ISSN 2348 – 8034
Impact Factor- 3.155

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

IMPLEMENTATION OF RADON COUNTER USING CCD IMAGE SENSOR MODULE

Gyu-Sik Kim[*1] & Tae-Gye Oh[2]
[*1,2] Department of Electrical Engineering, The Univ. of Seoul, Seoul, Korea

ABSTRACT
Radon is an invisible, odorless and chemically inactive radioactive gas that is produced by the decay of uranium ore. Various types of equipment and components have been proposed to date for radon detection. In this paper, a radon counter using CCD image sensor module is implemented. Through experimental studies, we found that the CCD image sensor module could be used for a radon counter.

Keywords: *radon, radon counter, CCD image sensor*

I. INTRODUCTION
Radon is an invisible, odorless and chemically inactive radioactive gas that is produced by the decay of uranium ore, such as radium, actinium, or thorium. Because inhaling radon and its radioactive decay products causes irradiation of lung tissue, prolonged exposure to high concentrations of radon significantly increases the risk of developing cancer. It has been reported that the US. Environmental Protection Agency estimates exposure to naturally occurring radon leads to 21,000 lung cancer deaths nationwide each year, making radon the nation's primary environmental health threat and second only to cigarette smoking as a cause of fatal lung cancer.

Various types of equipment and components have been proposed to date for radon detection. In [1], highly sensitive, electrostatic collection chambers have been developed for low-level radon measurements using CR-39 plastic track detectors. In [2], a radon detector employs an electrically charged pressed, porous metal filter that allows radon gas diffusion, while blocking ambient light, so that it readily traps both attached and unattached Po-214 and Po-2l8 ions, that may be present in gas passing through the filter, the filter being charged positively relative to an unbiased PN junction of a photo diode detector within a detection chamber. In [3], a passive direct-reading radon monitor utilizing a custom α particle detecting MOS integrated circuit and electrostatic radon progeny concentrator has been designed. In [4], a silicon PIN photodiode was designed and fabricated in consideration of low-leakage-current and high-bias-voltage application. In [5], a fast-responding passive radon detector using electrostatic concentration and enhanced readout electronics has been designed. In [6], an electrostatic concentrator constructed by metalizing a plastic funnel is used to focus charged radon progeny onto the exposed surface of an optical image sensor from a webcam. Alpha particles emitted by the collected progeny strike the image sensor, generating sufficient charge to completely saturate one or more pixels.

In this paper, a radon counter using CCD image sensor module is implemented. To demonstrate the practical significance of our results, we present some experimental results.

II. CCD IMAGE SENSOR MODULE
When an image is being captured by a network camera, light passes through the lens and falls on the image sensor. The image sensor consists of picture elements, also called pixels, that register the amount of light that falls on them. They convert the received amount of light into a corresponding number of electrons. The stronger the light, the more electrons are generated. The electrons are converted into voltage and then transformed into numbers by means of an A/D-converter. The signal constituted by the numbers is processed by electronic circuits inside the camera. Presently, there are two main technologies that can be used for the image sensor in a camera, i.e. CCD (Charge-coupled Device) and CMOS (Complementary Metal-oxide Semiconductor). [7]

CCD image sensors accomplish task of capturing light and converting it into electrical signals. Each cell of a CCD image sensor is an analog device. When light strikes the chip, it is held as a small electrical charge in each photo sensor. The charges are converted to voltage signal for one pixel at a time as they are read from the chip. This signal is amplified outside the sensor, see Figure 1.

Figure:

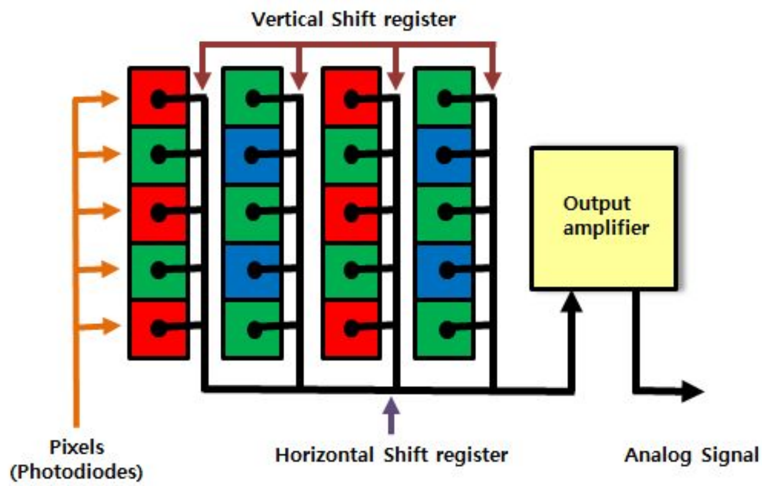


Figure 1. CCD operation principle

CCD sensors have had some advantages compared to CMOS sensors, such as better light sensitivity and less noise. In recent years, however, these differences have disappeared. The disadvantages of CCD sensors are that they are analog components that require more electronic circuitry outside the sensor. CCD sensors also require a higher data rate, since everything has to go through just one output amplifier, or a few output amplifiers. Figure 2 shows the CCD image sensor module used for our experimental studies.

