MICRO FIELD EMITTER DRIVE CdTe X-RAY IMAGER
(приглашенный доклад)

Toru Aoki, Masashi Nakagawa, Masayoshi Nagao[*], Chiaki Yasumuro[*], Seigo Kanemaru[*], Volodymyr Gnatyuk, Yoichiro Neo, Hidenori Mimura

Research Institute of Electronics, Shizuoka University, Japan
[*]AIST, Japan

We proposed a new addressing method that used a field emitter type electronic source for the radiation detector. And we have made it possible that this device operates at room temperature by using a cadmium telluride (CdTe) diode. In this addressing method, the electron energy from an electronic source in each pixel was highly uniform. Moreover, because the proposed device was actuated by the field emitter, it was expected to achieve the super-high resolution X-ray imager. We used the carbon nanoneedle field emitter, and the proposed device operation was confirmed by verifying the principle about one pixel.

The CdTe M-p-n diode and carbon nanoneedle field emitter were actually combined for the verification of the proposed principle that was the purpose of this study and it was experimentally confirmed. In the measurement system the carbon nanoneedle field emitter emitted electrons to the p-type CdTe side by applying the gate voltage (GV) of positive bias. At the same time, the n-type CdTe side attracted electrons by applying the anode voltage (AV) of positive bias. As a result, p-type CdTe side was negatively electrified by field emission electrons. In this case, the flowed dark current in this circuit was measured. Furthermore, in addition to this state, X-ray was irradiated to the CdTe detector. An electron-hole pair was generated as a result of the photoelectric effect by interaction between CdTe and X-ray and then a hole was recombined with a field emission electron. As the signal current, we measured the flowed current which was changing by X-ray irradiation. In the experiment, field emission electrons continuously bombarded the p-type CdTe side but an X-ray source was turned on and off every 20 seconds. The X-ray current measurement was carried out by changing the X-ray tube current. The tube current related to the X-ray radiation value, so we confirmed the relation between the tube current and signal current.

Fig. 1 shows the dark current measured when field emission electrons irradiated CdTe and at positive biased AV. If the dark current value is too large, the signal current is buried at radiation and X-ray is not detected. As it is seen from the results shown in Fig. 1, the anode current has a favorable small value at GV up to about 48 V. But the current was reversed from positive and negative at GV over 48 V. We have considered that this reverse phenomenon was caused by secondary electron emission. It happened because the number of secondary electrons emitted from CdTe exceeded the number of primary electrons irradiated to CdTe by the carbon nanoneedle field emitter.

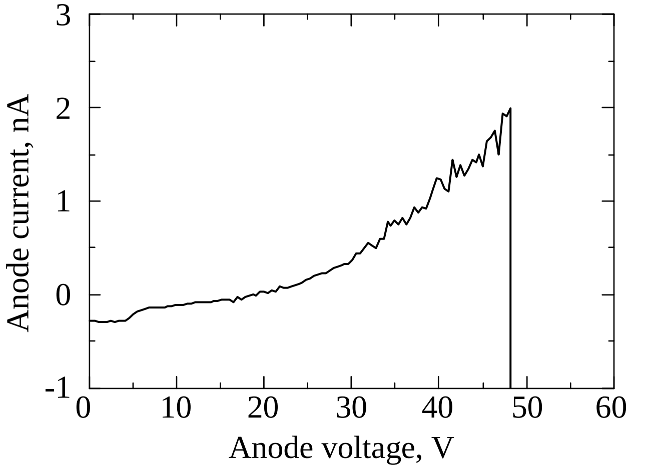

Fig. 1. The dark anode current as a function of applied anode voltage when field emission electrons irradiated CdTe

Therefore, the value of AV was fixed at 20 V and it was used in the experiment. It experimented under the standard condition by using X-ray. The experimental results are shown in the Fig. 2 and 3. As a result of the experiment 1, we confirmed that the CdTe-based structure fabricated in this study was sufficiently effective for photoelectric conversion.

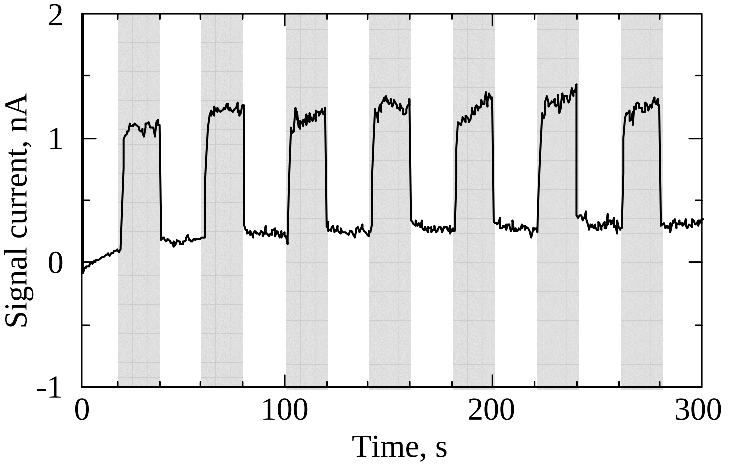

Fig. 2. The difference of the anode current in dark and X-ray irradiated conditions (experiment 1)

Furthermore, Fig.3 shows that an increase in the tube current causes a rise in the signal current. Because the tube current corresponded to the X-ray intensity, this current dependence of the signal was evidence that the radiation detector was sensitive to X-ray.

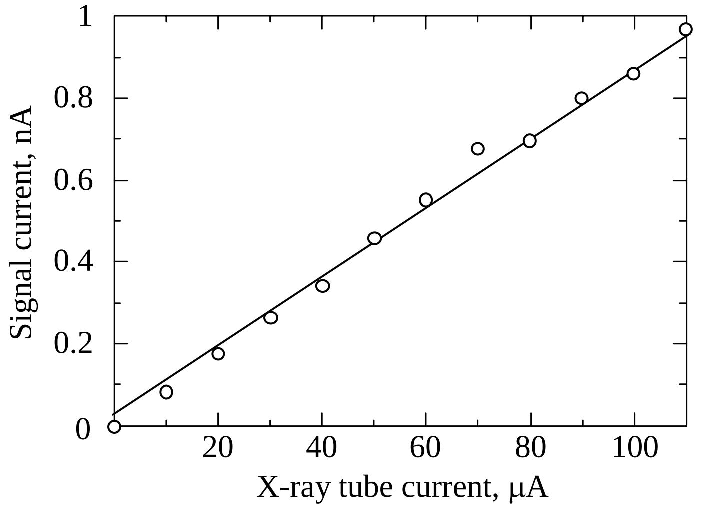

Fig. 3. The signal current as a function of the X-ray tube current

In this study, we have proposed a new addressing method that used a field emitter type electronic source in order to fabricate super-high resolution radiation detectors in the near future. We carried out verification of the operation principle about one pixel by using the CdTe M-p-n diode and carbon nanoneedle field emitter, and demonstrated the capability of this device to operate as a photoelectric conversion detector.

Secondary electron emission is due to work function and surface state of an Au electrode, so it is necessary to investigate electrode materials to apply higher AV and improve carrier collection efficiency. The results of this study have showed that the developed addressing method is promising for elaboration of two-dimension pixel devices.