



Materials engineering at a long pulse source

**Report of ESS Science Symposia held at
ISIS, Rutherford Appleton Laboratory, UK, 9-10
December 2011**



Science Drivers: Structural Integrity and Materials Performance

Over the last few decades, neutron diffraction has established itself as a unique and almost unrivalled tool for the non-destructive investigation of engineering materials, in particularly metals, and dedicated, optimized materials engineering beamlines are now part of the instrument suite at every major neutron source. The applicability of the technique has attracted wide interest beyond the traditional materials engineers and now also encompass as diverse fields as geology, ferroelectric smart materials and cultural heritage. The investigations can be undertaken both ex-situ, on static components in ambient conditions as well as in-situ, ranging from cryogenic to elevated temperatures, combined with simulated loading conditions. Although academic-industrial partnerships remain the norm, the technique has attracted significant interest and acceptance in industry, often contributing extensively to third-party funding of the facilities by selling beam time. Leaving the ability to investigate microstructural properties aside, the ability to determine accurately the triaxial residual stress fields inside large components remains unchallenged from emerging techniques such as synchrotron X-ray diffraction. Neutron stress measurements are still the only neutron scattering technique which has been standardized to pre/ISO levels. While demand for stress measurements in manufactured components, in particular welded components remains strong, the need for studying performance of materials and processes in-situ is gaining ground. As the demand for new materials and technologies to be stronger, lighter and more environmentally friendly grows, the in-depth understanding of the performance down to the atomic level becomes more critical. Additional needs were long time-base experiments of creep properties studies, which only require measurements every couple of days, but need automated sample handling.

A recent ESS Science Symposia workshop, entitled 'Materials Engineering at a Long Pulsed Source' was hosted and organized in collaboration with the ISIS Pulsed Neutron and Muon Source (STFC). The aim of the symposium was to assess the current status of materials engineering research using neutrons, and consult on the potential of facilities at ESS and ISIS second target station. 47 participants took part, spanning academics, industrial engineers, materials scientists and cultural heritage experts as well as instrument scientists from existing materials engineering instruments. A lively series of talks and discussion sessions were held. The symposium started with a discussion of the current scientific trends in a series of talks from Prof. John Bouchard, Dr. David Dye, Prof. Philip Withers and Prof. Alexander Korsunsky, whom are the leading exponents in the field. The second session gave an overview of the state-of-the-art instrumentation of leading materials engineering neutron diffractometers at both reactor and spallation sources by the lead scientists, Dr. Alex Evans, Dr. Xun-Li Wang, Dr. Shu Yan Zhang, Dr. Winfried Kockelmann and Dr. Eberhard Lehmann. Dr. Axel Steuer, Dr. Reinhard Kampmann and Dr. Markus Strobl also reported an update on the current status of the ESS project and up-to-date information on the ESS conceptual design. Dr. David Rugg, the corporate specialist from Rolls Royce provided an industrial perspective on the use of neutrons as a tool in industrial R&D and the requirements for more effective industrial take-up. Finally, the symposia closed with an open discussion session on the requirements and recommendation for a potential materials engineering instrument at the ESS.

The symposia highlighted the following needs:

Scientific drivers

- In-situ joining and processing
- Thermo-mechanical treatments
- Near surface measurements of the effects of surface treatments
- 3D mapping of residual stresses
- Deformation studies
- Imaging cracks within engineering components
- Large scale component stress analysis
- Combined macro-visualisation and microstructural studies of components
- Investigations of irradiated materials
- Studies of amorphous material

Future instrumental needs

- Better penetration (larger components)
- Better spatial resolution
- Faster dynamics
- Increased detector coverage
- Detector with better vertical resolution (especially for single crystal measurement)
- Detector for small angle scattering (Q range: $0.01-0.2\text{\AA}^{-1}$)
- Combination with imaging techniques ($\sim 1\mu\text{m}$ spatial resolution)
- Large, adjustable bandwidth (0.5-5.5Å)
- Adjustable instrument resolution (0.2-0.7%)
- Automated sample handling and collimator settings
- More lab space (e.g. equipped with EDM machine)

