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PROPERTIES OF CADMIUM TELLURIDE NUCLEAR DETECTORS

J. REBONDY and M. LAVAL

C. E. A., LETI B. P. 85, F 38041 Grenoble Cedex, France

Résumé. — Cet article résume les travaux effectués au LETI en vue de l'élaboration de détecteurs de rayonnements γ à base de différents types de cristaux de tellure de cadmium.

Abstract. — The results obtained at LETI on cadmium telluride nuclear radiation detectors prepared on various materials are shortly presented.

1. Introduction. — We intend to produce room temperature surface barrier γ -ray detectors able to operate in the 100-200 keV energy range. For our particular applications (medical) the following parameters are essential :

- possibility of producing a large number of detectors with similar and time invariant characteristics ;

- full charge collection efficiency in less than 10 μ s, with a detection probability better than 70 % in the energy range of interest, corresponding to a depletion layer of, at least, 2 mm ;

- energy resolution between 3 and 5 % at 100 keV, with a minimum noise coming from the detector ; therefore, the current generation must be below 10 nA at 1 000 V.

2. Detector preparation. — Our *cristallogénèse* Laboratory tested different methods of purification of the starting material and of crystal growth. Presently, the process generally includes one or two growths by the traveling heater method (THM). Chlorine is added for compensation of the defects. The p-type crystals obtained exhibit resistivities between 10^5 and $10^6 \Omega \cdot \text{cm}$.

The crystals are sliced in 2 mm thick samples, from which monocrystalline parts of 1 cm^2 are cut. After lapping with 10 μ grade alumina, the samples are cleaned in alcohol by ultrasonication. Metallic contacts are finally deposited by vacuum evaporation. Aluminium and platinum were found to give the best results.

We tried also evaporation of the contacts on finely polished or chemically etched surfaces, however, flashes at higher voltages and important leakage currents made the diode unuseful. Furthermore, we studied different processes to overcome the surface problem ; among them ionic bombardment, heating in vacuum at various temperatures just before the contacting... None of these treatments was found to really improve the quality of the device. However, by reducing the time spend between cleaning

and evaporation, we reached fairly good reproducibility.

The more specific detection performance of the spectrometers were also studied : energy resolution, charge collection efficiency, detection efficiency, including polarization. More than ten different crystals and a large number of detectors and contacts have been investigated. We built up a system of card indexing and have tried to bring out some conclusions by statistical approaches. It appeared that the THM, chlorine doped material gives the best detectors (a typical spectrum is reported on figure 1).

FIG. 1. — Co^{57} spectrum. The pulser gives the full charge collection.

But, there are still variations in resolution and charge collection efficiency. For detectors cut from the same ingot the mean FWHM is approximately 13 keV at 1 000 V for 122 keV quanta, with variations from 8 to 20 keV and with a charge collection of 40-50 %. But, for an other ingot, the FWHM reached 25-35 keV even if the charge collection reached 80-90 %. In fact, all our detectors show either a good energy resolution and a bad charge collection or the opposite, but never both parameters could be optimized.

All our detectors exhibit polarization when chlo-

FIG. 2. — CdTe n° 1755-17 (Cl).

FIG. 3. — CdTe n° 1755-17 (Cl).

rine is used for compensation. Progressively, both pulse amplitude and efficiency of detection decrease. Saturation is reached after several hours of biasing the counter. In general, during the first hour, the detection efficiency is reduced by 30 %. A proper surface treatment (etching) leads to a significant reduction of polarization, but other characteristics (noise) are, until now, badly affected. Instead of chlorine compensation, we tried either magnesium or zinc, but no satisfactory results have been achieved.

It appeared during this study that the surface problem may play a dominant role in the performance of the detectors and that bulk and surface properties have to be investigated separately, before the detector is realized. To investigate the bulk properties of the material, we started to use the time of flight technique with a 30-100 keV electron beam as excitation of carriers, the sample under test being maintained between 77 and 300 K and either d. c. or a. c. biased. Some preliminary results are reported on figures 2 and 3.

3. Conclusion. — Our goal was to investigate the possibility to use CdTe on larger scale. Even if we have found a small number of fairly good detectors, our main problem appeared to be the impossibility to obtain larger numbers of detectors with similar and time invariant characteristics. Therefore, more work has to be devoted in both crystal growth and contacting.