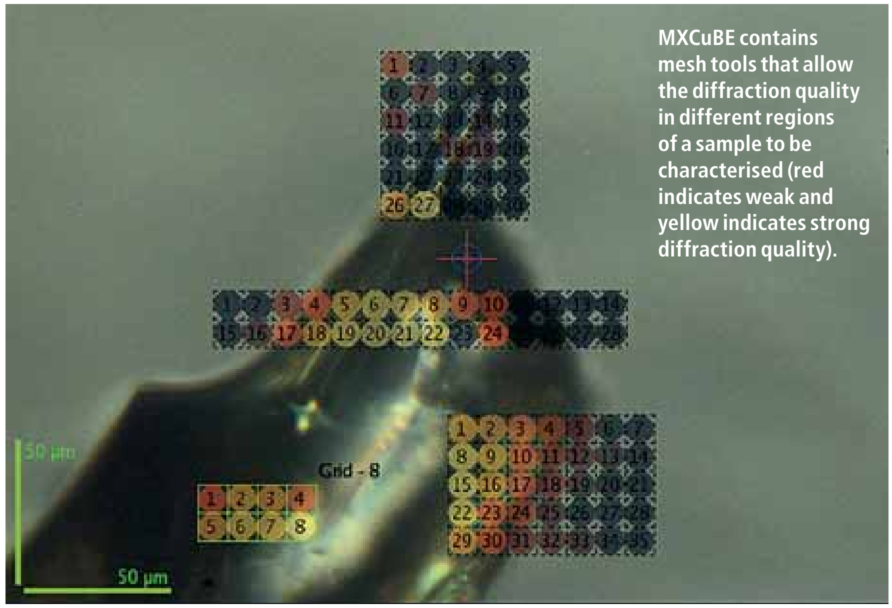
MXCuBE targets third phase

Europe boasts several synchrotron X-ray sources offering some 30 experimental stations for macromolecular crystallography. Thanks to the MXCuBE platform, originally developed at the ESRF, users now have a common standard and language to make the most of these facilities.

In studying the structure of biological molecules at synchrotron facilities, the macromolecular crystallography (MX) community typically performs complicated and demanding experiments on numerous samples. It is therefore vital that scientists have a user-friendly interface that provides intuitive access to the definition and control of those experiments. MXCuBE (MX Customized Beamline Environment) is a software platform dedicated to beamline control and data acquisition for MX experiments. It was originally developed at the ESRF in 2006 via a combination of in-house funding and support from the FP7 EU project BIOXHIT. The package has since matured into the MXCuBE2 application, which offers better integration with sample changing robots and provides more intuitive workflows for carrying out complex experiments.

MXCuBE is currently deployed on all MX beamlines at the ESRF, and is also used as the general user interface on many MX beamlines at several other European synchrotrons. In 2012 a memorandum of understanding was signed by six partners to establish the MXCuBE Consortium, with the goal of joint use and collaborative development of the platform. The initial partners were: the ESRF, the European Molecular Biology Laboratory; Global Phasing Limited; the HZB-Berlin in Germany; MAX-IV in Sweden; and SOLEIL in France. In 2014 two further light-source laboratories – ALBA in Spain and DESY in Germany – joined the consortium. The MXCuBE consortium thus has an unprecedented seven synchrotron facilities coordinating their efforts and sharing resources to provide an essential tool for MX experiment control and design.



MXCuBE contains mesh tools that allow the diffraction quality in different regions of a sample to be characterised (red indicates weak and yellow indicates strong diffraction quality).

Thanks to the MXCuBE Consortium structural biology researchers now have access to a common software platform, with only certain site-specific customisations, at the majority of European synchrotron sites. This allows users to focus on the experiments they would like to perform with minimal distraction from local beamline idiosyncrasies. For the synchrotron sites themselves, the collaboration has boosted the development of a mature and "battle-tested" system with an enormous amount of built-in scientific experience. For newer synchrotron facilities, or those with limited resources, the project has enabled the rapid implementation of a user interface with high-level functionalities.


U MUELLER, / HZB-BERLIN

Participants of the MXCuBE Consortium meeting held in June at the BESSY-II source in Berlin.

Towards MXCuBE3

New technologies in synchrotron and beamline instrumentation, as well as detector development, have recently given rise to an explosion of new options for conducting MX experiments including completely automatic data collection and new protocols for synchrotron serial crystallography. A jointly developed version of MXCuBE is the only way for the individual partners to fully exploit these new possibilities in a user-friendly manner.

To ensure the sustainability of MXCuBE the consortium is now collaborating on a common upgrade of the platform towards MXCuBE3 (MX^3), which will incorporate new software engineering paradigms and standards. Here, the goal is to develop a beamline control system that runs as a web application, providing easier integration with future computer platforms and offering a tighter integration with MX experiment database ISPyB and a better remote access experience for both new and experienced users.

This project will be a valuable opportunity to identify the strengths and weaknesses of the current platform and to learn about transitioning mission-critical applications between technologies, enabling MX^3 to offer an even broader portfolio of experimental possibilities to scientists using MX in structural biology and to companies using it as a tool for drug discovery.

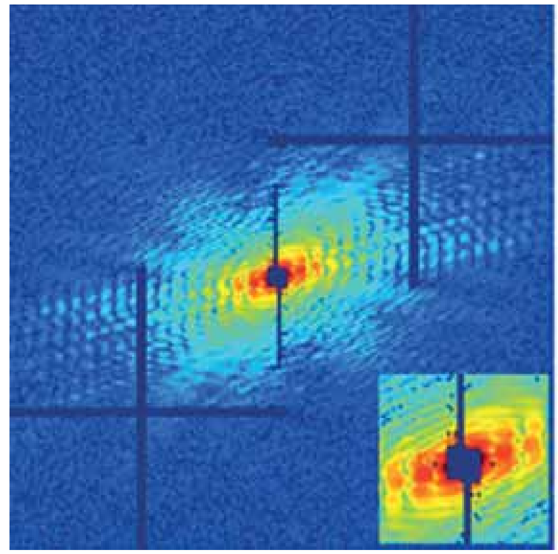
MXCuBE Consortium

Nanobiology: from 3D cellular

ESRF users are working at the intersection of nanotechnology and l
of cells, addressing the mystery of why teeth are so tough,

More than 350 years after Robert Hooke's pioneering observations of cells in cork, we are experiencing a revolution in cellular imaging. Optical microscopes are able to reveal the inner workings of cells in real time and with a spatial resolution surpassing 100 nm, while electron microscopy now approaches atomic resolution in images of single protein molecules. Bridging the gap between these two imaging modalities is X-ray microscopy, a relatively young method that seeks to capitalise on recent improvements in the brightness and coherence of synchrotron X-ray sources.

Coherent X-ray diffraction imaging (CDI), which is becoming available at the ESRF and a handful of other third-generation synchrotron sources worldwide, aims to recover a quantitative map of the 3D structure of a cell. CDI can image thicker specimens than electron microscopy and with higher spatial resolution than light microscopy.

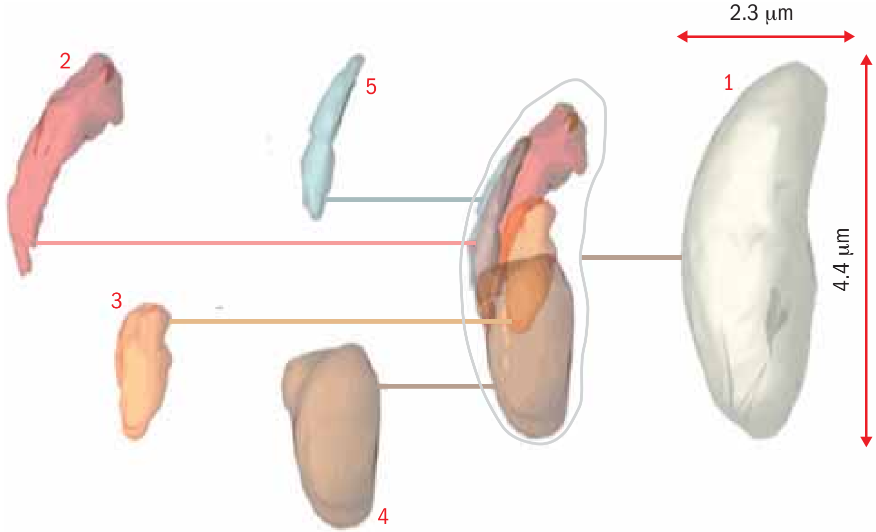


A representative diffraction pattern from the parasite *Neos* **enlarged version of the low spatial frequency region shown** **A 2D projection (right) of the reconstructed cell in which the**

Phase retrieval

An international team has recently used ESRF beamline ID10 to reveal the 3D inner structure of a parasitic cell with an overall spatial resolution better than 100 nm, marking an important demonstration of this powerful technique (*IUCrJ* **2** 575).

Like conventional computed tomography, CDI integrates multiple views of the same object from different angles. Whereas computed tomography relies on direct images of an object, CDI instead interprets the complex pattern of X-rays scattered from a sample induced by a coherent X-ray beam (above). The technique is constrained by what is commonly called the phase problem:



A deconstructed iso-surface model of the cell with 2D projections of 3D renderings showing: cell boundary (1); rhoptries (2); apicoplast (3); nucleus (4); and mitochondrion (5).

