Nuclear Science and Techniques **20** (2009) 46–50

Simulation of the anode structure for capacitive Frisch grid CdZnTe detectors

MIN Jiahua[1] SHI Zhubin[1,*] QIAN Yongbiao[1,2] SANG Wenbin[1] ZHAO Hengyu[1]
TENG Jianyong[1] LIU Jishan[3]

[1] *School of Materials Science & Engineering, Shanghai University, Shanghai 200072, China*

[2] *RAE Engineering Center, RAE Systems Inc., Shanghai 201821, China*

[3] *Shanghai Institute of Applied Physics, Chinese Academy of Sciences, Shanghai 201800, China*

Abstract CdZnTe (CZT) capacitive Frisch grid detectors can achieve a higher detecting resolution. The anode structure might have an important role in improving the weighting potential distribution of the detectors. In this paper, four anode structures of capacitive Frisch grid structures have been analyzed with FE simulation, based on a 3-dimensional weighting potential analysis. The weighting potential distributions in modified anode devices (Model B, C and D) are optimized compared with a square device (Model A). In model C and D, the abrupt weighting potential can be well modified. However, with increased radius of the circular electrode in Model C the weighting potential platform away from the anode becomes higher and higher and in Model D, the weighting potential does not vary too much.

Key words Frisch grid, CdZnTe detectors, Weighting potential

1 Introduction

Cadmium zinc telluride (CZT) has been important semiconductor detector for room temperature X- and γ-ray spectroscopy[1]. However, CZT's poor hole-transport properties limit the practical thickness of planar devices. Various electrode configurations have been implemented to reduce the depth dependence of the signal from CZT detectors. Since the improvements in planar device performance by using a capacitive Frisch grid, the detector has increasingly captured the recent research interests in gamma-ray detection applications[2-4].

In this paper, we report our progresses in simulating CZT detectors with a capacitive Frisch grid structure. It is true that bigger ratios of L/H and ε_r/d are of help in compressing the weighting potential towards the anode. However, the anode structure might have an important role in improving the weighting potential of detectors. In the simulation, four models with different anode structure for a CZT capacitive Frisch grid were studied by using finite element simulation (FE), while other conditions (the ratio of L/H and the ratio of ε_r/d) were kept constant.

2 Simulation model building

Fig.1 shows the structure of a CZT capacitive Frisch grid detector. The four models of anode structures of capacitive CZT Frisch grid detectors are shown in Fig.2: Model A with a square anode, Model B with a circular anode, Model C with a small guard ring, and Model D with a big guard ring.

The CZT detectors have a conduct screen (extension of the cathode) grounded or floated (electrically insulated from the CZT using a dielectric layer). All the detectors are in an L/H ratio of 90% (L, screen length; H, device height), with a 0.1-mm thick dielectric layer in relative permittivity of 4. In Model

Supported by National Natural Science Foundation of China (Grant No. 60676002 and No. 10675080).

* Corresponding author. *E-mail address:* shizhubin@shu.edu.cn

Received date: 2008-08-27

C and D, the guard ring and the circular anode are parted with a 1-mm gap. The dielectric layer has the same length as the extension layer of the cathode in the lateral face. In the simulations, weighting potential distribution in a symmetrical plane and a central axis of the models (Fig.3) was analyzed.

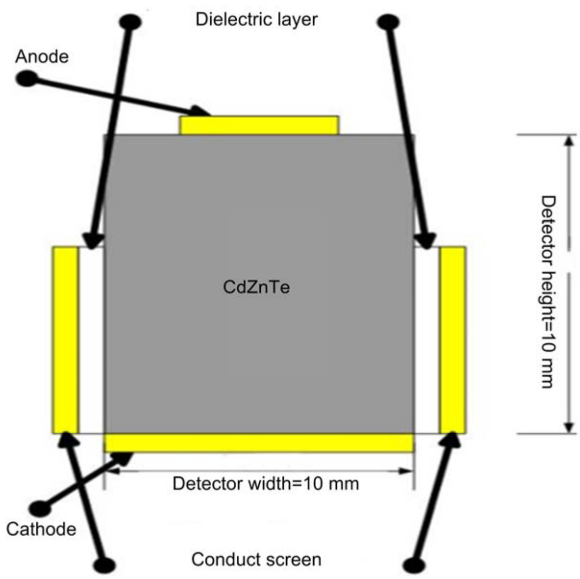

Fig.1 Structure of capacitive Frisch grid detector.

