Digest of Tech. Papers The 7th Conf. on Solid State Devices, Tokyo, Sep. 1975

B-5-2 High-Purity CdTe and Its Application to Radiation Detectors

Tsunemasa Taguchi, Junji Shirafuji, Yoshio Inuishi and Tetsuji Kobayashi*

Department of Electrical Engineering, Faculty of Engineering, Osaka University, Osaka

*Toshiba Research and Development Center, Tokyo Shibaura Electric Co., Ltd, Kawasaki

Cadmium telluride is the most promising semiconductor for α-particle or γ-ray detectors operating at room temperature because of its high mean atomic number (50) and large energy gap (1.5 eV).

The crystals for surface-barrier-type nuclear radiation detectors require to be a high resistivity above 10^9 Ω-cm and a large μτ product for both electrons and holes. The high-resistivity crystals have been grown by a travelling heater method (THM)[1,2] from Te solution. Recently, we have shown that it is possible to grow the high-resistivity CdTe single crystals above 10^6 Ω-cm without adding chemical impurities by the THM technique under a controlled Cd pressure.[3]

The object of this paper is to describe the crystal growth of high-resistivity CdTe crystals and the detection properties of α-particle and γ-ray using CdTe detectors.

Crystal Growth

The CdTe single crystals have been grown from Te solution at temperatures of 640 - 850 °C much lower than the melting point of CdTe. The undoped single crystals with the size of 10 mm$^\phi$ diameter and 50 mm in length were obtained and were of high-resistivity p-type. The characteristic of crystals has been investigated by means of electrical and optical measurements as functions of growth temperature and growth speed. Figures 1 (a) and (b) show the electrical properties of the crystals obtained at various growth temperature with a growth speed of 7 mm/day and at various growth speeds with a growth temperature of 675 °C, respectively. It appears that the highest resistivity and mobility are reached at the growth temperature around 675 °C and the growth speed of 3 mm/day. Around 675 °C, the existence region of solid CdTe is expected to be closer to the stoichiometric line.[4] Reducing the growth temperature below 640 °C leads to poor crystallinity and low Hall mobility.

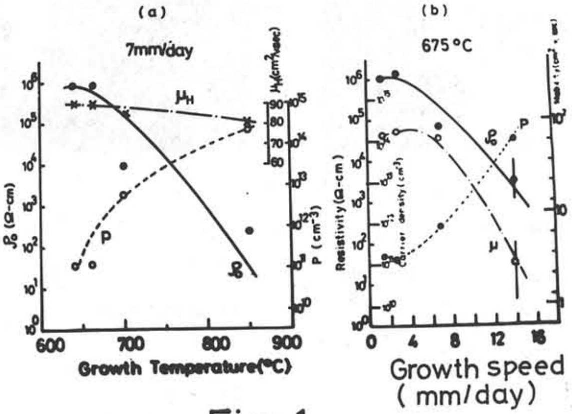

Fig. 1

Fabrication of Surface Barrier Diodes

After slicing into blocks with dimension of 25 - 100 mm^2 x 0.5 - 2 mm (thickness), the surfaces were etched chemically with a Br-CH_3OH solution. Au and Al contacts of equal area were then deposited by vacuum evaporation below 10^{-6} Torr onto two opposite faces as shown in Fig. 2. In this case, the surface barrier is produced on the Au electrode side.

The hatched region in Fig. 2 indicates the depletion layer formed under an relevant applied voltage. However, the diode showed a degradation in the I-V characteristic, being maybe due to a change in surface properties.

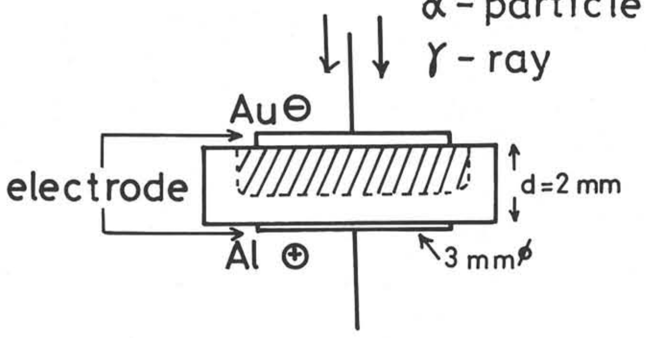

Fig. 2

Detection Characteristics

We carried out the detection of ^{239}Pu α-particle, and ^{60}Co and ^{137}Cs γ-ray at room temperature

Figure 3 shows the alpha response of α-particle from ^{239}Pu (5.15 MeV) at an applied bias of 30 V. The photopeak is clearly resolved. The signal was observed only when α-particles were irradiated to the Au electrode side. This shows that the charge transport is predominantly due to electrons. However, the efficiency of the charge collection is poor because of an weak applied field and a strong contribution of crystal imperfection.[5]

The Gamma detectors of CdTe do not need the ultimate in energy resolution, therefore, are adequate for applications like nuclear safeguards inspectors.

In summary CdTe is now capable of operating as a nuclear radiation detector. However, a significant improvement of the performance needs much reduction of trapping centers and an increase in resistivity. Also, the best procedures of the formation of electrode and crystal surface treatment must be established to high-resistivity CdTe.

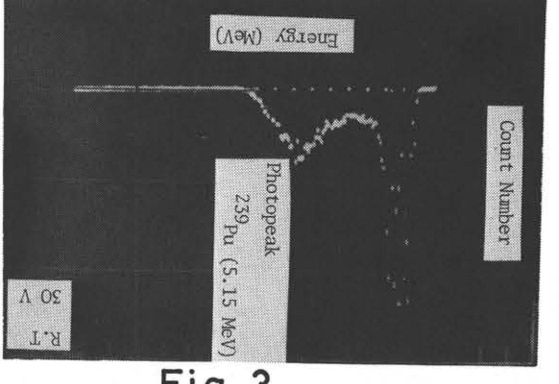

Fig. 3

1) R. Bell and F. Wald ; I E E E Trans. Nuclear Sience 21 (1974) 331

2) T. Taguchi, J. Shirafuji and Y. Inuishi ; Japan. J. appl. Phys. 13 (1974) 1169

3) T. Taguchi, J. Shirafuji and Y. Inuishi ; Journal. Jap. Association of Crystal Growth; submitted

4) D. Nobel ; Philips Res. Rep 14 (1959) 374

5) K. Zanio ; Appl. Phys. Letters. 14 (1969) 56