Figure:

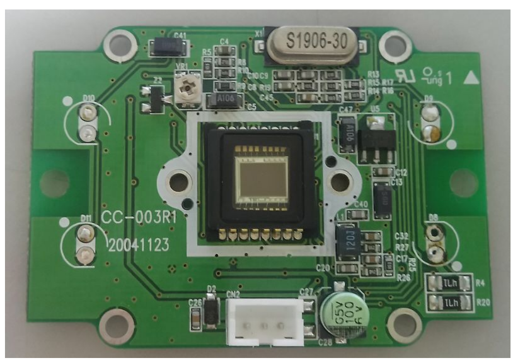


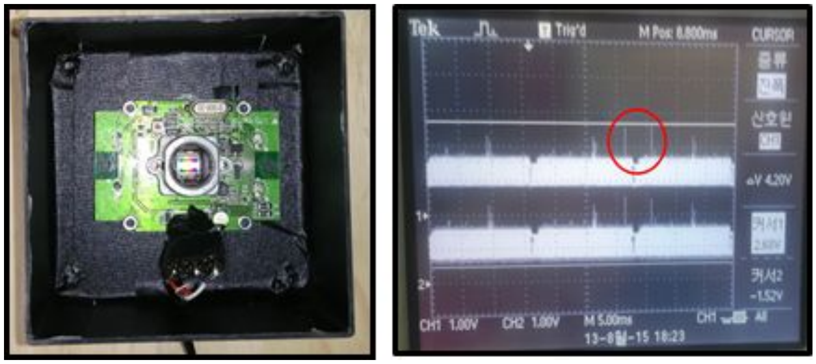
Figure 2. CCD image sensor module used for experimental studies

III. IMPLEMENTATION OF RADON COUNTER

CCD image sensors are used to detect the alpha emissions from radon progeny, in particular, 218Po and 214Po which have been concentrated onto the image sensor surface. The cover glass of a CCD camera module should be removed in order to make the alpha emissions hit the image sensor surface. As can be seen in Fig. 3 (a), the CCD image sensor module was placed in a light-blocking chamber. Normally, the output voltage of the CCD image sensor signal was kept between 1.78V and 2V. But, when the radon particle was detected, it was 2.68V as shown in Fig. 3 (b) (two pulses in a circle). Therefore, the comparator circuit with reference voltage of 2.4V can be used for the radon detection.

ISSN 2348 – 8034
Impact Factor- 3.155

Figure:



(a) (b)

Figure 3. CCD sensor module in a light-blocking chamber and detected radon

In order to investigate the performance of the implemented CCD sensor-based radon counter, the commercial radon detector : Safety Siren Pro Series3 - HS71512 was used. The methyl methacrylate box was made for these experiments. Radon emitting soil was placed on the shelf. Then, two radon counters was set under the shelf as shown in Fig. 4.

Figure:

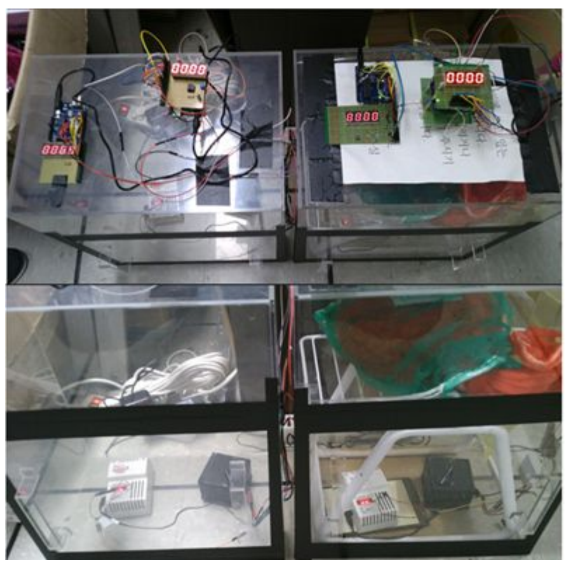


Figure 4. Experimental set-up for performance test

IV. RESULT & DISCUSSION

The measurement result using the CCD sensor-based radon counter is seen in Fig. 5. A Safety Siren Pro Series3 - HS71512 was used as a reference during this experiment. The Siren radon counter adopts a pin-type photo diode for radon sensing. It also has a electrostatic concentrator to deposit charged radon progeny onto the pin-type photo diode. It yields a count rate of about 6counts per hour. On the other hand, the CCD radon counter yields a count rate of about 3.75counts per hour. This may be due to the absence of the radon progeny collecting circuit such as an electrostatic concentrator.

