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GAMMA RAY SPECTROSCOPY USING A GERMANIUM LITHIUM-DRIFTED DIODE

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The lithium drift process has been used to make wide depletion layer diodes in germanium. For gamma ray spectroscopy diodes of germanium have a considerable advantage over those of silicon[1]) since the photo-electric absorption cross section varies approximately as Z^5. This advantage has been demonstrated by the work of Freck and Wakefield[2]) and has been confirmed by work in this laboratory.

Furthermore, as the energy of the gamma ray decreases the ratio of the photo-electric to Compton cross-section increases. This is shown in fig. 1 which

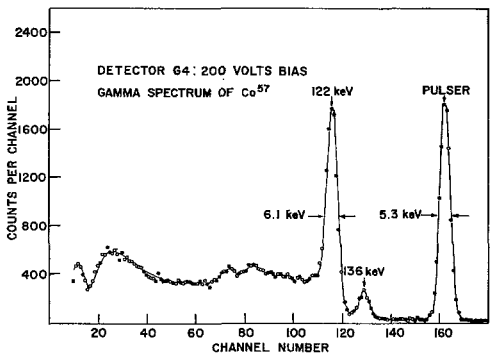

Fig. 1. Spectrum of cobalt-57 gamma rays taken using a cooled lithium-drifted germanium diode. The Compton background is sufficiently low that it cannot be detected.

is the spectrum of Co^{57} taken with a 0.5 cm^2 area, 0.5 cm depth of depletion layer, lithium-drifted germanium diode, operated at 77°K. The Compton cut-off should occur at 40 keV, but is sufficiently low that it cannot be distinguished from the "multiple Compton" background. The 122 keV and and 136 keV lines are readily resolved, each having a full width at half maximum of 6.1 keV. This is only slightly wider than that expected from electronic noise which, as indicated by the pulser data, is 5.3 keV (f.w.h.m.). The photo-electric efficiency of the 122 keV gamma ray is estimated to be greater than 7 % [3]).

The absorption of gamma rays by germanium is sufficiently high that there is a significant probability for the absorption of the secondary gamma ray of a Compton reaction. As the energy of

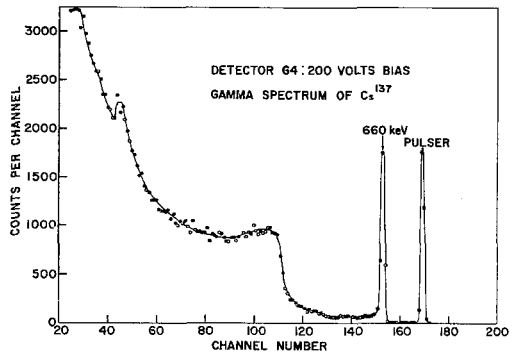

Fig. 2. Spectrum of cesium-137 gamma rays showing a high photo-electric peak. The height of the peak, relative to the Compton background, has been found to be volume dependent.

the secondary gamma ray and the associated Compton reaction electron add up to 660 keV, the absorption of the secondary adds to the counts in the photo-electric (or total absorption) peak. For Cs^{137} the height of the photo-electric peak has

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[1]) J. L. Blankenship and C. J. Borkowski; IRE Trans. on Nuclear Science, NS-9 (1962) 181. See also the review article by J. W. Mayer ibid., p. 124.

[2]) D. V. Freck and J. Wakefield, Nature 193 (1962) 669.

[3]) A. R. Jones, Health Physics 8 (1962) 1.

been found to vary with a 1.0, 2.5 and 5.0 mm depletion layer detector as 0.8, 1.0 and 1.8 times the height of the Compton background. The resolution of the photo-electric peak was approximately 7 keV in each case. Fig. 2 is a Cs^{137} spectrum, taken with the same detector used to obtain the data of fig. 1, showing the photo-electric peak about twice the height of the Compton background. The photo-electric efficiency is estimated to be 0.4 % for the 660 keV gamma ray.

Although the results quoted indicate that high resolution gamma spectroscopy is becoming practical with semiconductor counters, a word of caution is necessary. The diffusion coefficient of the lithium atoms in germanium is sufficiently high at room temperature that a significant redistribution of the lithium occurs over a period of a few days. Consequently, a germanium lithium-drifted diode will require a drift processing procedure to restore good characteristics each time it is put in operation.