Nanoscale secret to teeth's toughness

An interdisciplinary team has used the ESRF to help explain why teeth are able to withstand a lifetime of use. Unlike normal bone tissue, damage occurring in dentin (the bone-like material that comprises the bulk of human teeth) does not heal by tissue replacement or remodelling. The new study reveals, however, that the internal stress in dentin stops cracks from propagating into the sensitive interiors of teeth.

Paul Zaslansky at the Charité–Universitäts-medizin Berlin and co-workers studied the nanostructure of dentin under various stress conditions, and found that the mineral nanoparticles of dentin tightly interact with the dense network of collagen fibres in which they are embedded. The nanoparticles become increasingly stressed in reaction to the compression of the fibres, which increases the resistance of tissues against cracks propagating into the biostructure.

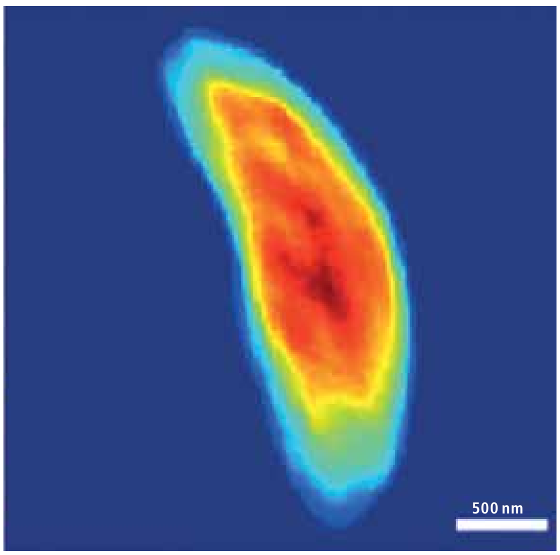
Studying the tiny structures was made possible by state-of-the-art equipment at ESRF beamline ID16 and also the BESSY II source in Germany. "Specialised high-quality and high-power synchrotron X-ray techniques were needed, in particular nanobeams that were used to create virtual slices through the dentin showing the local orientation of the mineral nanoparticles," explains Peter Cloetens, scientist in charge of beamline ID16A-NI. "Cutting-edge microscopy techniques exploiting tiny and very intense X-ray beams are increasingly being used to solve problems in biology and medicine at the new nano-imaging facilities of the ESRF."

The team also demonstrated that heat significantly weakens the link between mineral particles and collagen fibres, resulting in dentin's brittle behaviour. "The hope is that the results inspire the development of tougher ceramic structures for tooth repair or replacement," says PhD student Jean-Baptiste Forien, first author of the study (*Nano Letters* **15** 3729).

Matthew Chalmers

ʳ imaging to DNA construction

ɔiology, with recent studies demonstrating sub-100 nm 3D imaging
and establishing the foundations for DNA nanotechnology.



**ɔora caninum taken at the 0° tilt angle (left), with an
the missing data at the centre is due to a beam stop).
X-ray beam shines into the page.**

the phases of the diffracted X-rays, which represent half of the data required to produce an interpretable image of the object, can not be measured by current detectors. Optical microscopes can avoid this by using a lens to collect diffracted light, but CDI requires powerful computer algorithms to synthesize and interpret the data.

Since the first demonstration of CDI in 1999 at the National Synchrotron Light Source in the US by John Miao of the University of California at Los Angeles, who led the recent ESRF study, the technique has been used to image a broad range of samples from inorganic nanoparticles to whole cells. Biological specimens pose a particular challenge for CDI because they scatter X-rays weakly. While higher X-ray doses can compensate for this, they must be kept to a minimum because biomaterials are sensitive to radiation damage.

Cryogenic conditions

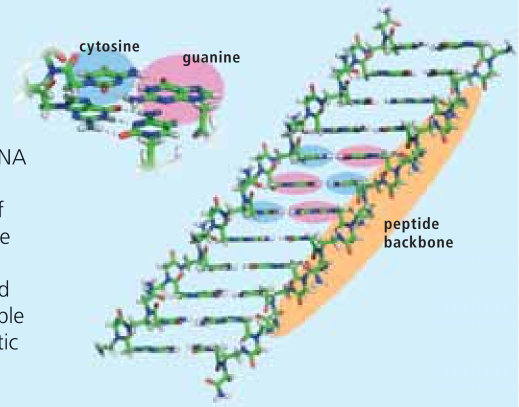
In a first of its kind experiment, our team combined 3D CDI with cryogenic techniques to reveal the architecture of a cell at high spatial resolution. By rapidly freezing the cell while in its native environment, cryogenic techniques allow for long-term interrogation by X-rays. Specifically we investigated a parasite known as *Neospora caninum*, which is closely related to plasmodium and toxoplasma – the causative agents of malaria and toxoplasmosis. The experiments clearly reveal the distinctive banana shape of the cell and the organisation of its inner structures, which are important for infecting its hosts (left).

“This is a first-of-its-kind experiment.”

In general, this study demonstrates the utility of quantitative 3D imaging of whole, frozen-hydrated cells using hard X-rays. As new, brighter and more coherent X-ray sources continue to emerge worldwide, such as ESRF–EBS, we can look forward in the next five years to routine and quantitative imaging of whole cells in 3D with spatial resolutions of tens of nanometres. Such studies are important for obtaining a deeper structural understanding of cells, and may lead to advances in the fields of imaging, biology and medicine, in addition to the development of nano- and biomaterials.

Jose Rodrigez, University of California, Los Angeles, US

Building with life’s building blocks



In 1981, Nadrian Seeman realised that DNA could have uses beyond encoding life. He envisioned scientists taking control of the highly predictable sequence-selective process whereby the four nucleotides – adenine (A), cytosine (C), guanine (G) and thymine (T) – assemble into a stable double helix, opening up a new world of synthetic crystal lattices constructed from DNA.

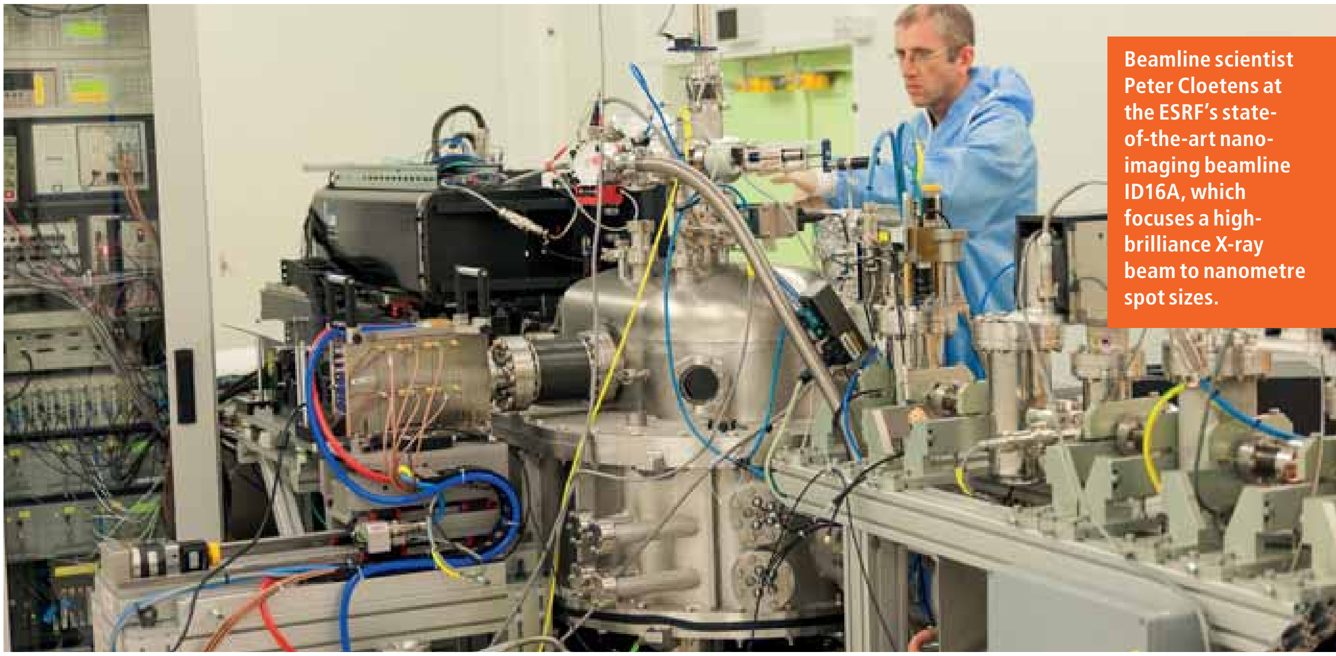
Since these early insights showing the potential of DNA as a building material, there has been a growing effort to embrace structural DNA nanotechnology for applications ranging from molecular biophysics to therapeutics for human health. Synchrotron X-rays have an important role to play in such studies.

Examples of molecular self-assembly are widespread in the biological world, from the ability of DNA to spontaneously form helices to peptides that assemble into nanotubes and fibrils. Thanks to an artificially synthesised polymer called PNA (peptide nucleic acid) that has attributes of both chemical families, researchers are now seeking to converge the distinct fields of DNA and peptide self-assembly for eventual DNA nanotechnology applications.