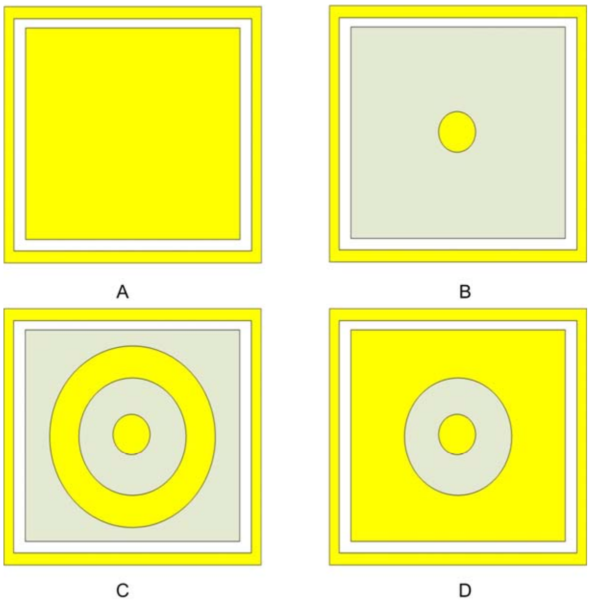

Fig.2 Four models of anode electrode structures of capacitive Frisch grid CZT detector. Model A: a planar electrode, Model B: a circular electrode, Model C: a small guard ring and Model D: a big guard ring.

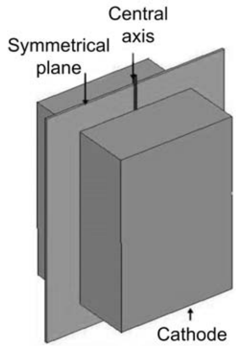

Fig.3 Illustration of the symmetrical plane and the central axis of the models.

3 Simulation results and discussion

Finite element analysis was carried out to obtain the 3-dimensional weighting potential distribution for the four models. The weighting potential distribution in the symmetrical plane of Model A, with a square anode, is shown in Fig.4. The weighting potential distributions in the symmetrical plane of Model B, C and D, with different circular anodes, are shown in Fig.5, Fig.6 and Fig.7, respectively. From Fig.4, the weighting potential is compressed to the anode, which is constricted to a normal square anode. However, at 2.5mm from the anode, there is an abrupt weighting potential. This is because that at the contour plane of the dielectric layer and grounded conduct screen the conduct screen can affect the surface there directly. Therefore, it is better to make the dielectric layer longer than the grounded conduct screen, so as to let the weighting potential change smoothly.

In Fig.6, it can be seen that the grounded guard ring can compress the weighting potential seriously with decreased radius of the circular electrode. And the abrupt weighting potential can be well modified. With larger radius of the circular electrode, however, the weighting potential away from the anode becomes higher. This can cause increased leakage current of the device. The reason of this phenomenon is that except the guard ring and a circular electrode there is a large region in the detector surface to which voltage is not applied. That will weaken the effect of the guard ring. Then Model D can solve this problem.

Fig.7 shows the weighting potential distribution of Model D. It can also be compressed to the anode intensively just like model C. In this model, increasing the radius of the circular electrode does not cause much change in the weighting potential away from the anode. However, the abrupt weighting potential still exists, but it is in the acceptable range.

It should be noted that the weighting potential distributions in modified anode structures (Model B, C and D) are optimized, compared with a normal square anode (Model A). And the abrupt weighting potential will not exist if the dielectric layer wraps the whole lateral of the device.

It is apparent that the weighting potential is compressed greatly and the single charge structure of Frisch detector can work more efficiently compared with the others discussed in this paper. Therefore, Model D will be a promising structure for optimization of the anode of Frisch detector.