Figure:

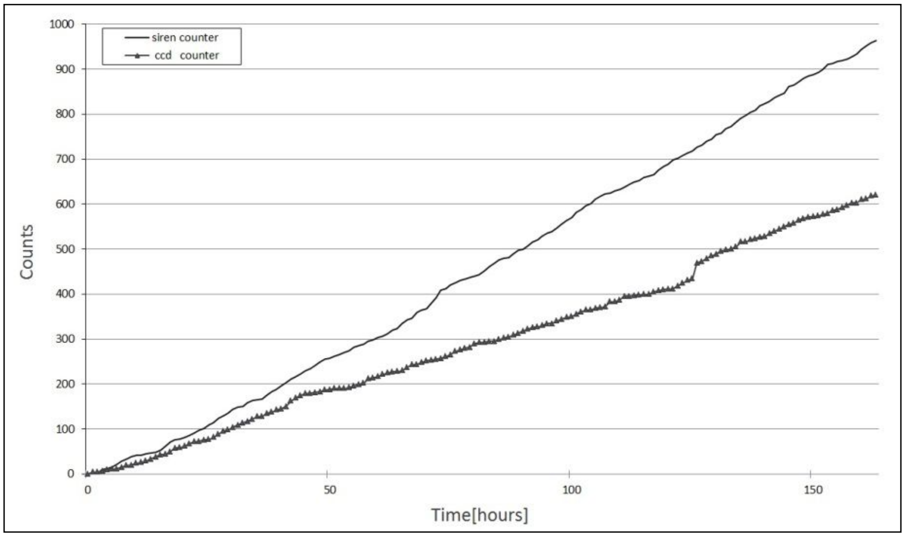


Figure 5. Measurement results showing the feasibility of CCD sensor-based radon counter

V. CONCLUSION

A radon counter using CCD image sensor module is implemented. For radon emitting soil, a measured count rate of 3.75counts per hour was observed. Through experimental studies, we found that the CCD image sensor module could be used for a radon counter. More studies, such as adopting of electrostatic concentrator, calibration of CCD module, and linear regression analysis should be followed.

VI. ACKNOWLEDGEMENTS

This study was funded by the Korea Ministry of Environment (MOE) as ‘‘the Environmental Health Action Progra m.’’

REFERENCES

1. *Hiroshi Miyake, Keiji Oda and Masami Michijima, "Portable and High-Sensitive Apparatus for Measurement of Environmental Radon Using CR-39 Track Detector," Japanese Journal of Applied Physics, vol.26, No.4, pp.607-610, April, 1987*
2. *Peter J. Diamondis, "Radon gas measurement apparatus having alpha particle-detecting photovoltaic photodiode surrounded by porous pressed metal daughter filer electrically charged as PO-219 Ion accelerator," US patent, P.N. 5489780, Feb. 1996*
3. *R. H. Griffin, H. Le, D.T. Jack, A. Kochermin and N.G. Tarr, "Radon Monitor using Custom α - detecting MOS IC," in Proceedings of IEEE Sensors 2008, Lecce, Italy, pp.906-909, Oct. 2008.*
4. *Han Soo Kim, Se Hwan Park, Jang Ho-Ha, Dong-Hoon Lee, and Seung Yeon Cho, "Characteristics of a Fabricated PIN Photodiode for a Matching With a CsI(TI) Scintillator," IEEE Trans. Nucl. Sci., vol.57, NO.3, pp. 1382-1385, June, 2010*
5. *R.H. Griffin, A. Kochermin, N.G. Tarr, H.McIntosh, H.Ding, J.Weber and R.Falcomer, "A sensitive, fast-responding passive electrostatic radon monitor," in Proceedings of IEEE Sensors 2011, Limerick, Ireland, Oct., 2011*
6. *Ryan H. Griffin and N. Garry Tarr, "Optical image sensors and their application in radon detection," in Proceedings of SPIE Vol.8915, pp.8915C-1~7, Oct., 2013.*
7. *http://www.axis.com/files/whitepaper/wp_ccd_cmos_40722_en_1010_lo.pdf*