BNC High-Purity Germanium Detectors

Berkeley Nucleonics has been a leader in the field of semiconductor gamma- and X-ray detectors for over 30 years. In the early days, this meant lithium-compensated germanium. Then, when General Electric first produced high-purity (intrinsic) germanium crystals in 1972-73, BNC manufactured the first commercial HPGe planar detectors, soon followed by the first HPGe coaxials. Since that time, BNC HPGe detectors have explored outer space, gone to the depths of mines in search of β-β decay in enriched germanium, and found uses throughout the world in nuclear power plants, environmental measurements, and aerospace studies.

HPGe has an impurity level of ~10^{10} impurities per cubic centimeter and is designated either P-type or N-type, based on the type of impurity. One surface of the crystal has a lithium-diffusion N⁺ layer, ~0.5 mm thick; the other surface has a thinner P⁺ layer formed by boron ion implantation or gold metallization.

When a bias voltage is applied to the crystal, incident ionizing radiation creates charge carriers that are swept toward oppositely charged contacts. In P-type coaxial (IGC series) and well detectors (IGW series), the applied voltage is positive, and holes are the primary charge carriers. In N-type coaxial (NIGC series) and planar crystals (IGP or NIGP detectors), the outer face is the thin P⁺ layer and the applied bias is negative. Electrons are the main carriers. These detectors have lower trapping levels and are less sensitive to neutron damage.

BNC also manufactures lithium-drifted silicon, Si(Li), detectors for X-ray spectroscopy.

Selecting a Detector

All BNC HPGe and Si(Li) detectors can be temperature cycled and stored indefinitely at room temperature. Several parameters are useful in the selection of a detector for a particular application.

Energy Range

In general, IGC detectors are suitable for energies of 40 keV to 10 MeV. N-type coaxials extend the range down to 4 keV. For lower-energy gammas, planar detectors are recommended for the 3 keV-1 MeV range, since they have better energy resolution and less sensitivity to high energy background than do NIGC detectors. For X rays from 109 eV to 60 keV, Si(Li) detectors are preferred.

Efficiency

The IEEE Standards describe efficiency as absolute, the ratio of photons detected to all photons emitted by the source, or relative, which compares the number of photons detected to the number detected by a 7.62 mm × 7.62 mm (3" × 3") NaI(Tl) scintillation detector. Efficiency is also related to crystal size. Thus, coaxial detectors are frequently “sized” by percent relative efficiency. PGT IGC detectors, for example, are available in 10-100% relative efficiency.

It is important to select the appropriate size. An overly large detector wastes money and may create high count rate problems. A small detector will be less expensive, but can cost more in time required for an analysis.
A variety of liquid-nitrogen cooled cryostats, including dipstick, unitary, and portable styles, along with the JT Cool cryocooler, can be selected. The BNC QUIET ONE™ ultra-low microphonics mounting system assures the best possible resolution even in the noisiest field deployment situations. Beryllium and low-Z organic windows and well inserts are needed for lower energy ranges. Low-background materials, as well as lead shields, can be specified if needed.

BNC can design a system best suited to your nuclear spectroscopy needs.

### Energy Resolution

Energy resolution is a measure of how well neighboring or overlapping peaks can be distinguished from one another. The usual standard for energy resolution is the full width at half maximum (FWHM) for the full energy peak of the Co60 1.33 MeV line. Usually, a second value, at one-tenth the maximum (FWTM), is also determined. The ratio of these, FWTM/FWHM, is called peak shape, and is used in computer analysis of complex spectra. For lower-energy regions, the FWHM of the 5.9 keV line of Fe55 or the 122 keV line of Co57 is reported.

Resolution may be limited by the multichannel analyzer (MCA) used. For example, if the MCA has only 4000 channels available for a 2MeV energy range (i.e., only 2 channels per keV), then the difference between a 2.2 keV FWHM detector and a more expensive 1.7 keV FWHM detector will hardly be noticed.

### Other Factors

The peak-to-Compton ratio is sometimes more important than resolution or efficiency. At the lowest energy ranges, the peak-to-background is the significant factor because the Compton effect is small compared to scattering and window and edge effects. For planar detectors, the active area, depletion depth, and window thickness need to be considered.

All these measures of detector performance are dependent also on the other system components. BNC offers three types of preamplifier: resistive feedback, optical reset, and transistor reset.