Technology
for SR science

XH - *Germanium microstrip detector for dispersive X-ray spectroscopy*

J Headspith[1], J Groves[1], G Salvini[1], M Kogimtzis[1], R Farrow[1], Prof. J Evans[2], Prof. T Rayment[3]
[1] CLRC Daresbury Laboratory
[2] University of Southampton
[3] University of Birmingham

Introduction

XH is the worlds first 50μm pitch Ge Strip detector which has been designed specifically for Energy Dispersive EXAFS (EDE).
Carrying on from the CLRC development of XSTRIP[1], a Si based detector system, XH makes use of amorphous germanium (a-Ge) contact technology produced by LBNL[2] and readout ASICs developed by CLRC.
XH is designed to address the issues of detection efficiency and radiation damage that limit the effectiveness of the original XSTRIP system.

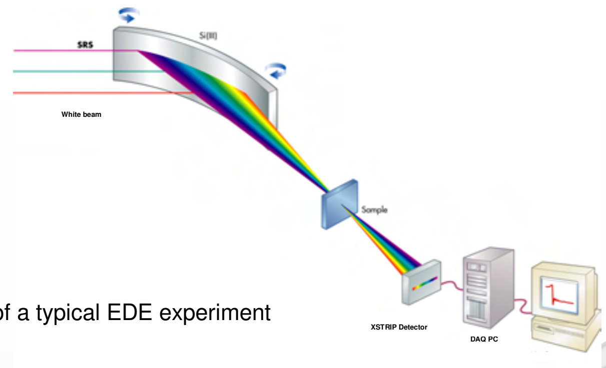


Figure 1: Layout of a typical EDE experiment

Experimental requirement for EDE

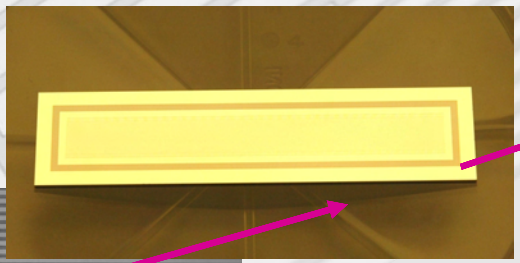
Scanning EXAFS uses a monochromatic beam of X-rays to explore an absorption edge of the sample being studied. Typically a monochromator bandpass of 1eV is stepped through a few hundred eV surrounding the absorption edge and data is taken at each point. This process takes tens of minutes. A technique called QuEXAFS has been developed for dynamic experiments where the monochromator moves continually and results in experiment times in the order of seconds. However the short time spent at each point limits the statistical quality of the data.

Energy Dispersive EXAFS (EDE) overcomes these issues and relies on a curved polychromator which provides an energy dispersed beam with a bandpass of about 1keV. The energy spread is determined by the curvature of the crystal and the starting energy by the angle of the polychromator to the white beam, see figure 1.
EDE has the advantage of taking data for every point of a spectrum simultaneously allowing dynamic reactions to be followed in time.

XSTRIP

The existing XSTRIP detector is an ultrafast system capable of following fast chemical processes. The heart of the system is a 1024 strip Silicon linear array detector and XCHIPs readout ASIC (Figure 2 shows the XSTRIP detector head) which directly records the transmission of the sample.
This system has been used extensively on the SRS, been trialled at the ESRF and is currently in use at the PFAR.

Figure 4: The Ge detector at LBNL



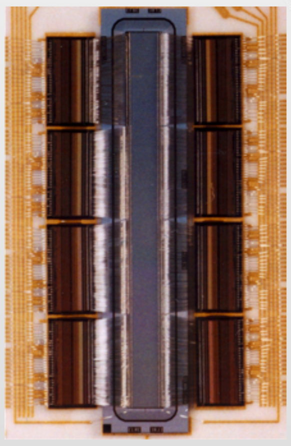


Figure 2: XSTRIP detector head

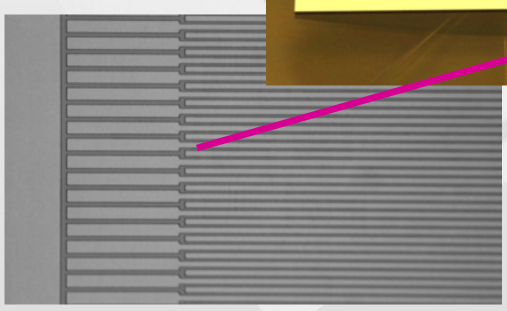


Figure 3: Magnified image of the Ge detector surface

Ge detector

The existing Silicon detector used in XSTRIP suffers from poor efficiency and radiation damage at high photon energies (above 15keV). The use of Ge as the detector has the benefit of improving the efficiency, due to its higher atomic number, and being tolerant to radiation damage. However processing and lithography of Ge is tricky and the production of fine pitch structures is difficult.
The detector used in XH has been developed at LBNL and utilises a-Ge contact technology. The a-Ge contact allows for relatively simple fine pitch contact processing and thin contact dead layers (window) neither of which are a applicable to the traditional Li drifted approach.

