DEVELOPMENT OF A NEW SOLID STATE NEUTRON DETECTOR FOR POCKET DOSEMETER

Toshikazu Suzuki, Toshiya Yamano, Yoshiteru Yoshida,
Kazuo Tsukino and Takao Urushibata
Tokyo Factory, Fuji Electric Co., Ltd.
Fuji-cho 1, Hino, Tokyo 191, Japan

Noritada Sato
Research Laboratory, Fuji Electric Co., Ltd.
Nagasaka 2-2-1, Yokosuka, Kanagawa 240-01, Japan

SUMMARY

A new solid state neutron detector for a pocket dosemeter was developed. This is one of planer type p-n junction silicon semiconductor detectors. A thick p+ layer of boron-10 is made on a n type high-purity silicon substratum by a plasma CVD (Chemical Vapor Deposition) process.

The detector, amplifier and discriminator are assembled as a hybrid integrated circuit for compactness together with a polyethylene radiator to obtain neutron sensitivity up to MeV region.

DETECTOR STRUCTURE AND FABRICATION

Figure 1 shows the structure of the present detector. A SiO_2 film of about 1 μm is formed by SiH_4 on a surface of n type silicon substratum of 10k ohm-cm. A window for doping boron-10 with enriched B_2H_6 is provided on the surface by photo-etching process. The window is then coated with a boron-10 film of 0.6 um in thickness by dc plasma doping process. A p+ layer is also formed in the process simultaneously. Electrodes for signal lead are made by vacuum depositioning of aluminum onto both surfaces of the substratum.

Figure 2 shows the density distribution in the boron layer of boron-10 atoms, boron-11 atoms, hydrogen atoms and silicon atoms. This distribution was obtained by a secondary ion mass analysis. Figure 3 shows the block diagram of the present detector. We have employed a charge amplifier as a preamplifier and a bipolar amplifier having 1.5 μsec shaping time as a linear amplifier. All these circuits consist of chip electronic parts and miniflat integrated circuits, and compose one hybrid integrated circuit mounted on a ceramic substratum together with a 0.8 mm thick polyethylene radiator (1). A bias voltage of the detector is +5V, which is common with a power source voltage.

RESULTS

Figure 4 shows the pulse height spectrum of the detector for thermal neutrons. The thermal neutron sensitivity measured over the discrimination level in this figure is 3.50×10^{-4} cps/nv, the sensitivity to 1 MeV and 144 keV fast neutrons is 2.52×10^{-4} cps/nv and 3.13×10^{-4} cps/nv, respectively. Although the moderator is as small as 1 cm, the sensitivity to fast neutrons is not much different from the thermal neutron sensitivity by measuring recoil protons from the radiator. A water phantom of 20 x 30 x 40 cm was used for these measurements.

REFERENCES

(1) N. Kobayashi, et al.: Nuclear Instruments and Methods 242 154 (1985)