A team of researchers including Ehud Gazit and Or Berger from Tel Aviv University and Linda Shimon from the Weizmann Institute of Science in Israel has recently used X-ray diffraction at ESRF beamline ID29 to demonstrate the ability of very short PNA building blocks to self-assemble into ordered architectures. The team synthesised 16 different PNA structures with all possible combinations of the A, T, G and C base pairs, and found that they could grow structures *in vitro* with an elongation rate 20 times faster than other known rapidly elongated systems such as microtubules. The newly characterised assemblies also had intriguing optical properties, emitting different colours of light over a range of excitation wavelengths, showing potential for organic nano-photonic devices.

Using the energy-tuning capabilities of ID29 to collect atomic resolution data on thin, needle-like crystals of the GC PNA, it was found that molecules form classical Watson-Crick hydrogen bonds that are further stabilised by stacking interactions (*Nature Nanotechnology* **10** 353).

Linda Shimon, Weizmann Institute of Science, Israel



Beamline scientist Peter Cloetens at the ESRF's state-of-the-art nano-imaging beamline ID16A, which focuses a high-brilliance X-ray beam to nanometre spot sizes.

PIERRE JAYET

Enter the X-ray nanoprobe

New instrumentation and techniques at the ESRF allow researchers to tackle individual nano-objects ranging from biomaterials to next-generation transistors.

It is almost 60 years since physicist Richard Feynman's famous lecture "There's Plenty of Room at the Bottom" in which he envisaged the ability of scientists to manipulate individual atoms and molecules. The term "nanotechnology" was coined in 1974, and since the early 1980s the scanning tunnelling microscope has allowed scientists to see directly into this unfamiliar world.

Synchrotron X-rays are forging a second revolution in our understanding and control of nature at the nanoscale. With a wavelength spanning 0.01–10 nm X-rays offer a unique non-destructive probe for characterising materials. Coupled with advanced analytical techniques and computer modelling, researchers can now create materials with specific chemical and physical hierarchies and therefore tailor the properties of systems ranging from steel or wood to new functional materials for advanced nanoelectronics and nanomedicine applications.

Beyond ensemble averages

The increase in the brightness of synchrotron X-ray sources has delivered ever-increasing resolution for crystallography and spectroscopy. Until recently, however, these parameters were mostly determined as averages over macroscopic regions in real space. Experiments have therefore been restricted to spatially homogeneous samples, excluding device structures and many compound materials that are crucial for technological progress.

Accessing nano-objects at the ESRF

- Beamline **ID01** offers coherent nano-focus diffraction and scanning methods or full-field diffraction microscopy for the study of surfaces, near-surface structures, thin films and buried interfaces on the atomic to micrometre length scale;
- **ID13** provides small focal spots for diffraction and small-angle X-ray scattering, offering both single crystal and scanning diffraction experiments;
- Beamline **ID16A** is 185 m long and provides nano-focused beams for analytical imaging including X-ray fluorescence microscopy and nano-tomography;
- **ID16B** is 165 m long and provides a versatile X-ray microscope for hard X-ray nano-analysis combining X-ray fluorescence, X-ray absorption spectroscopy, X-ray diffraction and 2D/3D X-ray imaging techniques.
- Beamline **ID21** offers an X-ray microscope dedicated mainly to micro-X-ray fluorescence and X-ray absorption near edge structure.

The development of X-ray optics for nano-focused beams is changing that picture, limiting ensemble averages to the X-ray beam size while preserving the high resolution of traditional X-ray methods. In addition, the high degree of coherence expected from the next generation of synchrotrons such as ESRF–EBS will further boost the development of 3D imaging techniques that are not limited in resolution by the focal spot size.

Dedicated group

In order to exploit these capabilities the ESRF has recently established a dedicated X-ray nanoprobe (XNP) group, which intends to foster the ESRF's leading role in methods and enabling technologies involving nano-beams (beamlines in the XNP group are listed left).

The nanoprobe beamlines are equipped with the latest technologies in fast and reliable nano-positioning, focussing optics, and 2D detectors. Together, explains XNP Group leader Tobias Schülli, this leads to the production of multidimensional data at a rate that would not have been technically sustainable only a few years ago. "The frontiers that need to be pushed further are now determined by the X-ray source, and in this perspective the ESRF–EBS will increase our capacities in terms of spatial or temporal resolution by several orders of magnitude and open an entirely new window to the nano world," he says.

Matthew Chalmers

Pixirad-1 System

The **Pixirad-1 System** is the first commercial product of Pixirad Imaging Counters s.r.l.

The core of the X-ray imaging system is a new detector, based on chromatic photon counting, that has been realized coupling a pixelated large area ASIC, known as **Pixie-II**, to a matching pixelated sensor by flip-chip bonding technique. The Pixirad-1 System is able to deliver extremely clear and highly detailed images for medical, biological, industrial and scientific applications.

Pixirad-1 Detector Module options

ASIC[1]:

– Pixie-II read-out ASIC, 60 µm hexagonal arrangement

Sensors:

– 650 µm thick CdTe crystal Schottky type

– 750 µm thick CdTe crystal Ohmic type

– 500 µm thick GaAs crystal

[1] The Pixirad-1 Detector Module Unit is ready to use the new Pixie-III ASIC

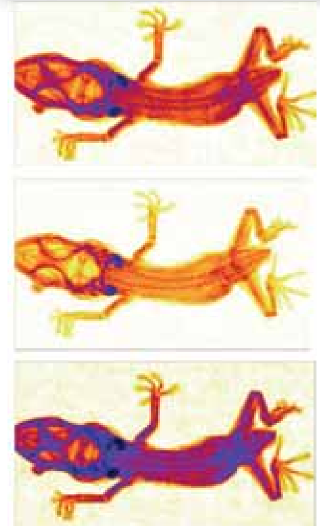
Due to its architecture the Pixie-II ASIC is able to count incident X-ray photons according to their energy in order to produce two 'color' images from a single exposure.

Low Energy Sensitivity

Images of a very low contrast object, taken with
a) 200 electrons global threshold corresponding to 1 keV (LOW counter, all photons)
b) at 6 keV threshold (1200 electrons). This image was taken in a single shot together with the previous one at 1 keV threshold

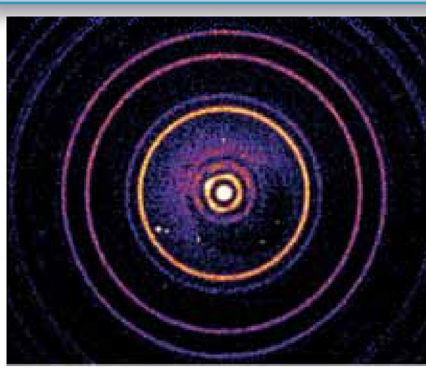
Chromatic Photon Counting

Three 'colors' from a single exposure



Images of a small dry animal obtained simultaneously by :
a) counting the X-ray photons with a low energy threshold (LOW COUNTER, all photons);
b) counting the X-ray photons with an higher threshold (HIGH COUNTER, high energy photons);
c) subtracting the previous pictures one from another (low energy photons)

X-ray Diffraction at 40 keV



Attenuated Beam and diffraction rings from a Ce02 powder (obtained at the Cornell Synchrotron on a 40 keV beam line)

Pixirad-2 System

The new commercial product of Pixirad Imaging Counters s.r.l.

The **Pixirad-2** Detector Module Unit has 2 detector blocks (based on the **Pixie-II** ASIC) in a 2x1 pattern, with a global active area of 62 x 25 mm2.

The Pixirad-2 System is able to deliver extremely clear and highly detailed images for medical, biological, industrial and scientific applications.

Pixirad-2 Detector Module options

ASIC[1]:

– Pixie-II read-out ASIC, 60 µm hexagonal arrangement

Sensors:

– 650 µm thick CdTe crystal Schottky type

– 750 µm thick CdTe crystal Ohmic type

– 500 µm thick GaAs crystal

[1] The Pixirad-2 Detector Module Unit is ready to use the new Pixie-III ASIC

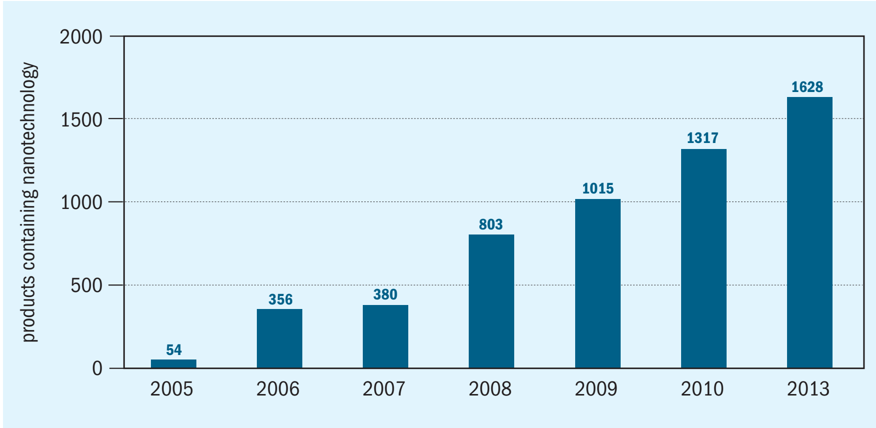
Ohmic CdTe: Low Energy Sensitivity

Images of a very low contrast object, taken: a) at 1 keV threshold (200 electrons, LOW counter, all photons); b) at 6 keV threshold (1200 electrons) in a single shot

http://www.pixirad.com/

Nanotoxicity under the microscope

Study sheds light on the cellular processes that enable nanoparticles to enter the human body.



