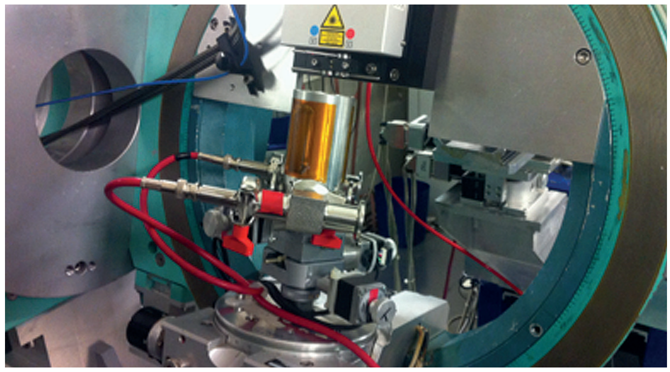
XMaS takes the strain off Moore's law

The ESRF's XMaS beamline is helping IBM and other electronics companies develop piezoelectric transistors that are faster and less power hungry than existing devices.

For the past 10 years, computer clock-speeds have flat-lined, marking the demise of a 40-year-old trend known as Moore's law. This trend has seen the dimensions of individual devices in integrated circuits halve every two years or so, with a corresponding increase in processing ability. But with transistor gate lengths now measuring a few tens of nanometres, yet switching-voltages remaining at the 1V level, we are close to the limit of silicon CMOS technology due to the difficulty in extracting heat from devices.

Piezoelectric transistors are seen by IBM and others as one of the most promising ways to get Moore's law back on track. Simulations show that clock-speeds 10 times larger than today's CMOS equivalent are possible by using a small voltage to switch small regions of piezoresistive materials between an insulating and conducting state – a process that also consumes 100 times less power than today's CMOS transistors, studies show. In 2012, IBM researchers developed the first piezoelectric-effect transistor, but the challenge now is to find out if these attractive features are scalable to the dimensions of CMOS devices.



NPL/XMAS

Interferometer and sample holder on the XMaS Huber diffractometer during commissioning in February 2014 as part of the Nanostrain project.

Nanostrain is a three-year, €4 m project funded under the European Metrology Research Programme (supported by the EC and EURAMET) to characterise strain at the nanoscale under industrially relevant conditions. Involving Europe's leading metrology laboratories and companies including IBM and ST Microelectronics, the success of the project relies on new synchrotron X-ray techniques under development at the ESRF's UK-operated XMaS beamline.

Promising results

The aim is to combine X-ray diffraction, which is routinely used to measure the atomic periodicities in crystalline materials, with laser interferometry, which is able to measure extremely small displacements in bulk materials. This will enable the team to link intrinsic displacements due to changes of the unit cell's size and ionic movements, with macroscopic changes that typically are also due to extrinsic phenomena such as defects and domain-wall motion. "The main challenges are sensitivity and noise levels, so we have developed an interferometer mount to create a rigid and stable system," explains Tom Hase, co-director of Warwick University in the UK.

Members of the Nanostrain team from the UK's National Physical Laboratory carried out the first tests of the new tool at the ESRF in February this year – with promising results. "During the first commissioning time we measured the displacement on a piezoelectric single crystal both in static and dynamic electric fields and observed displacements of less than 1 nm, which is well within the desired range," explains Carlo Vecchini of NPL. The next goal at XMaS is to push the switching frequencies from around 100 Hz to the kHz and possibly up to 1 MHz by the end of the project, he says. "This will enable the simultaneous measurement of macroscopic displacement, electric polarisation and X-ray diffraction data in near operational conditions."

Experiments on real samples will be carried out this summer, and the advanced X-ray techniques are expected to benefit other areas of XMaS science. "The Nanostrain project has already led to advances in the ways that multiferroic materials can be studied on the XMaS beamline, and we anticipate further application of the methodologies to a wide range of material systems," says XMaS co-director Chris Lucas of Liverpool University in the UK.

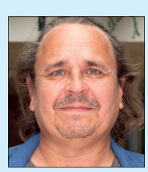
Matthew Chalmers

Movers and shakers

New ESRF group heads

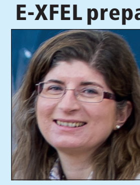
Sakura Pascarelli has replaced Nick Brookes as head of the Electronic Structure and Magnetism Group, while remaining scientist-in-charge of the XAS beamlines BM23 and ID24. Pascarelli, who trained as a physicist, joined the ESRF staff in 1997 having previously worked on the Italian CRG beamline BM08 (GILDA). Her research currently focuses on studies of matter at extreme conditions of pressure, temperature and magnetic fields using X-ray absorption spectroscopy and X-ray magnetic linear and circular dichroism.

Gordon Leonard has been appointed head of the Structural Biology Group, having previously been the group's deputy head. Leonard has been at the ESRF since 1996, with research interests including LysR transcription factors and the elucidation of the crystal structures of proteins and nucleic acids at ultra-high resolution. He replaces Sean McSweeney, who has taken up a position at Brookhaven National Laboratory in the US.



Veijo Honkimäki, previously head of the high-energy diffraction and scattering beamlines ID15A&B, has become head of the ESRF's Structure of Materials Group – which includes ID15 and five other beamlines plus associated facilities. Honkimäki, who previously was deputy head of the group, joined the ESRF in 1995 and works in the area of materials science. He replaces Roberto Felici.

E-XFEL prepares for users



One of the first ESRF staff members, **Silvia Bertini**, has been appointed head of the User Office at the European XFEL in Hamburg, Germany – a newly created position in preparation for the facility's first user operation in 2017. Bertini took up a secretarial post at the ESRF in 1991 and then worked in the Office of the Directors of Research between 1994 and 2004. Following a move to the Administration team of EMBL Hamburg, Bertini joined the European XFEL in 2012.