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Sensitivity Improvement of Radon Counter Using a Fan

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***Abstract*— Radon is a radioactive gas that is colorless, odorless, and tasteless and is impossible to detect without the use of sensitive test equipment. In this paper, a PIN photodiode radon counter was implemented. The radon counter is designed to notify the user of the level of radon gas on either a short-term or long-term basis, and is updated every hour if there is a change in the level of radon gas. A micro fan is used to improve air flow in chamber, resulting in better sensitivity. Through some experimental studies, it was found that the sensitivity of the radon counter could be much improved with the help of micro fans.**

***Keywords*— radon, PIN photodiode radon counter, micro fan, chamber, sensitivity**

I. Introduction

Radon is a natural, inert, invisible, odorless and chemically inactive radioactive gas emitted from the earth. It is produced by the decay of uranium ore, such as radium, actinium, or thorium. Because it is inert and does not chemically bond to elements, it is released from soil into the atmosphere. Radon is emitted almost everywhere on earth, but some geographical regions have higher concentrations than others. When radon decays, it released alpha particles with energy of 5.5 MeV. 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], the system is developed which monitors the radon level, using a PIN diode for detecting the radon particles and a data processing module with Wi-Fi communication capabilities for the transmission and management of measurement results. In [7], 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 PIN photodiode radon counter is implemented [8]. The radon counter is designed to notify the user of the level of radon gas on either a short-term or long-term basis, and is updated every hour if there is a change in the level of radon gas. A micro fan is used to improve air flow in chamber, resulting in better sensitivity. Through some experimental studies, it was found that the sensitivity of the radon counter could be much improved with the help of micro fans.

II. PIN Photodiode Radon Counter Using A Fan

Radon is a radioactive gas that is colorless, odorless, and tasteless and is impossible to detect without the use of sensitive test equipment. Radon is a naturally occurring gas produced by the breakdown of uranium in soil, rock, and water. The EPA presently suggests that corrective action should be taken to reduce the radon levels in your home if measured over the long term at 4 pCi/L or greater. Recently a PIN photodiode is more widely used than a conventional PMT, because it requires less bias to operate it and it is very compact. A PIN photodiode radon counter shown in Fig. 1 was implemented for detecting of radon gas in this paper [8]. The LCD display shows the level of radon gas in Pico Curies per liter (pCi/L). The display range is 0.0 to 999.9.

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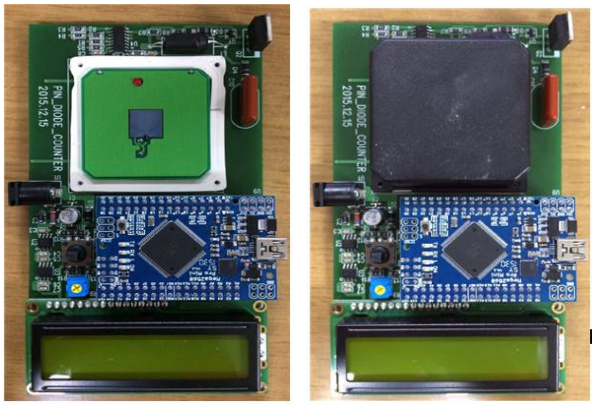
The radon counter developed in this paper is designed to notify the user of the level of radon gas on either a short-term or long-term basis, and is updated every hour if there is a change in the level of radon gas.



(a) opened chamber **(b) closed chamber**

Fig. 1. Implemented PIN photodiode radon counter

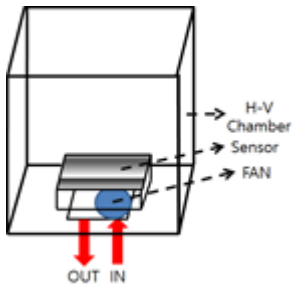
Fig. 2. Micro fan used to improve air flow in chamber

As shown in Fig. 2, a micro fan is used to improve air flow in chamber, resulting in better sensitivity. The size of the micro fan RFA1504 is 15mm x 15mm. Its rated speed is 16,000 rpm. The rated voltage and rated current are 5 V and 42 mA, respectively. The micro fan is attached underneath the high voltage chamber as shown in Fig. 3.

III. Experimental Results And Discussions

In order to investigate the feasibility of the micro fan for the improvement of sensitivity of radon counters, some experimental studies were attempted. Fig. 4 shows the sensitivity test of radon counter using a micro fan. First, some experimental results are presented, which show sensitivity improvement in the case of background condition. As shown in Fig. 4 (a), the radon counter is set on the floor of university lab.

This experiment was done for 123 hours. The micro fan was initially set to 0 rpm. After 48 hours elapsed, the speed of the micro fan was changed to be 16,000 rpm. Then, it was stopped when 96 hours elapsed. Fig. 5 shows the experimental results of cumulative radon counts. As shown in Fig. 5, for the range of 48 to 96 hours, the slope of the graph was much higher than those of the other ranges. Averagely, the sensitivity of fan ON was improved 50% better than that of fan OFF.