The number of products containing nanotechnology as part of their composition, as listed by the Nanotechnology Consumer Product Inventory (from Beilstein *J. Nanotechnol.* 6 1769).

Nanomaterials are increasingly found in consumer products, ranging from children's cuddly toys to food additives. Nanoparticles (NPs) also have great potential in the biomedical field, particularly for drug delivery, biosensors and theranostics. However, their impact on human health and the environment is not well understood. NPs can enter the human body via the dermal, respiratory, ocular or gastrointestinal systems. While this can be exploited for medical treatments, it also poses concerns about the detrimental effects of NPs on living systems. The activity of NPs in contact with biological systems is unpredictable, and can vary from being regenerative to highly carcinogenic.

Much of the knowledge in this area has come from phenomenological *in vitro* and *in vivo* studies of cells and animal models, which show that direct cellular entry of NPs is one of the mechanisms through which they impart toxicity. Researchers are therefore focussing on rigorous and quantitative physicochemical methods to study the interactions between nanoparticles and model cell membranes.

Synchrotron X-ray diffraction has already offered key insights into the membrane fusion process, and can be readily applied to assess how NPs impact this process in order to gain cellular entry. Membrane fusion is energetically analogous to the transitions between lipid mesophases with different curvatures, and the way NPs influence this energetic landscape can be evaluated using synchrotron X-ray scattering (SAXS).

Unique method

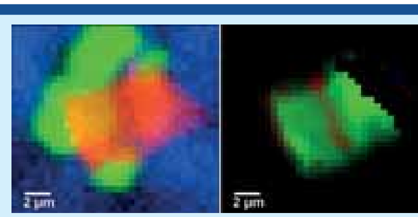
A simple but unique method developed at the ESRF's UK-operated beamline BM28, XMaS, for studying soft nanofilms at the mica-water interface has allowed users to characterise a number of different model membrane structures over the past few years. Using X-ray reflectivity to study the interactions of these systems with different types of nanoparticles, it is now clear that whether the particles will disrupt or intercalate into the lamellar structures depends on the particle size, surface hydrophobicity and charge, and dosage.

Complementary investigations using high-pressure SAXS at Diamond Light Source in the UK revealed that 14 nm hydrophobic silica nanoparticles lowered the energy required for the transition from a lamellar to an inverted hexagonal phase, whereas hydrophilic silica nanoparticles of comparable size exhibited a less pronounced effect.

Taken together, these results show the effects of nanoparticles on the model membrane structures and on the energetic process of membrane fusion in endocytosis. The major task ahead is to understand the correlation between the physical parameters that characterise nanoparticles and their interactions with model membrane systems. These include nanoparticle geometry, surface charge and surface chemistry, and designing membrane systems that mimic the structural and compositional sophistication of cell membranes. This also represents opportunities for contributions to understanding nanotoxicity from a physicochemical perspective using X-ray techniques (*Advances in Colloid and Interface Science* **218** 48).

Charlotte Beddoes and Wuge Briscoe, University of Bristol, UK

Users track silver nanoparticles in blood



Maps of the distribution of Ag (red), Cl (green) and S (blue) in the region surrounding a micrometric agglomerate of AgNPs released by a commercial burn dressing.

Silver has been used to treat wounds since ancient times, acting as a multispectral antibacterial, antiseptic and anti-inflammatory agent. Today, the medical community is trying to develop innovative silver-based materials that deliver optimal antibacterial action while minimising dosage and side effects – in particular for the treatment of severe skin burns. Nanotechnology offers great potential for this application, yet knowledge of the chemical behaviour of silver nanoparticles (AgNPs) in humans is currently limited.

A European research team has collaborated with ESRF beamline ID21 to develop an innovative multi-technique approach for studying the chemical dynamics of AgNPs in biological fluids. The method combines single-particle ICP-mass spectrometry with X-ray microspectroscopy (µXRF and µXANES speciation and imaging) to identify and quantitatively characterise the various chemical forms of silver in complex fluids such as blood. It allows the dynamics of AgNPs to be understood at the level of picograms.

The new approach was used to investigate the presence of AgNPs in blood after the application of a commercial dressing for burns, which contains a coating of AgNPs to help prevent infection. Results showed that non-functionalised silver nanoparticles in the wound undergo dissolution before reaching the bloodstream. This behavior maximises the local antibacterial action while also favouring later removal of the metal in the form of deactivated protein complexes.

The experiment is part of an ongoing effort at ID21 to understand the impact of nanoparticles on the body, and demonstrates the power of synchrotron techniques to help researchers develop nanomaterials for medicine (DOI 10.1007/s00216-015-9014-6).

Marco Roman, Ca' Foscari University of Venice, Italy

Data storage seeks spherical solution

Studies of spherical nanoparticles using nuclear resonant scattering pave the way for novel storage media with capacities of 20 Tbit per square inch.

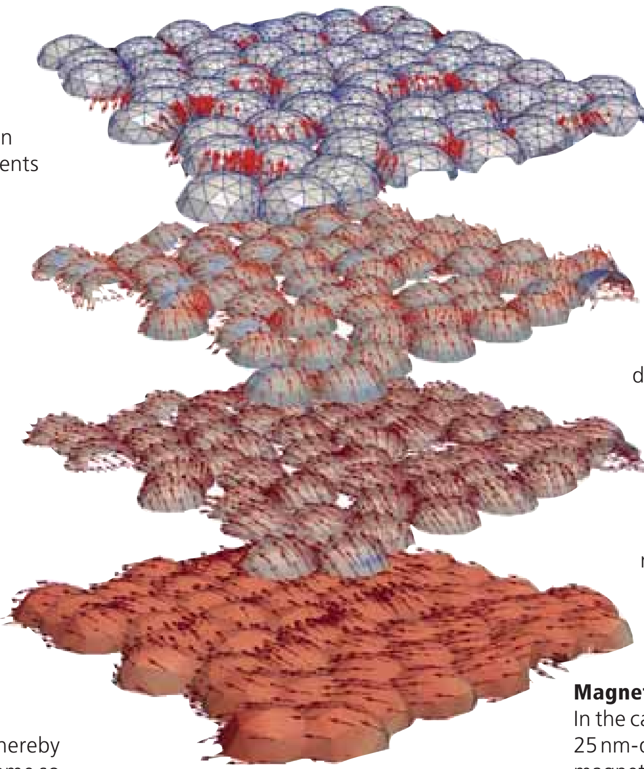
In 2014, more than 100 billion e-mails were sent each day and over 50 billion hours of video were watched on YouTube. People also increasingly share their experiences on social-networking sites, store documents in data clouds, download maps on smartphones and connect to the digital world in endless other ways. This generates enormous amounts of data that needs to be stored.

The vast bulk of information is stored magnetically on disks and tapes. In order to maximise the amount of stored information in a given volume we need to fabricate ever smaller magnetic regions that are well separated and interaction-free. Today, the latest technologies use hundreds of magnetic grains measuring roughly 10 nm across to store a single bit of information. But the miniaturisation trend is facing a fundamental limit caused by the superparamagnetic effect, whereby individual grains in the medium become so small that they are no longer stable against thermal fluctuations.

New media required

This problem first arose in the early 2000s in hard disks that stored information in magnetic domains magnetised in the plane of the magnetic layer. The breakthrough came in 2005 when materials with perpendicular magnetic anisotropy were proven to be a suitable recording medium. Combined with earlier developments in read-head technology based on giant and tunnelling magnetoresistance, together with new technical solutions such as "dynamic flying height", commercial storage capacity has recently reached 1 Tbit per square inch.

Further increase of capacity is only possible by introducing a new generation of storage devices. By storing information on distinct nanostructures, rather than in grains on a continuous film, "bit-patterned media" (BPM) are predicted to have a storage density exceeding 20 Tbit per square inch. Since magnetic materials can exhibit unusual properties at the nanoscale, however, finding the best nanostructured system to build the next data-storage revolution is a major challenge.



Simulated magnetic moment configuration for 25nm-diameter spheres coated with an iron layer 26 Å (a), 34.5 Å (b), 48.5 Å (c) and 70.5 Å (d) thick. Red represents the x-y and blue the z-components.

"Miniaturisation is coming up against a fundamental limit."

In our most recent experiment, we wanted to investigate how the curvature and inter-particle distance of spherical nanoparticles affect the evolution of magnetism in a deposited iron film. Spherical silica nanoparticles coated with iron are highly promising candidates for BPM devices because their geometry and preparation parameters can be tuned over a wide range. Depending on the preferred magnetic configuration in the iron coating, magnetic information can be stored either by the collective magnetic orientation (pointing "up" or "down") or by the circulation of a vortex.

Nuclear resonant scattering (NRS), which exploits the excitation of nuclei from the ground state to gather information about the magnetic and electronic environment of a nucleus, is a powerful tool for characterising magnetic recording devices and has already significantly improved hard-disk read heads. Using *in situ* NRS at ESRF beamline ID18, we considered two sizes of spheres with diameters of 25 and 400 nm. Combined with atomic probe microscopy techniques and micro-magnetic calculations, we were able to model the development of magnetic moments in the ferromagnetic iron layer (*Nanoscale* **7** 12878).