Annex 1 - List of Participants

Prof Carla Andreani	UNIVERSITA' ROMA TOR VERGATA
Prof John Bouchard	The Open University
Dr Martyn Bull	STFC
Mrs Genoveva Burca	The Open University
Mr Daniele Cortinovis	STFC
Mr Harry Coules	Cranfield University
Dr Catrin Davis	Imperial College
Prof Alison Davenport	University of Birmingham
Dr Hongbiao Dong	University of Leicester
Dr David Dye	Imperial College
Dr Alexander Evans	Institut Laue Langevin
Dr Christopher Frost	STFC
Dr Evelyne Godfrey	Open University
Prof Giuseppe Gorini	Milano-Bicocca University
Dr Francesco Grazzi	CNR-ISC
Dr Michael Hofmann	TU Mnchen
Dr Thomas M. Holden	Northern Stress Technologies
Dr Stephen Hull	STFC
Prof Michael Hutchings	The Open University
Dr Jon James	The Open University
Mr Reinhard Kampmann	Helmholtz-Zentrum Geesthacht
Dr Joe Kelleher	STFC
Dr Winfried Kockelmann	STFC
Prof Alexander Korsunsky	University of Oxford
Dr Eberhard Lehmann	PSI
Dr Yanling Ma	STFC
Mr Bundi Edem Maingi	Alimex Consultant Ltd
Mr Carsten Ohms	Joint Research Centre
Mr Sanjooram Paddea	The Open University
Mr Jan Pilch	Academy of Sciences of the Czech Republic, v.v.i.
Dr Timmy Ramirez-cuesta	STFC
Dr Mustapha Rouijaa	Helmholtz-Zentrum Geesthacht
Dr David Rugg	Rolls Royce
Dr Antonella Scherillo	CNR-ISC/STFC
Prof Andreas Schreyer	Helmholtz Zentrum Geesthacht
Dr Petr Sittner	Institute of Physics ASCR
Dr Axel Steuer	ESS AB
Dr Markus Strobl	ESS-AB
Dr Andrew Taylor	STFC
Mr M Burak Toparli	The open University
Dr Xun-Li Wang	Oak Ridge National Laboratory
Prof Philip Withers	University of Manchester
Dr Pingguang Xu	Japan Atomic Energy Agency
Prof Felix Fernandez-Alonso	Science & Technology Facilities Council
Mr Jim Nightingale	STFC
Mr Peng Zhang	Triamond Technology Partners
Dr Shu Yan Zhang	STFC

Annex 2 – Programme

Friday 9 December 2011

12:00 – 14:30	Registration, coffee and networking
14:30 – 14:40	Welcome and introduction Andrew Taylor, ISIS, UK
14:40 – 14:50	ESS Update, Welcome and outline of workshop scope Axel Steuwer, ESS, Sweden
14:50 – 17:30	Session 1: Trends in ME research Using Neutrons
14:50 – 15:10	Nuclear Power Research using Neutron John Bouchard, Open University, UK
15:10 – 15:30	Advanced Material Investigations David Dye, Imperial College, UK
15:30 – 15:50	Strain AND Imaging: A more complete engineering picture? Philip Withers, University of Manchester, UK
15:50 – 16:10	Needs of the industrial user David Rugg, Rolls Royce, UK
16:10 – 16:20	Tea, coffee
16:20 – 17:30	Session 2: The status Quo of ME Instrumentation with a view to Imaging
16:20 – 16:40	Strain scanners: SALSA, POLDI Alex Evans, ILL, France
16:40 – 17:00	VULCAN at the SNS: Scientific Opportunities, Industrial Applications and Challenge Xun-Li Wang, SNS, USA
17:00 – 17:20	Strain Tomography: Principles, Practice, Perspectives Alexander Korsunsky, University of Oxford, UK

Saturday 10 December 2011

09:30 – 12:15	Session 2: The status Quo of ME Instrumentation with a view to Imaging
09:30 – 09:55	Setting the Scene: Numbers, statistics and figures of ME research with neutrons Axel Steuwer, ESS, Sweden
09:55 – 10:20	Neutrons for Materials Engineering at ISIS: current capabilities Shu Yan Zhang, ISIS, UK
10:20 – 10:45	IMAT: an imaging and engineering facility for ISIS TS-II Winfried Kockelmann, ISIS, UK
10:45 – 11:10	Advances in Neutron Imaging Eberhard Lehmann, PSI, Switzerland
11:10 – 11:25	Tea, coffee
11:25 – 11:50	Structured Pulse Engineering Diffractometer (SPEED), a beamline being proposed for the ESS Reinhard Kampmann, HZG, Germany
11:50 – 12:15	Basic considerations on instrumentation for engineering diffraction at ESS Markus Strobl, ESS, Sweden
12:15 – 13:30	Lunch