The key parameters for the detector are:

- 1024 strips
- 50μm pitch
- 5mm strip length
- 1mm Thick
- 1pA leakage current
- 100V bias
- efficiency 100% (over the working range of 5 – 35 keV)

Figure 3 shows a close up of the image illustrating quality of the photolithography after device processing.
Figure 4shows the fabricated detector at LBNL.

X2CHIP

To achieve fast readout speeds required for EDE the X2CHIP readout ASIC developed by CLRC is used. The key parameters of this ASIC:

- 128 charge integrating preamps
- 4 differential analogue outputs with 32:1 multiplexing of input data
- 2pC or 10pC selectable dynamic range.
- integration times in the range of 1μs – 1s
- device readout time of 10μs
- non linearity 0.03%

Figure 5 shows the CAD layout of the X2CHIP

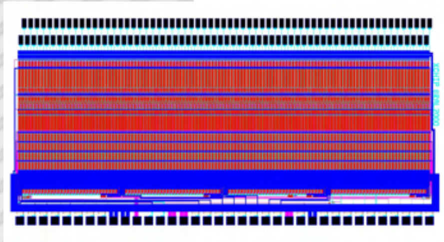


Figure 5: X2CHIP layout

Detector head

To achieve best signal quality the 8 X2CHIPs and 32 front end buffering amplifiers are placed within the cryostat.
Placing this density of electronics within the cryostat has many technical challenges. One major difficulty being the electronics will not operate at 77K. This requires complex thermal engineering to ensure base temperature of the readout electronics is 240K.
To avoid heating the detector through the bonding wires an intermediate ceramic bonding stage tied to the cold finger is used.
Figure 6 illustrates the detector head assembly

Figure 7: XH cryostat at LBNL

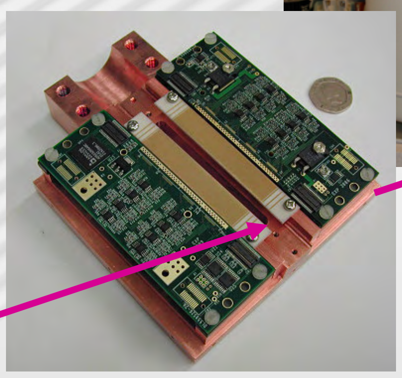


Figure 6: XH detector head assembly

Cryostat

To reduce the leakage current of the detector it is operated within a cryostat at a base temperature of 77K. The 25 litre cryostat has been designed and fabricated by LBNL. It is estimated that the cryostat will provided a three day holding time. Figure 7 shows the completed cryostat at LBNL

Data acquisition

The DAQ system hardware is provided by Sundance Multiprocessor Technology Ltd with interface software written by 3L Ltd. The system comprises:

- 32x 14bit 5MHz ADCs
- 2x FPGA/DSP processing units
- 512MB data memory

The DAQ allows the system to handle data at the rate of 200MB/s and perform accumulation and data framing algorithms. The large system memory provides storage for a possible 100,000 independent time frames.

User interface

The user interface for the system has been built around the EDE technique and allows the user flexibility of system operation. The system is controlled from its own PC or via a TCP/IP connection from a beamline computer system. This flexibility provides simple standalone or integrated operation.
The User interface will allow for remote triggering and sequencing of external experimental equipment such as stop flow cells. Example data derived from the user interface is shown in figure 7.

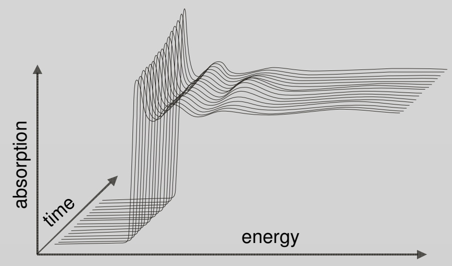


Figure 7: Example time resolved EDE data

For further information contact:
Janet Groves
Technology
CCLRC Daresbury Laboratory
Daresbury, Warrington
Cheshire, WA4 4AD
T: +44 (0)1925 603881

www.cclrc.ac.uk

References
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2 P N Luke, C P Cork, N W Madden, C S Rossington, M F Wesela IEEE Transactions on Nuclear Science Vol 39 No 4 590