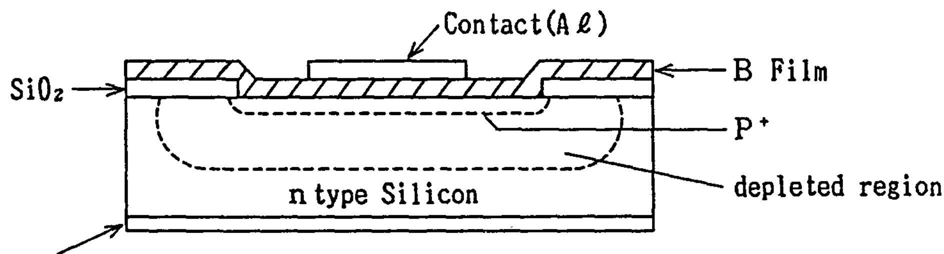

Fig.1. Structure of the present detector

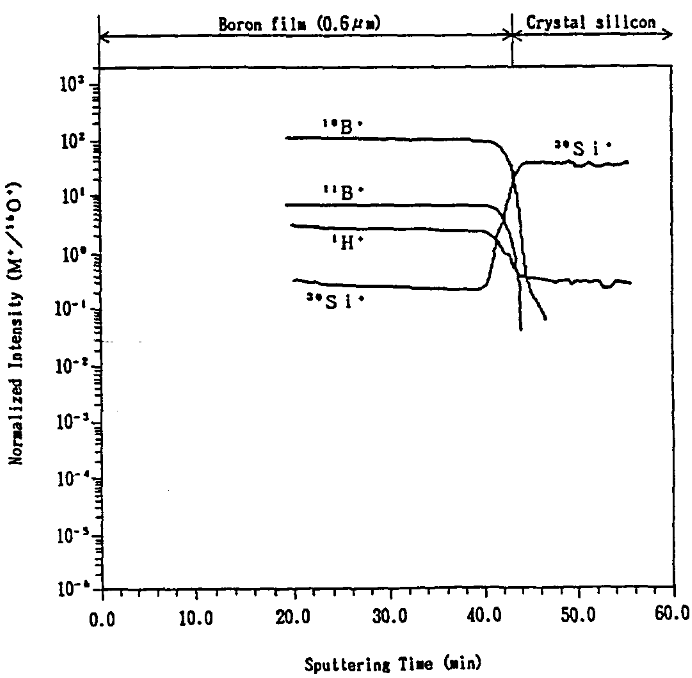

Fig.2. Measured distribution of atomic density for ^{10}B, ^{11}B, ^{1}H and ^{30}Si in the surface of the present detector

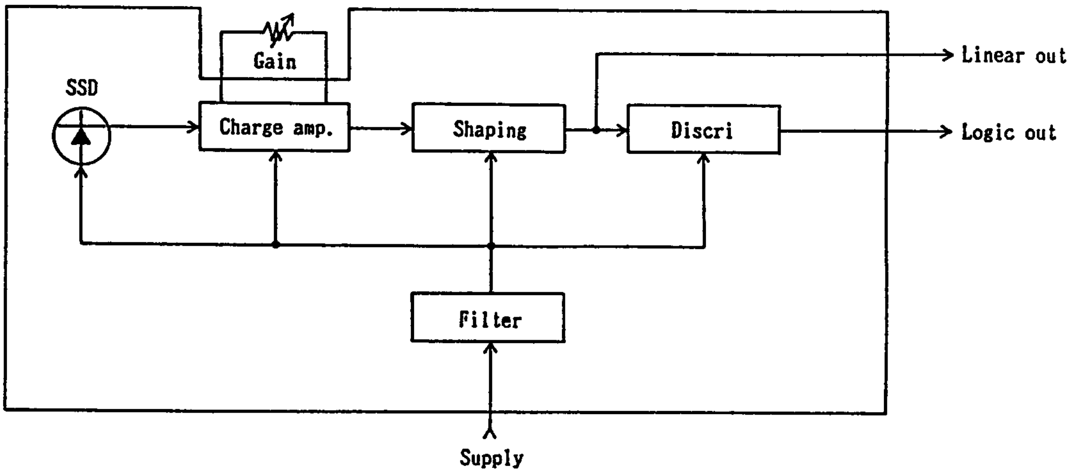

Fig.3. Block diagram of the present detector

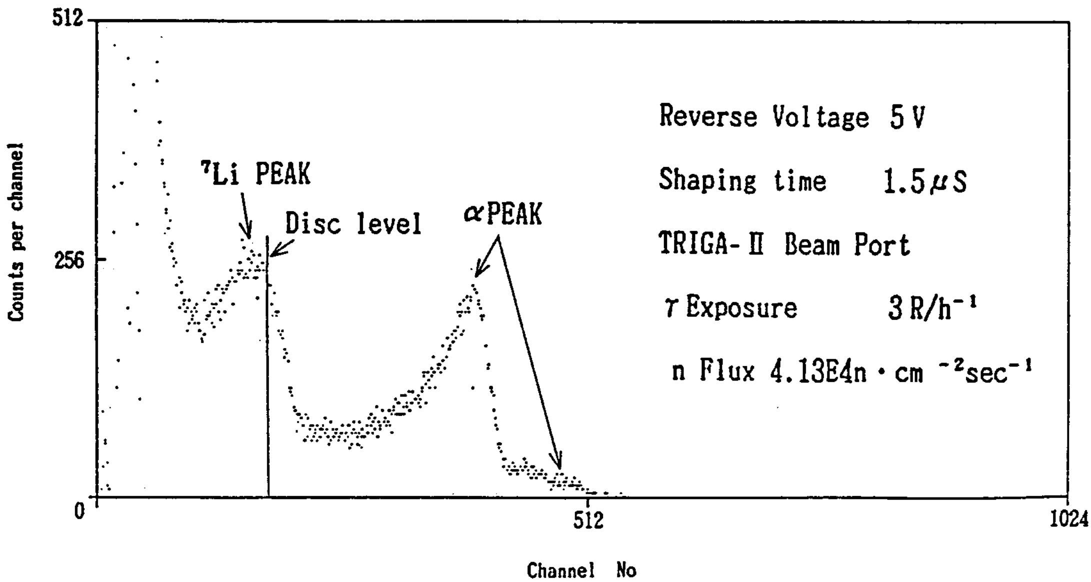

Fig.4. Pulse height spectrum for thermel neutron obtained by the present detector