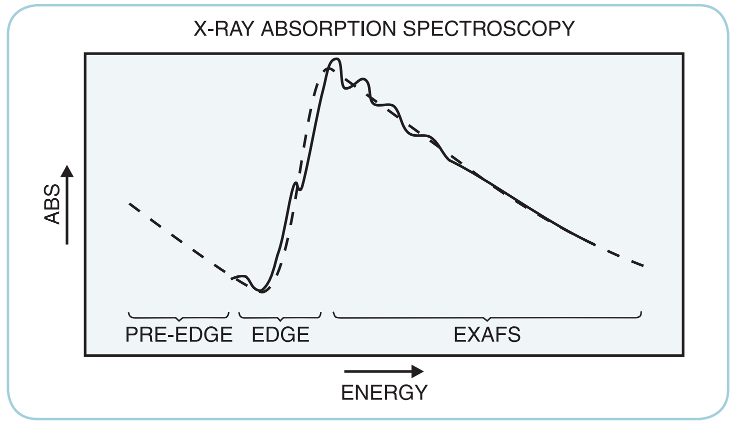
Germanium Array Detectors

Introduction

The broad-band x-ray flux from synchrotron radiation sources has revitalized the relatively old experimental technique known as x-ray absorption spectrometry. X-ray absorption spectroscopy measures the attenuation of an x-ray beam passing through a sample, just as do the more familiar infrared or UV-visible techniques. Typical x-ray energies are on the order of 300 eV to 30 keV or more, compared to visible light of 2–3 eV and infrared energies of about 0.05–0.5 eV. High energy x-ray absorption transitions involve core electrons which are only slightly perturbed by chemical changes in the valence electrons, hence each element has characteristic absorption edges at which the x-ray energy is just sufficient to liberate a particular type of core electron. Since edges are generally well separated in energy, x-ray absorption is a technique which can uniquely probe the environment of any element from carbon through the transuranics. A generalized x-ray absorption spectrum is illustrated at right.

CANBERRA has been the leader in the development and production of Germanium Array Detectors for this application. Herein you will find a brief summary of our capabilities and products.

Discrete or Monolithic – Both from CANBERRA



Schematic representation of a typical X-ray absorption spectrum. The edge, or XANES, region extends over 25 to 50 eV and the EXAFS is typically observable over several hundred to 1000 eV.

Discrete Array Detectors

Most of the x-ray array detectors manufactured by CANBERRA have been made with discrete LEGe or Ultra-LEGe detector elements coupled to reset preamplifiers. Because of the high count rates involved, the Integrated-Transistor Reset Preamp (I-TRP) is used exclusively in this application.

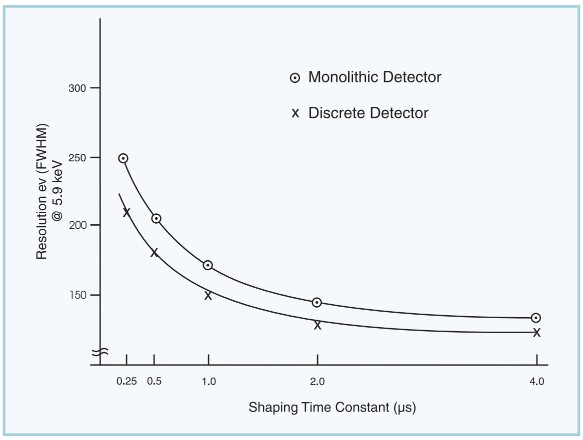
The discrete element detectors take full advantage of the performance characteristics of LEGe and Ultra-LEGe detectors, notably the energy resolution with short pulse processing (shaping) times. These detectors operate well with shaping time constants of 1/8 µs and up. The Ultra-LEGe detector extends the usable energy range down to 300 eV or so, depending on the cryostat window. Because of the difficulty in handling large numbers of detector elements, discrete array detectors are limited to about 36 channels.