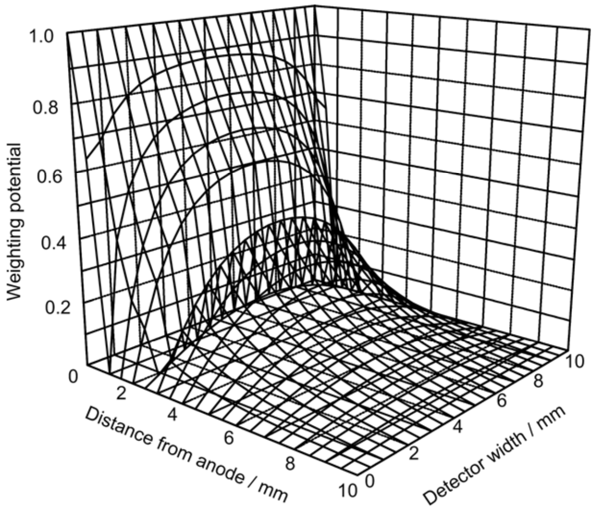

Fig.4 Model A: The weighting potential distribution of the capacitive Frisch grid with a square electrode.

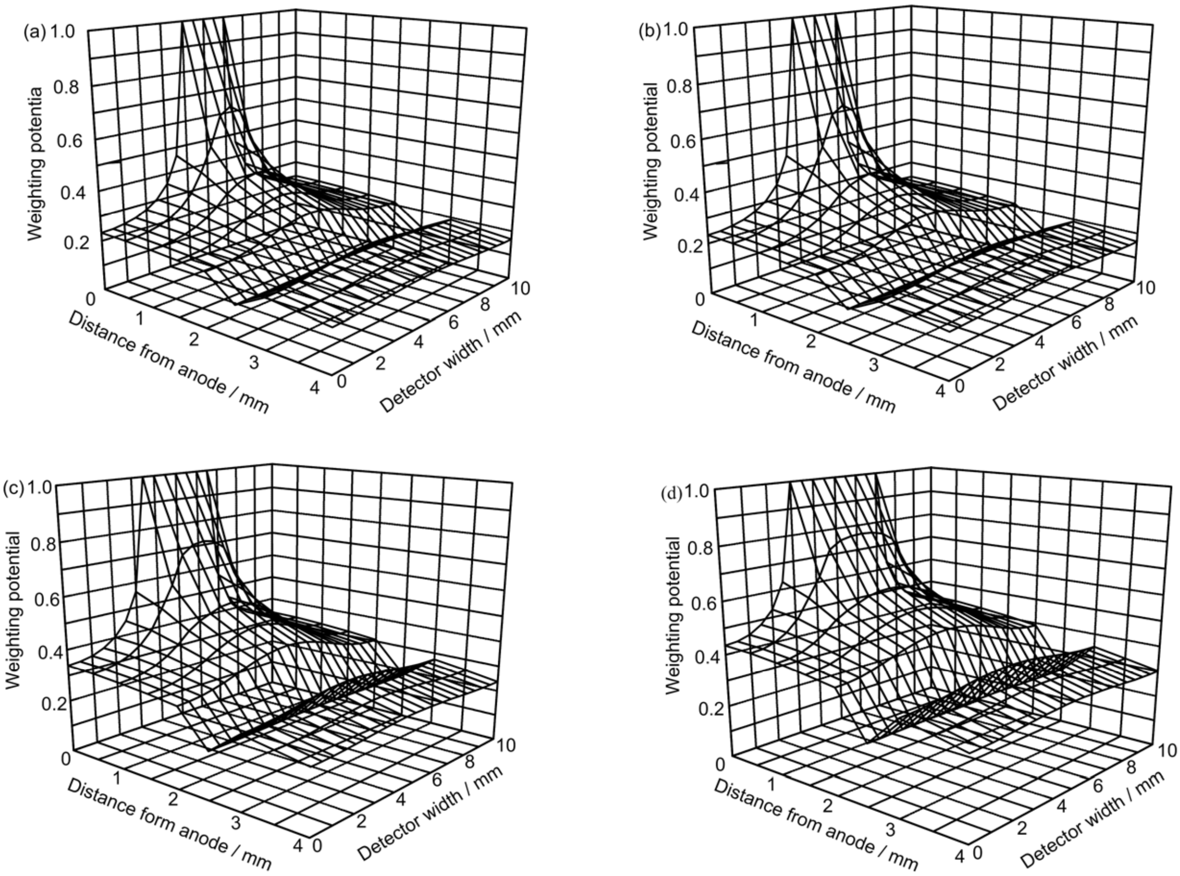

Fig.5 Model B: The weighting potential distribution of the capacitive Frisch grid with a circular electrode in radius of (a) 0.5 mm, (b) 1 mm, (c) 1.5 mm, and (d) 2.0 mm.