Magnetic tuning

In the case where iron was evaporated on 25 nm-diameter particles, iron becomes magnetic in regions where the particles touch each other. This creates a series of uniformly distributed magnetic domains that are useful for magnetic storage media, with further iron deposition enhancing the exchange interaction between particles and resulting in a magnetic structure that involves several particles (see image).

With 400 nm-diameter spheres, in contrast, the system could be considered as a sum of individual magnetic particles where the magnetic structure is governed by the topology of the spheres. The magnetic moments align along a spiral path or a vortex on the upper part of the sphere, and with increasing iron thickness this spiral "spreads down" the sphere and therefore eliminates the out-of-plane magnetisation component.

We therefore conclude that the magnetic structure can be fine-tuned through the size of the spherical template together with the thickness of the magnetic layer. This is a fundamental step towards future >20 Tbit per square inch applications, with further studies planned in order to extend our knowledge to other magnetic materials such as cobalt platinum or iron platinum alloys.

Daniel Geza Merkel, Wigner Research Centre for Physics in Budapest, Hungary; Dimitrios Bessas, ESRF.

lambda

Large Area Medipix3 Based Detector Array

LAMBDA detector

The LAMBDA pixel detector is designed for high-end X-ray experiments, particularly at synchrotron sources. Using the Medipix3 chip, it achieves an extremely high image quality by combining effectively noise-free photon-counting operation with a small pixel size of 55µm.

For fast and time-resolved experiments, LAMBDA can be read out at up to 2000 frames per second with no time gap between images.

LAMBDA X-Ray Pixel Detector System

Pixel size:	$(55\mu m)^2$, $(110\mu m)^2$ in color mode
Detector layout:	1 module (780k pixels) or 3 modules (2.3M pixels), 196k or 589k pixels in color mode
Sensor area:	85mm x 28mm or 85mm x 90mm
Max frame rate:	2000 frames per second, no time gap
Noise:	Photon counting – noise free at 5keV
Sensor:	300µm-thick silicon, 1000µm-thick CdTe, or 500µm-thick GaAs
Quantum efficiency:	90% at 10keV (Si) or 75% at 40 keV (GaAs) or 75% at 80 keV (CdTe)
Max. count rate:	Up to 10^8 counts/mm^2/s
Counter depth:	Up to 24 bit
Energy binning:	Up to 2 thresholds, up to 8 in color mode

The LAMBDA pixel detector is available with different sensor layers for different X-ray energy ranges. For hard X-ray detection, the GaAs and CdTe LAMBDA systems replace the standard silicon sensor layer in LAMBDA.

This provides high quantum efficiency at high X-ray energies (75% at 40keV for GaAs, and 75% at 80keV for CdTe), while retaining single-photon counting performance and a frame rate over 100 times higher than a standard flat-panel hard X-ray detector.

Our newest product is the 2M line which combines 3 modules in a single detector systems with more than 2 Million pixels, while retaining the unique properties and speed of up to 2000 fps of the single module cameras.

We'd be also happy to work with you on individual detector solutions. Contact us any time at www.x-spectrum.de

The Final Repository for Short-Lived Radioactive Waste in Forsmark, Sweden, stores low- and medium-level waste from Sweden's nuclear industry. Lying 50 m below the Baltic seabed it was the first facility of its kind when it opened in 1988.

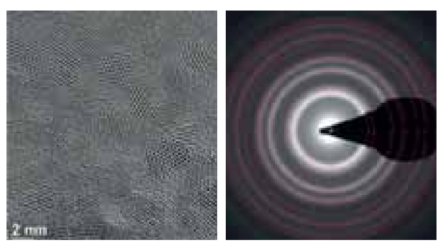
LASSE MODIN

Colloidal concern for waste storage

Radionuclide experiments reveal the chemical structure of neptunium colloids in aqueous solutions, which is key to assessing the safety of long-term nuclear waste storage.

More than 400 nuclear power stations are currently in operation, supplying 10% of the world's electricity and producing a growing volume of high-level radioactive waste. Geological disposal is a promising way to deal with such waste, but before such facilities can be built it is vital to assess the long-term safety of geological repositories. The chemical behaviour of radionuclides under geological conditions must be well understood, particularly in the presence of naturally occurring colloidal substances. When radionuclides are attached to or incorporated into colloids, the resulting colloidal particles could potentially allow the transport of radionuclides into the geosphere and eventually the human environment.

A team of users has exploited the ESRF's Germany-operated beamline BM20, also known as ROBL, to investigate the potential formation of neptunium (Np) colloids under aquatic conditions relevant to geological nuclear waste disposal. The major isotope of neptunium ^{237}Np, which has a half-life of more than two million years, is considered to be one of the most problematic radionuclides in radioactive waste disposal. Working with ROBL staff, Richard Husar of Helmholtz-Zentrum Dresden-Rossendorf (HZDR) in Germany and co-workers have now gained unprecedented insights into the chemical and physical behaviour of this long-lasting isotope.



TEM image of Np particles (left) and corresponding electron diffraction pattern, demonstrating crystalline structure.

Dual approach

The team carried out two studies in parallel, corresponding to different natural chemical systems. The first dealt with a simple aqueous system containing Np, water and carbonate species. Results showed that tetravalent neptunium, Np(IV), has an intrinsic tendency to form nano-sized NpO_2 particles under aquatic conditions, which exist as stable colloids in aqueous solutions (*Chem. Commun.* **51** 1301). The second study focussed on an aqueous system containing silicates, demonstrating the formation of another type of Np colloid in which Np is incorporated into the silicate network to form amorphous colloidal Np-silica particles (*Environ. Sci. Technol.* **49** 665).

Taken together, explains co-author Harald Zänker of HZDR, the studies show that Np could potentially form several different types of stable colloids under the geological conditions relevant to radioactive waste storage. "The formation of such colloids could drastically increase the concentration of mobile Np species as waterborne colloids and eventually facilitate the transport of Np nuclides from the repository sites into the surrounding environment," he says. "The chemical structure is one of the fundamental factors that determine the actual physical/chemical behaviour of such substances, such as solubility or reactivity."

Huge benefits

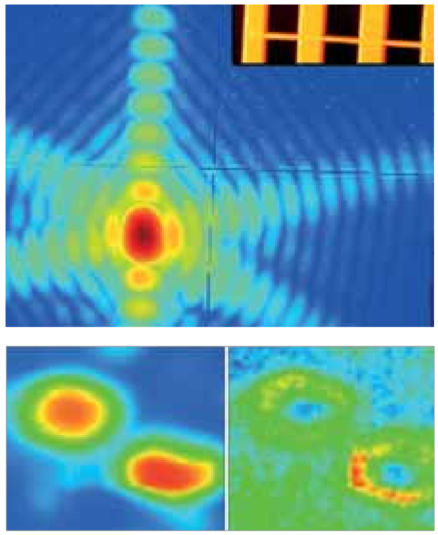
Synchrotron-based X-ray absorption spectroscopy (XAS) is uniquely suited to provide structural information about substances in solution. "The ROBL beamline at the ESRF is one of a handful of places worldwide where we're allowed to handle high amounts of radioactive materials for XAS experiments in a synchrotron facility," says co-author Atsushi Ikeda-Ohno of HZDR. "This peculiarity of the ROBL beamline provides a huge benefit for our studies."

The team is now planning to further investigate the physical and chemical behaviour of Np colloids under geological conditions, such as their interaction with barrier materials and co-existing minerals. "Based on the outcomes of these two studies, we are also developing another research programme focusing on other radionuclides that are important to radioactive waste disposal, such as plutonium and zirconium," says Ikeda-Ohno.
Matthew Chalmers

Pushing nanotech to the wire

By unravelling the detailed structure and composition of nanowires and other complex nano-objects, users are clearing a path to next-generation devices.

Nanoscale materials and structures promise unique properties and improved device functionalities. Nanowires show particular promise for next-generation computing devices, but so far such technologies remain at the R&D stage. Synchrotron X-ray nanoprobes provide new opportunities to characterise complex nanowire structures with a high spatial resolution while avoiding the traditional averaging that could hide important local properties, helping to turn nanowires into technology.



Top: Coherent Bragg diffraction image of a self-suspended gold nanowire, with an AFM image of the nanowire crossing silicon microtrenches shown in the inset.
Bottom: Fluorescence maps indicating indium (left) and gallium (right) distributions within 500 nm-wide single InGaN nanowires.

Coherent diffraction

As part of an ongoing research programme, a French team led by Oliver Thomas of Aix-Marseille University and IM2NP recently used a powerful technique developed at beamline ID01 called coherent Bragg diffraction to investigate the mechanical behaviour of single gold nanowires. Combined with an *in situ* scanning force microscope (SFINX) at ID01, the study revealed the properties of the nanowire in unprecedented detail as it was bent using an AFM tip. The symmetry of the resulting diffraction image (top) shows that the wire is of high crystalline quality and a perfect starting point for deformation studies.

More recently, the same team used similar techniques at ID01 to study defects in gallium nitride nanowires, which have promising optoelectronic properties for applications. Specifically, the team measured for the first time the displacement field induced by inversion domain boundaries (IDB), which separate different polarity domains in the material. The data revealed complex IDB configurations with a resolution of just 6 nm, allowing the team to unambiguously determine the absolute polarity of each domain. The study demonstrates that coherent diffraction techniques can reveal an extremely precise inner view of the microstructure of small crystals in the presence of interacting defects, and can be applied to materials under complex *operando* conditions (DOI: 10.1021/acsnano.5b03857).

