

## Development of Silicon PIN detector for Radon monitoring

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### 1. Introduction

Radon is a radioactive noble gas that is formed from the decay of radium. Radon is significant contaminant that affect indoor air quality. Radon gas from natural source can accumulate in buildings, and radon is reportedly the second most frequent cause of lung cancer, and radon-induced lung cancer is the 6<sup>th</sup> leading cause of cancer death overall [1]. Therefore, it is very important to monitor the radon. One of the most popular way to monitor the radon is to measure  $\alpha$  particles, which are generated from the decay chain of radon. The radon monitor has been imported until recently, and the development of high sensitive  $\alpha$  particle detector is very important to monitor and control the radioactive radon in environment. In the present work, a silicon PIN diode was developed, the radon from environmental sample could be successfully monitored by measuring  $\alpha$  particles.

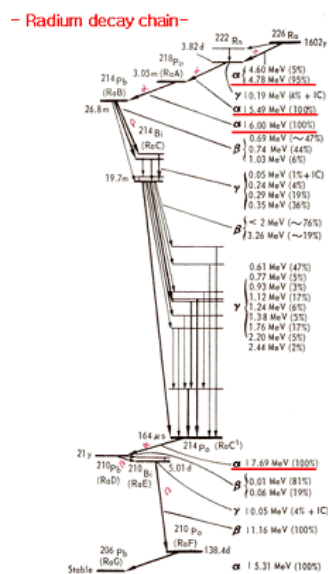


Fig. 1. Decay chain of Ra-226

### 2. Methods and Results

The silicon PIN diode was developed to measure the  $\alpha$  particles from radon. The I-V curve of the PIN diode was obtained, and the energy spectrum of  $\alpha$  particle from <sup>241</sup>Am source was measured. The decay  $\alpha$  particles from radon was measured with environmental soil sample. The sensitivity of the PIN diode was determined and it was comparable with that of the commercial radon monitor.

### 2.1 Fabrication of PIN diode

The PIN diode structure was designed based on SRIM code [2] and TCAD simulator. The energies of  $\alpha$  particles from radon are known to be from 4.78 MeV to 7.49 MeV, and it is important to design the detector for  $\alpha$  particle to stop at the active region of the PIN diode. The active area of PIN diode was  $10 \times 10 \text{ mm}^2$ , and two guard rings were designed to make the leakage current of the detector smaller. Edge protection design was used to make sure the stable detector performance when high voltage was biased on the diode.

The semiconductor planar process was used to make the PIN diode for  $\alpha$  particle detector [3]. Fig. 2 shows the Si PIN detector for radon monitor.

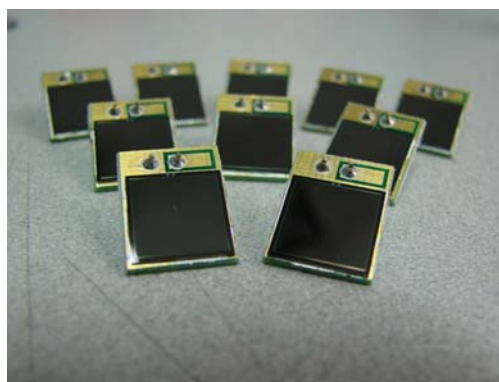


Fig. 2. PIN detector for radon monitor

### 2.2 Detector Performance

The operating properties of Si PIN detector were obtained by measuring the I-V curve and energy spectrum of detector. Parameter analyzer (Model No : Hewlett Packard 4155B) was used to bias high voltage and read the leakage current from the detector, when the I-V curve was measured. The energy spectrum was measured with 5.4 MeV  $\alpha$  particles from <sup>241</sup>Am radiation source. The signals from the detector was amplified with the pre-amplifier (Cremat CR-110), and shaped with amplifier (ORTEC 572 A). The signal was digitized and stored with MCA.

### 2.3 Radon measurement from environmental sample

An soil sample was obtained, and the  $\alpha$  particle from the sample was measured with the detector. It is known that the activity of the sample was 5.6 Bq/g, and the emission ratio of  $\alpha$  particle in sample was 25 %.

The detector was installed in metal box of alpha spectrometer (ORTEC SOLOIST), and soil sample was also inserted in the metal box.

[3] J. Kemmer, "Fabrication of low noise silicon radiation detectors by the planar process", Nucl. Instr. Meth. A 169, pp. 499 – 502, 1980.

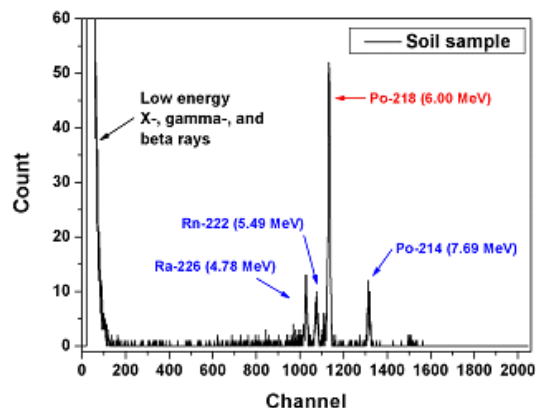


Fig. 2.  $\alpha$  energy spectrum from the soil sample measured with PIN diode

The peaks of  $\alpha$  particles from radon of soil sample could be clearly seen in the spectrum. The radon sensitivity of the detector was measured and it was determined to be 0.309 cpm/pCi/L, which was almost same as the sensitivity of commercial radon monitor (0.3 cpm/pCi/L).

### 3. Conclusions

Si PIN diode was developed for the radon sensor. The entrance window of Si PIN diode was designed to make the energy loss of  $\alpha$  particle small. Silicon planar process was employed to make the Si PIN detector. The leakage current and  $\alpha$ -particle energy spectrum was measured with the Si PIN detector. The  $\alpha$  particle from environmental radon sample was successfully measured with the Si PIN detector.

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- [2] J. F. Ziegler, J. P. Biersack, "SRIM-2000, 40: The Stopping and Range of Ions in Matter", IBM-Research, Yorktown, NY 2000.