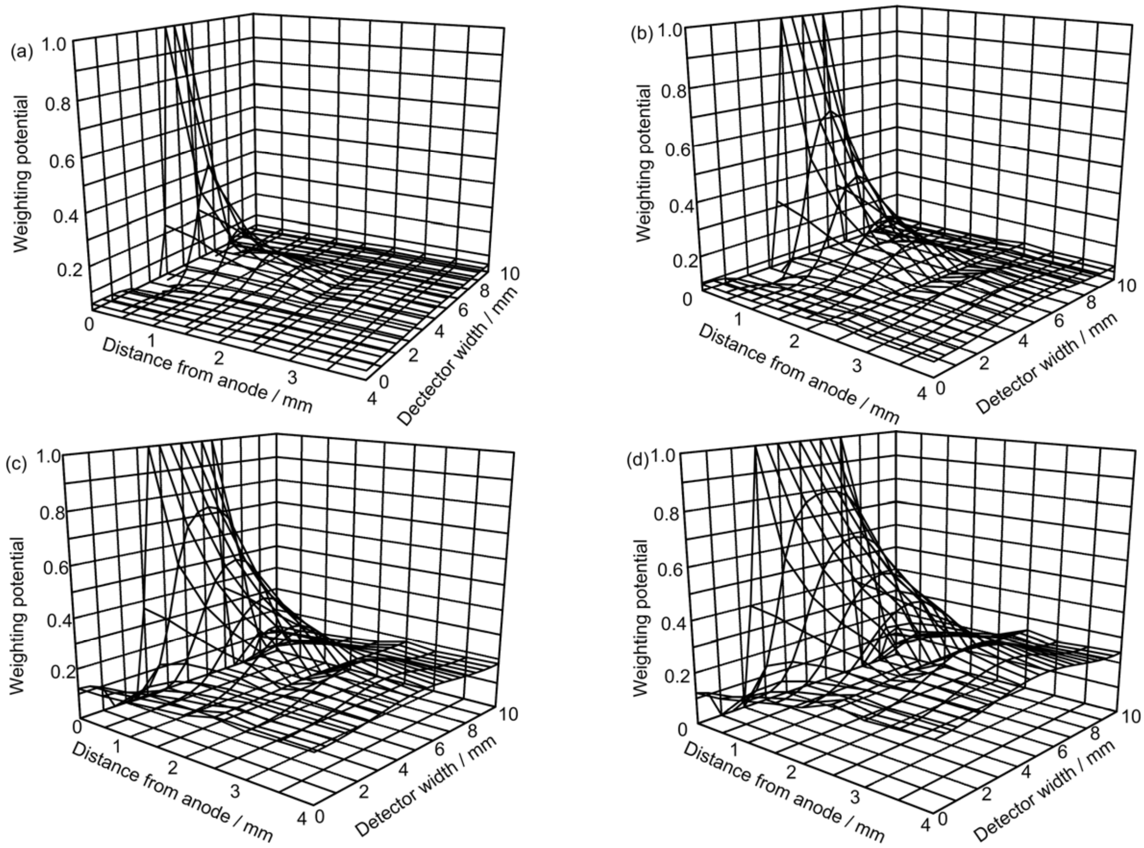

Fig.6 Model C: The weighting potential distribution of the capacitive Frisch grid with a guard ring and a circular electrode in radius of (a) 0.5 mm, (b) 1 mm, (c) 1.5 mm and (d) 2.0 mm.