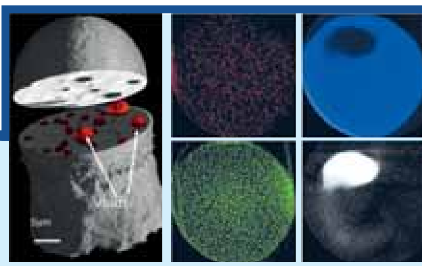
Pioneering methodology

Focussing on slightly more complex indium gallium nitride nanowires, which are of great technological interest for high-efficiency multijunction solar cells, light-emitting diodes and lasers, a recent study by researchers from the ESRF and the Georg-August-Universität Göttingen in Germany used beamline ID16B to determine the composition and the short- and long-range structural order of single self-assembled nanowires.

A combination of spectroscopic techniques including nano-XRF, polarisation dependent nano-XANES, and nano-XRD revealed a large phase separation at the bottom and a single phase at the top of the nanowires (bottom figure). The pioneering methodology offers researchers a better understanding of the underlying growth concepts of many other nanostructures in materials science, claims the team (*Nano Letters* **14** 1300).
Matthew Chalmers

INDUSTRY CASE STUDY

Copper pillar probe for 3D chip integration



Nano-computed tomography of a copper pillar reveals the distribution of voids (left), while fluorescence tomography slices at different heights (right) show the distribution of silver (red), nickel (blue), tin (green) and copper (grey).

For the past 50 years, transistors have continued to get smaller, faster and more efficient. The exponential "Moore's law" trend has put the microelectronics industry at the centre of economic and social development, but fundamental issues such as heat management and current leakage are now bringing it to an end. In order to build processors that can embrace ever larger data sets and novel IT paradigms, manufacturers are turning to greater 3D integration of chips.

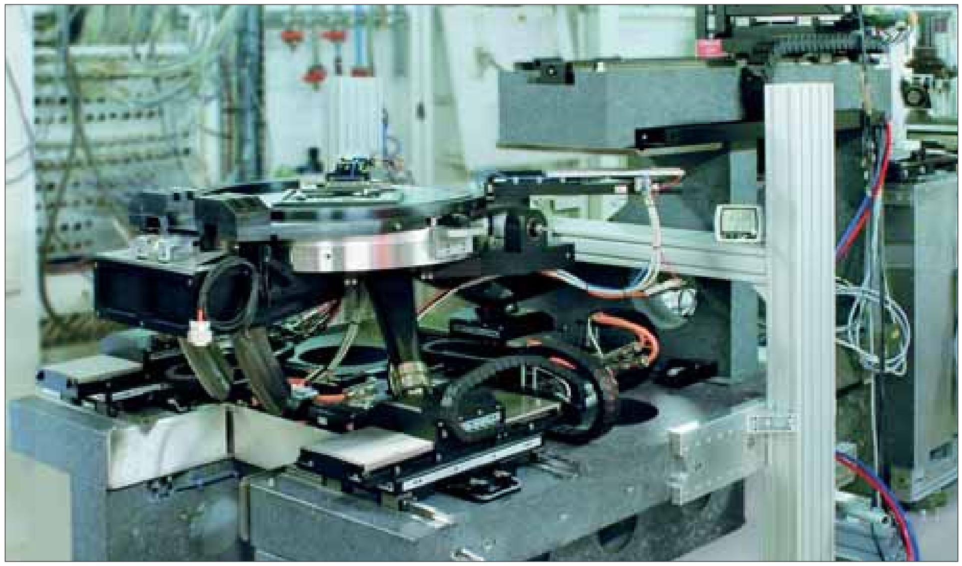
A key component of 3D architectures is the "through-silicon-via" (TSV), which ensures that different layers of the 3D stacked structure can communicate at high speeds. Copper pillars measuring between 1–20 µm in diameter present a promising TSV but also a major manufacturing challenge, since any defects or voids can lead to spikes in the current density that may damage components and affect device performance.

As part of a major European public–private programme called IRT Nanoelec, semiconductor manufacturer ST Microelectronics has used X-ray nano-tomography and fluorescence at ESRF beamline ID16A to visualise voids and elemental phases in copper pillars integrated into a prototype 3D chip. The extremely small spot size and high penetration depth of the X-ray beam revealed the existence of voids in the sample with a resolution of just 23 nm. X-ray fluorescence, meanwhile, allowed the team to establish the presence of different elements – including the complex phases that result from alloys formed during soldering.

The success of the experiment has led ST Microelectronics to invest in a long-term proposal to characterise even smaller voids in copper pillars and to explore other promising TSV architectures. The ultimate aim is to be able to apply the technique to ensembles of TSVs and to perform *in operando* analyses on whole working devices.

Positioning solution for a new imaging method with synchrotron radiation

In a joint project, the ANKA at the KIT, the Fraunhofer IZFP, Germany, and the ESRF, France, have developed synchrotron laminography, which allows the examination of large-surface objects. Examples of such object geometries are found in wind energy or aerospace, where the method can be applied to detect damage in the inner structure and manufacturing faults. The instrument has been in operation since 2007 at the ESRF synchrotron radiation source at the imaging beamline ID19. The instrument is able to depict the smallest three-dimensional structures without damaging them.



Maximum demands on the positioning of the sample and detector

In laminography, the sample is positioned between the X-ray source and the detector and scanned under rotation around an axis tilted with respect to the beam direction. The volume data can be reconstructed from the different projection. Maximum precision and stability (both of the detector and the sample) are essential during examination to allow subsequent reconstruction of meaningful images. The challenge was to position the heavy detector (100 kg) with a straightness of motion of less than 0.1 µrad or 100 nm resp. and a resolution of 50 nm, whilst eliminating leverage and torque at the same time. When positioning the sample, the angle at which the sample is exposed to the synchrotron X-ray beam had to be adjustable. The position of the sample itself had to be finely adjustable individually, securely and repeatably. In addition, the entire instrument had to be maneuvered easily from the optical path when not in use or during reference measurements.

Practical solution for a complex task

Thanks to the close co-operation of the customers with the engineers and developers from PI, this complex task was solved in a practice-oriented manner. The aim of the team of specialists, co-ordinated by PI miCos, is to develop application-specific solutions that go beyond offering individual components and include system integration as well as the complete instrumentation. This capability has again been demonstrated with the instrument for computed laminography. In the project, the detector and sample positioning consists of three co-operating systems: a Z stage with granite base, a detector stage moveable in three directions, and sample positioning. The latter consists of a six-axis positioning system and a rotation and tilting stage on which the actual sample carrier is held magnetically.

Positioning samples with sub-micrometer accuracy

The requirement for the samples was to be positioned with high accuracy. This is where the six-axis positioning system came into operation. This SpaceFAB is designed symmetrically, where three legs with a fixed length are each mounted onto an XY stage in a ball joint. The samples can be positioned with six degrees of freedom. Essential features are the freely selectable pivot point of the parallel-kinematic system and its high stiffness. The linear travel ranges are 150 mm × 150 mm × 50 mm, at 0.2 µm position resolution, ±12.5° tilting is possible for the axial angle, and ±5° for the other directions. Precision is provided by optical linear encoders and the high-precision mechanical components.

Benefits for various fields

The study results achievable today with such a synchrotron laminography method can benefit a host of fields, from industry-oriented research to geology and life sciences. A major contribution was provided by the bespoke positioning solution created by the specialists of the "Beamline Instrumentation", which can even align large samples and consequently rather high loads with micrometer precision.

PI in brief

Over the last four decades, the PI Group, with their headquarters in Karlsruhe, Germany, has developed into the leading manufacturer of positioning systems with accuracies in the range of only a few nanometers. With four company sites in Germany and 11 sales and service offices abroad, the privately managed company operates globally. More than 850 highly qualified employees all over the world enable the PI Group to fulfill almost any requirement from the area of innovative precision positioning technology. All key technologies are developed inhouse. This allows the company to control every step of the process, from design right down to shipment: precision mechanics and electronics as well as position sensors. The PI miCos GmbH in Eschbach, Germany, joined the PI Group in 2011. The company is specialized in applications in the areas of ultrahigh vacuum, air bearings technology, linear motors, parallel-kinematic positioning systems with six degrees of freedom and engineering services for system integration.

Author: Birgit Schulze

PI

Web www.pi.ws

Scattering without prejudice

Chair of the ESRF Science Advisory Committee, **Des McMorrow**, describes his fortuitous career and why X-ray science is one of the most exciting fields to work in.

From an early age, physicist Des McMorrow was aware that there was something big to be understood about the world – something that he was not being told about at school. His teachers alluded to things like quantum mechanics and relativity, he recalls, but to satisfy his young mind he turned to science documentaries on television. When it was time to go to university, he chose to study biology. But just before he started he decided to change to engineering. "I wanted to do something more obviously applicable," he says. Then, one year into the course he finally switched to physics. "I initially thought it was too tough, but ultimately I was driven to study it."

McMorrow's decision to pursue a research career was made while undertaking a summer internship in the space physics group at The University of Sheffield, and during his PhD he soon found himself exposed to the ILL in Grenoble. "It was then that I realised the power of central facilities," he says. "I saw that you could address a more profound range of issues than was possible with local probes such as NMR."

Des McMorrow in brief

Born: 1961, London.

Education: BSc physics, The University of Sheffield (1983); PhD low-temperature physics, University of Manchester (1987).