Monolithic Array Detectors

CANBERRA now has the capability to make segmented planar Ge detectors using advanced photolithographic techniques. This technology lends itself to the production of pixel detectors wherein multiple elements are formed in a single slice of germanium. Monolithic array detectors offer improved packing density compared to discrete array detectors. The packing density is defined as the active detector area divided by the total area circumscribed by the array. Monolithic detectors, which have no dead space between elements, have virtually 100% packing density. The packing density of discrete array detectors ranges from about 35 to 55%. Packing density is an important factor in applications requiring an optimized solid angle and best fit to detection area.

Germanium Array Detectors

Because of the relative ease of handling a single workpiece, monolithic detectors can be made with a large number of pixels or channels. For all multi elements detectors from 4 to 100 channels and where a good energy resolution and the best packing ratio is required. The resolution is very close to the one of a discrete array Ge detector and the combination of their fast proprietary reset preamplifier and their high energy resolution even at short shaping time allows very high count rate without any crosstalk between channels. The resolution with a 1/2 µs Gaussian filter is about the same as that of a discrete detector using a 1/4 µs filter.



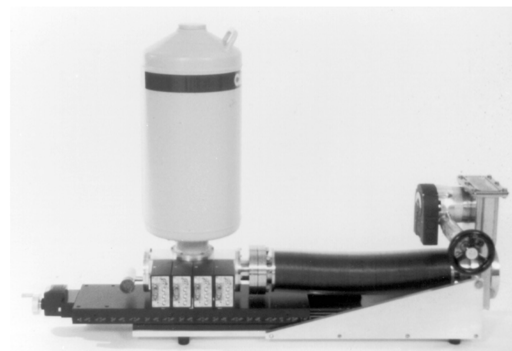
These curves illustrate typical performance of monolithic and discrete array detectors.

The Windowless Retractable Ultra-LEGe or Monolithic Array Detector (WRULEAD)

The WRULEAD is an Array Detector equipped with a gate valve and a translation mechanism allowing the detector to be positioned in a vacuum chamber in close proximity to the x-ray source with little or no intervening material. This provides for detection of low energy x rays that are severely attenuated by the thinnest available beryllium. Of course the detector must be retracted and the gate valve must be closed whenever the chamber vacuum is poor. With extreme care and caution the WRULEAD can be used successfully but the user is responsible for any damage or loss in performance caused by the environment.

Examples of Array Detectors

Here are photographs of several Array Detectors with different configurations, element count and array patterns. Several of these designs have been standardized and produced in some quantity. We encourage new customers to choose one of the existing designs which minimizes cost and risk. Of course simple modifications to existing designs can be implemented economically.

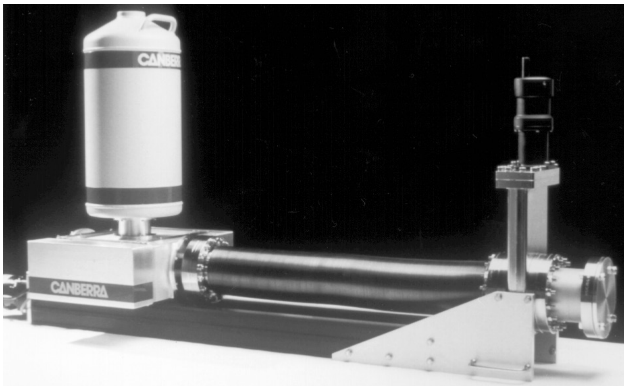


7 Element WRULEAD:
WRULEADs of this size are much more popular than larger ones, probably because of the risk of loss in the case of damage.

13 Element Compact:
The first array detector CANBERRA made for synchrotron radiation had 13 elements and we have made many since. The experience has fully cured us of triskaidekaphobia.

19 Element Discrete:
Starting with a symmetrical 13 element pattern, 19 elements is the next larger Array Detector. We have made several detectors of this size.

Germanium Array Detectors



30 Element WRULEAD:
This detector of extreme proportions is the largest WRULEAD we have built.

32 Element Discrete:
Many detectors of this size have been made.

36 Pixel:
Germanium detector.

100 Element Monolithic:
This is the first 100 element detector manufactured commercially.

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