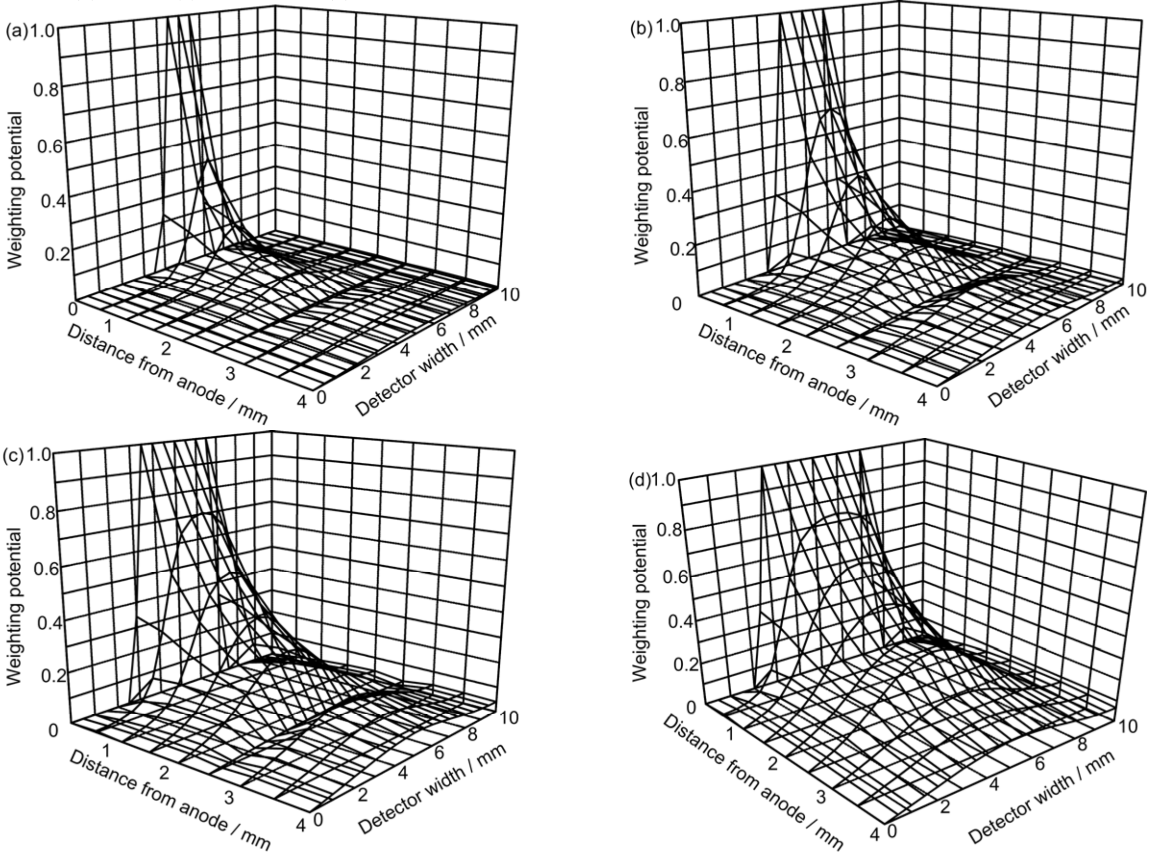

Fig.7 Model D: The weighting potential distribution of the capacitive Frisch grid with a big guard ring and a circular electrode in radius of (a) 0.5 mm, (b) 1.0 mm, (c) 1.5 mm and (d) 2.0 mm.

4 Conclusion

Four anode structures of capacitive Frisch grid structures have been analyzed with FE simulation, based on a 3-dimensional weighting potential analysis. The weighting potential distributions in modified anode devices (Model B, C and D) are optimized compared with a square device (Model A). In model C and D, the abrupt weighting potential can be well modified. However, with the increase of the radius of the circular electrode in model C the weighting potential platform away from the anode becomes higher and higher and in Model D, the weighting potential does not vary too much.

References

1 Butler J F, Lingren C, Doty F P. IEEE Trans Nucl Sci, 1992, **39:** 605–609.

2 Montemont G, Arques M, Verger L, *et al.* IEEE Trans Nucl Sci, 2001, **48:** 278–281.

3 McNeil W J, McGregor D S, Wright G W, *et al.* Appl Phys Lett, 2004, **84:** 1988–1990.

4 Kargar A, Jones A M, McNeil W J, *et al.* Nucl Instrum Methods Phys Res Sect A, 2006, **558:** 497–503.

5 Eskin J D. J Appl Phys, 1999, **85:** 647–659.

6 Nemirovsky Y, Ifraimov M, Ludwig A. J Appl Phys, 2000, **88:** 5388–5394.