Career: Research fellow, University of Edinburgh (1987–1990); research fellow University of Oxford (1990–1993); senior scientist (1993–2003), Risø National Laboratory; professor of physics, UCL (2004–present).

Family: One son.

Interests: Walking, skiing, family.

From neutrons to X-rays

The focus of McMorrow's 30-year-long research career, during which he has published more than 180 scientific papers, is how low dimensionality and quantum effects can give rise to new electronic and magnetic states, which have relevance for high-temperature superconductivity, and other exotic electronic states emerging in the presence of quantum phase transitions. Neutron scattering is a powerful probe of such systems, but during a postdoc at the University of Edinburgh, McMorrow started working with X-rays under the late Roger Cowley, who was a pioneer of the X-ray triple-axis spectrometer. It wasn't long before he encountered his first synchrotron and, as with his first experience of the ILL, the event was pivotal to his research career – although he does not have a preference for either neutrons or X-rays. "I am a believer in scattering without prejudice!" he says.

"Where the ESRF leads, others follow."

In the mid-1990s, soon after he took up a permanent position in the Risø National Laboratory in Denmark, McMorrow carried out experiments at the ESRF's "Troika" beamline and has since become a regular user. He says that the ESRF stands out among the world's light sources – not just because of the technical virtuosity and innovation of the beamlines, but also the strong collaboration with beamline scientists. "The ESRF is more than a user facility," he explains. "Where the ESRF leads, others follow."

It was around the turn of the millennium, after he had worked up to become group leader for neutron and X-ray scattering at Risø, that he had one of the worst times in his career: arriving at work one morning he was informed that the research reactor had sprung a tritium leak. "That was the end of the party, although out of the ashes eventually came the European Spallation Source," he says.

Research focus

Until recently, McMorrow was acting director of the London Centre for Nanotechnology at University College London (UCL). Although he does not consider himself to be a nanotechnologist, he has benefitted from being located in the centre's multidisciplinary environment. Researchers have been interested in nanoscale processes for decades, he argues, but the real power of nanotechnology is in bringing communities together. He is now vice dean for research in the mathematical and physical sciences faculty at UCL, developing research strategies. "UCL has benefitted enormously from its involvement with central facilities including the ESRF and is keen to do more to improve such interactions," he says.

McMorrow does his best to stay close to research, citing the exciting opportunities made possible by the new beamlines of the ESRF Upgrade Programme and also next-generation sources such as ESRF-EBS and X-ray free electron lasers. "If I was working in a field with less opportunities and less progression, I might be tempted to go into management full time, but it's difficult not to be excited when there's so much going on," he says. Having become chair of the ESRF Science Advisory Committee earlier this year, one of his main challenges is to help prepare the next tranche of beamlines for ESRF-EBS.

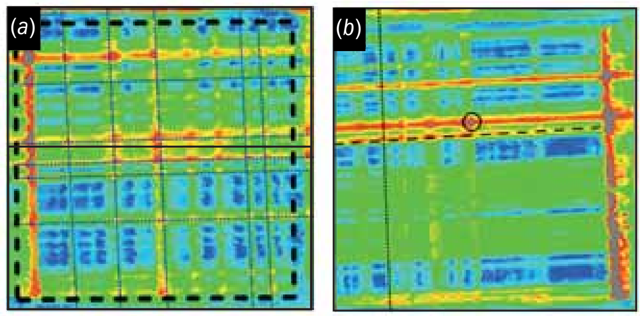
There have been many high points in his career, he says, with particular satisfaction coming from his work in designing instruments, having them manufactured, and then producing science with them. And he is certainly glad that he trusted his high-school physics instincts. "I've been incredibly fortunate to work on projects that I'm interested in."

Matthew Chalmers

Firm characterises wafers of tomorrow

Semiconductor manufacturer Siltronic has obtained a quantitative picture of the materials homogeneity in silicon–germanium substrates.

Silicon, the workhorse of the semiconductor industry, is coming up against its physical limitations. To continue with the miniaturisation and functional diversification of micro- and nanoelectronics, manufacturers are pairing silicon with alternative semiconductor materials. Such approaches demand sophisticated characterisation techniques that can probe complex nanoscale materials structures with high resolution in a quantitative and model-free way.



Maps showing the absolute lattice tilt in as-grown (left) and polished (right) SiGe layers measuring 100 × 100 μm, revealing a crosshatch pattern caused by plastic relaxation of lattice-mismatched SiGe films.

Aiming for perfection

A powerful non-destructive technique developed at ESRF beamline ID01 called scanning X-ray diffraction microscopy allows industry researchers to detect the slightest imperfections in the crystalline structure of heterogeneous structures and thin films, even in fully processed chips. Offering an unprecedented strain resolution of a few parts per million and a spatial resolution down to 100 nm, the technique has recently been trialled by Germany-based wafer manufacturer Siltronic to evaluate silicon–germanium substrates for advanced device architectures.

Any imperfections in the microscopic structure of materials, such as defects or variations in the orientations of the crystal lattice, can severely affect the performance of tiny semiconductor devices. This is critical when matching silicon with another material such as germanium, since it creates greater structural complexity and new interactions that must be understood in order to fully exploit the potential of the technology.

In conjunction with ESRF staff and IHP (Innovations for High Performance Microelectronics) in Frankfurt (Oder), Siltronic investigated a sample comprising step-graded silicon–germanium layers on 300 mm silicon wafers, which is a promising substrate for sub-10 nm CMOS transistors. The high penetration depth and small spot size of the ESRF X-ray beam allowed the team to establish a correlation between real-space morphology and structural properties of the sample at the micrometre scale. "There is simply no other technique available that would give you this information," says Siltronic R&D project manager Peter Storck. "This is brand new, so we were very excited to try it out."

The results showed a local correlation between the microscale strain field and composition distribution, indicating that the adatom surface diffusion during growth is driven by strain field fluctuations induced by the underlying dislocation network of the silicon–germanium buffer. The data also revealed that superficial chemical–mechanical polishing of surfaces does not lead to any significant change of tilt or strain variations compared to as-grown samples, even for very different surface morphologies (*ACS Appl. Mater. Interfaces* **7** 9031).

Close collaboration

The team has since undertaken further tests of a silicon–germanium buffer in conjunction with a functional, strain-engineered germanium layer. Knowing how this layer varies at the nanometre scale is vital for CMOS engineers, explains Storck, because it forms the basis for subsequent device processing.

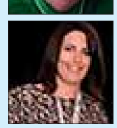
"IHP suggested these advanced metrology opportunities to Siltronic, and the company saw a high potential to push its R&D activity for product development using this kind of information," says Thomas Schröder, head of materials research at IHP. "They selected the most interesting wafers and it was the job of IHP to carry out the studies and data analysis in close collaboration with the ID01 team."

Matthew Chalmers

Movers and shakers

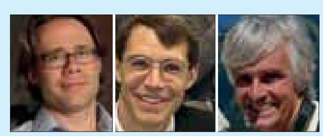

MALTA-CONSOLIDER TEAM

Paul Loubeyre (left), a long-standing ESRF user, was awarded the Bridgman Award at the joint 25th AIRAPT and 53rd EHPRG conference held in Madrid in September. The prestigious award, which is named in honour of the Nobel prize-winning physicist Percy Bridgman, is given to scientists who have made outstanding contributions to the development of high-pressure science and technology. Loubeyre, who is based at the CEA in Bruyères-le-Châtel in France, has carried out numerous experiments at ESRF beamlines since the start of user operation. Most of his work was performed at the high pressure XRD beamlines ID09A and ID27, but there were several others including ID16, ID24 and ID28. An early high-impact study in 1996 described the equation of state of hydrogen at megabar pressures, and Loubeyre was also awarded the ESRF Young Scientist Award in that year.



ESRF scientists **Igor Melnikov** and **Bénédicte Lafumat** won the OlexSys Crystallographic Computing Poster Prize and the RCSB Protein Data Bank Poster Prize, respectively, for posters exhibited at the 29th European Crystallographic Meeting held in Croatia in August.

Following reorganisation within the ESRF Experiments Division, three new beamline group leaders have been appointed:



Pieter Glatzel (Electronic structure, magnetism and dynamics); **Tobias Schülli** (X-ray nanoprobe); and **Michael Wulff** (Complex systems and biomedical sciences). The other beamline group leaders are: Gordon Leonard (Structural biology); Veijo Honkimäki (Structure of materials); and Sakura Pascarelli (Matter at extremes), who was previously head of the Electronic structure and magnetism group.