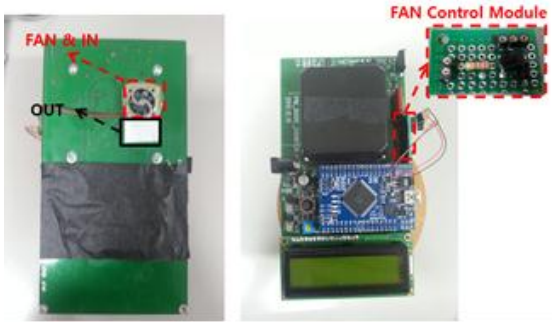
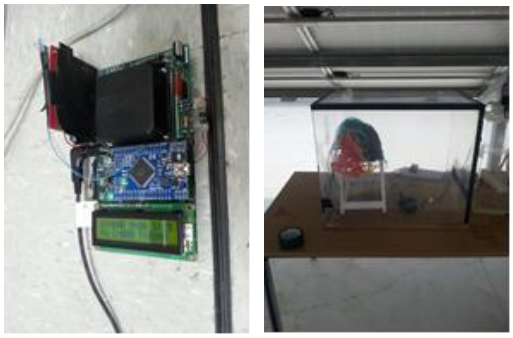


Fig. 3. Micro fan attached underneath the high voltage chamber



(a) without radon soil **(b) with radon soil**

Fig. 4. Sensitivity test of radon counter using a micro fan

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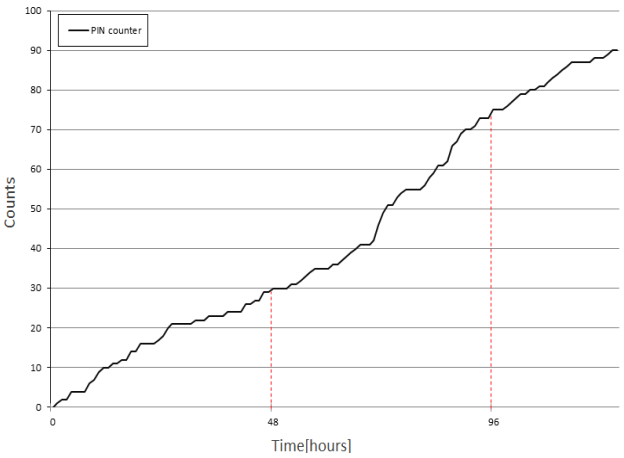

Fig. 5. Sensitivity test results in the case of background condition

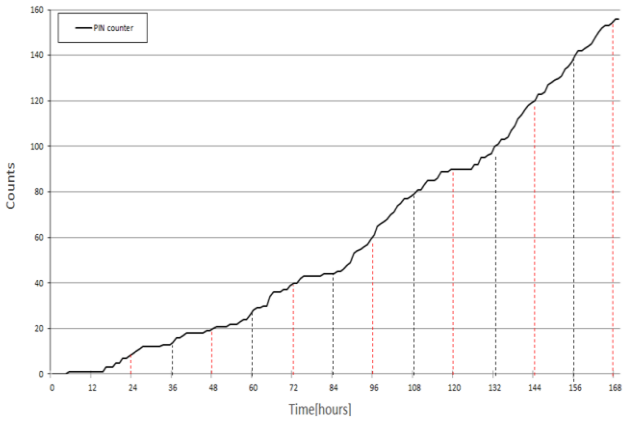

Fig. 6. Sensitivity test results in the case of radon emitting soil

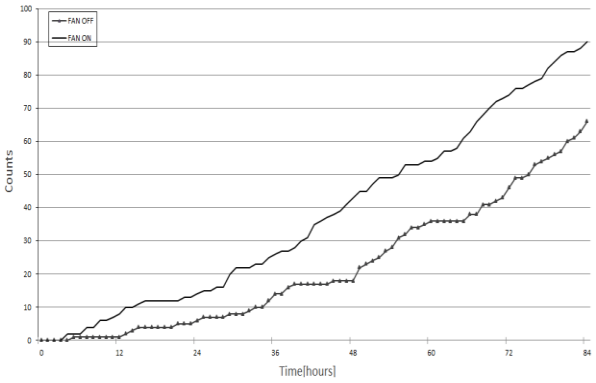

Fig. 7. Sensitivity test results for fan ON and fan OFF

Second, the sensitivity test of radon counter was done in the case of radon emitting soil as shown in Fig. 4 (b). The methyl methacrylate box was made for these experiments. Radon emitting soil was placed on the shelf. Then, the implemented radon counter was set under the shelf. This experiment was done for 168 hours. The micro fan was initially set to 0 rpm. After 12 hours elapsed, the speed of the micro fan was changed to be 16,000 rpm. Then, it was stopped when 24 hours elapsed. Thus, the micro fan repeated ON and OFF every 12 hours. Fig. 6 shows the experimental results of cumulative radon counts. The fan ON data and fan OFF data were selected separately from Fig. 6. In Fig. 7, the upper data curve is cumulative radon counts for the case of fan ON. The lower data curve in Fig. 7 is cumulative radon counts for the case of fan OFF. Averagely, the sensitivity of fan ON was improved 35% better than that of fan OFF in the case of radon emitting soil. Through experimental studies, it was found that the sensitivity of the radon counter could be much improved with the help of micro fans.

IV. Conclusion

Various types of equipment and components have been proposed to date for radon detection. In this paper, a PIN photodiode radon counter was implemented for detecting of radon gas in this paper. The LCD display shows the level of radon gas in Pico Curies per liter (pCi/L). The display range is 0.0 to 999.9. The radon counter is designed to notify the user of the level of radon gas on either a short-term or long-term basis, and is updated every hour if there is a change in the level of radon gas. A micro fan is used to improve air flow in chamber, resulting in better sensitivity. Through some experimental studies, it was found that the sensitivity of the radon counter could be much improved with the help of micro fans.

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