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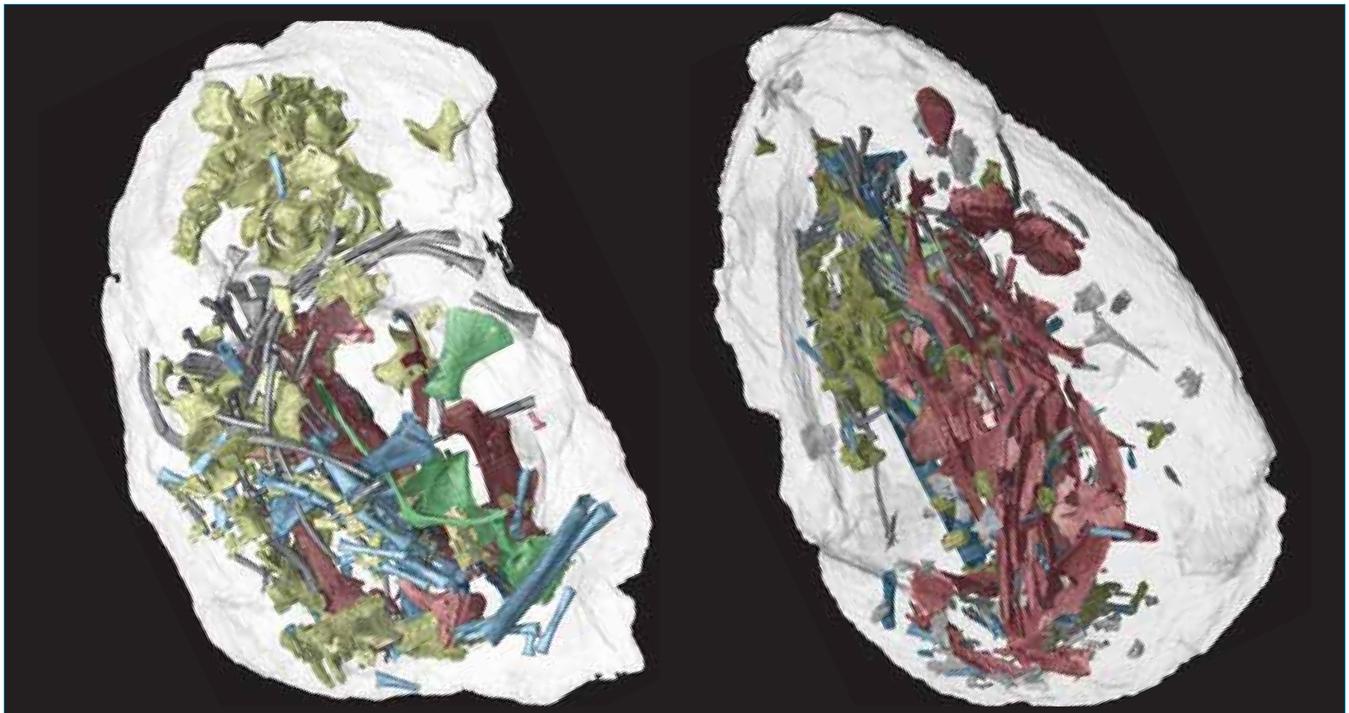

Geckoes not unique: These striking 3D renderings of two fossil eggs shed light on the rare reproduction strategy of squamates, which comprise lizards and snakes. Obtained using micro-tomography at ESRF beamline ID19, the images show the enclosed embryonic bones of eggs found in Thailand that date back more than 100 m years, revealing: the skull and mandible (red); vertebrae (yellow); ribs (grey); pectoral and pelvic girdle (green); and limbs (blue). Lizards display a remarkable range of reproduction modes but until now it was thought that geckoes are the only species to produce fully calcified rigid-shelled eggs, in contrast to the parchment-shelled eggs observed in other lineages. The new study, carried out by an international team led by Vincent Fernandez of the ESRF and the University of the Witwatersrand, South Africa, reports the first attested fossil eggs of lizards combining hard eggshells with exquisitely preserved embryos, demonstrating that the evolution of rigid-shelled eggs is not an exclusive specialization of geckoes (DOI:10.1371/journal.pone.0128610).

In the corridors

Extreme light source switches on

The first facility of the Extreme Light Infrastructure (ELI) project – the ELI-Beamlines centre near Prague in the Czech Republic – was inaugurated in October at a ceremony attended by ESRF Director-General Francesco Sette (pictured) and other leaders of European research infrastructures. ELI, which is a key part of the European Commission's ESFRI roadmap and includes centres in Hungary and Romania, will be the world's biggest and first international user facility in beamline and laser research. The project will focus on new interdisciplinary research opportunities using lasers and the secondary radiation derived from them, showcasing successful global collaboration in X-ray science.

ESRF summer medal bonanza

The ESRF secured a total of 36 medals in athletics, swimming, sailing, golf, badminton, mountain-biking and bowling at the 15th ASCERI Summer Atomiad, held in Belgium in June. The event, which the ESRF has participated in since 1996, brought together more than 1200 competitors from 37 research institutes across Europe for two days of sport, with the European Commission's Joint Research Centre ISPRA in Italy declared the overall winner. ASCERI's objective is to contribute to a united Europe by bringing together members of public research institutes.

Gearing up for the data deluge

Three additional blade chassis with 2700 processor cores and 62,000 graphical processor cores have been installed in the ESRF computing centre, bringing the theoretical total compute power close to 100 Tflops (100×10^{12} floating point operations per second). The additional processing capacity is vital for keeping up with user demands: in October this year, the ESRF set a new record for data production on the beamlines with 90.9TB produced in a single day, and total annual data production is soon set to exceed 2PB (2×10^{6} GB) per year.

New communication channels open

ESRF/D MCBRIDE

The ESRF has launched a blog to keep users and other core audiences up to date with the evolution and implementation of ESRF–EBS, the new name for Phase II of the ESRF Upgrade Programme. Launched in May, ESRF–EBS will see the construction and commissioning of the first of a new generation of ultra-brilliant synchrotrons: www.esrf.eu/ebs. The Communication group has also launched a monthly electronic news alert to keep users in touch with the latest information and results from the facility. The service requires a simple e-mail registration and can be accessed on the ESRF homepage.

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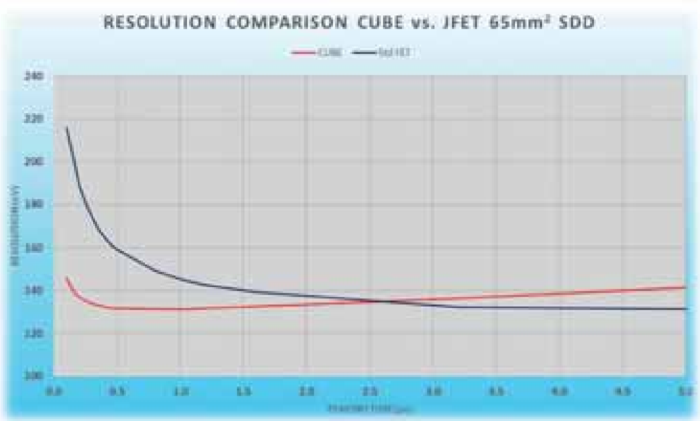
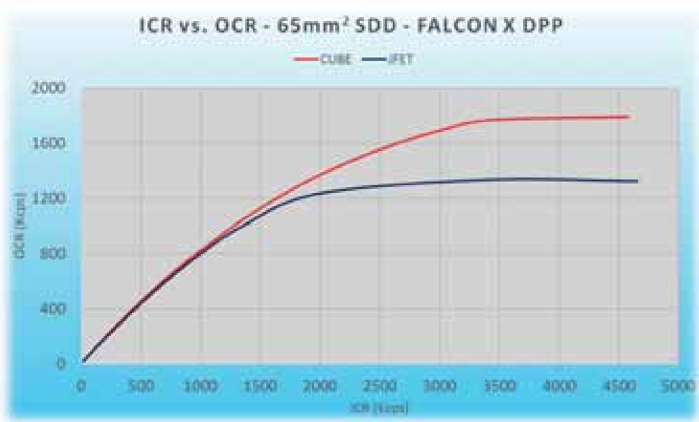


New CUBE detectors offer improved resolution at shorter Peaking Times



New CUBE detectors - compatible with the latest Digital Pulse Processors - offer higher output count rate

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(6 element monolithic arrays)

(13 element, focussed)

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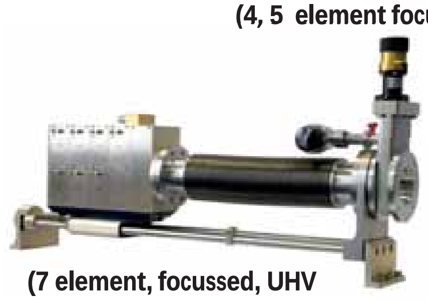
- Slide options: manual / adapted for translation tables
- Gate valve and bellows design for UHV compatibility

(4, 5 element focussed)



(7 element, focussed, UHV compatible, gate valve, bellows)

(windowless)

SGX Sensortech has a distinguished heritage in the manufacture of **Silicon Drift (SDD) and Si(Li) detectors.** Previously known as e2v scientific and Gresham Scientific, SGX specialises in producing detectors from standard designs through customised assemblies to complex multi-element detectors.

SGX Sensortech (MA) Ltd, Watery Lane, High Wycombe, Bucks, HP10 0AP, UK
www.sgxsensortech.com

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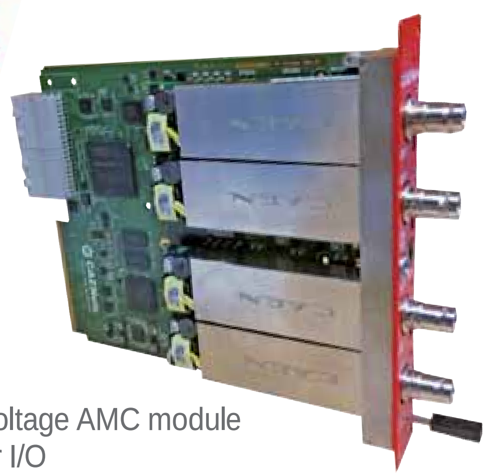

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