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Design of a multi-anode microchannel array detector system

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Abstract

The Multi-Anode Microchannel Array (MAMA) is a photon counting detector which utilizes a photocathode for photon to electron conversion, a microchannel plate for signal amplification and a proximity focused anode array for position sensitivity. The detector electronics decode the position of an event through coincidence discrimination. These detectors are designed to provide high spatial and temporal resolution for applications in low-light level imaging and spectroscopy at ultraviolet, FUV and EUV wavelengths. Many space ultraviolet astrophysics missions such as STIS are using MAMA detector systems. Several MAMA detectors have been produced by Nanjing Electronic Devices Institute (Nanjing, China). The development of the MAMA systems based on these detectors is performed by Northwest Institute of Nuclear Technology. In this paper, both the design of the MAMA detector system and the progress of the project are presented.

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Keywords: Multi-Anode Microchannel Array (MAMA); Ultraviolet detector; Image acquisition

1. Introduction

Multi-Anode Microchannel Array(MAMA) detector was first introduced by J.G. Timothy, who have been working on MAMA detector system since 1970s [1]. The MAMA detector system has been designed to provide the high spatial resolution, very large number of image elements to satisfy the demanding requirements of high-resolution imaging and spectroscopy at ultraviolet, FUV and EUV wavelengths for a number of applications in modern space astronomy. Since the MAMA employs a random readout technique, the arrival time of a detected photon can be determined with high accuracy. For this reason, MAMA detectors are also being employed for high-time-resolution applications such as speckle imaging, astrometry, and image reconstruction at both ultraviolet and visible wavelengths.

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MAMA detector systems have been successfully used in many space ultraviolet astrophysics missions such as STIS(Space Telescope Imaging Spectrograph) [2,3], ACS(Advanced Camera for Survey) SBC(Solar Blind Channel) [4], HiRES(High-Resolution EUV Spectroheliometer) [5], and COS(Cosmic Origins Spectrograph) [6]. There are numerous reports about these MAMA detector systems on SPIE, which shows that most of these MAMA systems are now working on good condition and have obtained many useful astrophysical image.

Several (360×1024)-pixel MAMA detectors (see Fig. 1) [7] have been produced by NEDI (Nanjing Electronic Devices Institute, Nanjing, China). These detectors have passed the test conducted by NEDI researchers, who told us that these detectors were in good condition. We began to develop MAMA detector systems based on their devices in 2002. We will describe the design of our MAMA detector system and the progress of the project in the following sections.

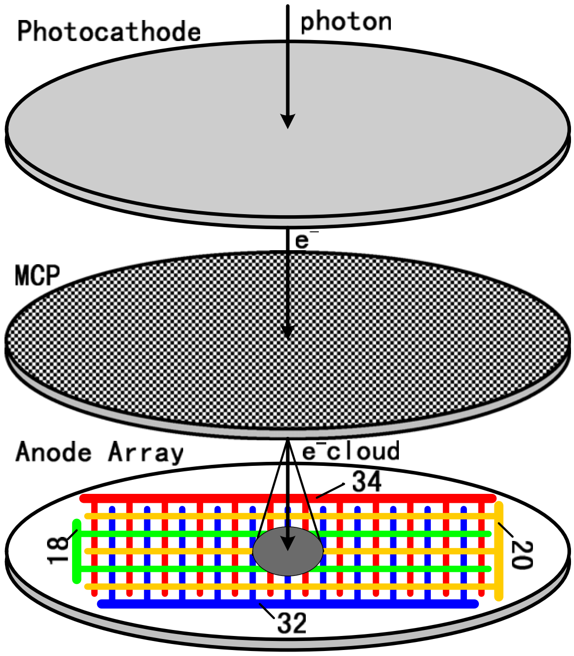

Fig. 2. Schematic of the MAMA detector.

2. The MAMA detector system

The components of the MAMA detector system consist of the tube assembly (see Figs. 1 and 2), and the associated analog and digital electronic circuits (Fig. 3). The tube assembly contains a high-gain microchannel plate(MCP) with the photocathode material deposited on, or mounted in proximity focus with, the front surface. Two layers of precision anode electrodes mounted in proximity focus with the output surface of the MCP detect and locate the positions of the electron clouds generated by the single photo events. The associated circuits include charge amplifiers, comparators, decoder electronics, memory module, HVPS (high-voltage power supply) for the MAMA detector, LVPS (low-voltage power supply) for the whole system, the controlling module and a computer with the specific software.

Fig. 1. MAMA detectors.

The MAMA detector works as shown in Fig. 2. UV photons enter and hit the photocathode on the front of the MAMA detector. The cathode produces an electron when a photon hits it and the electron is accelerated into the MCP pores. The MCP amplifies the number of electrons, which fall as a shower onto the anode array as they leave the MCP. The anode array is a complex comblike pattern. When electrons strike certain anodes, charge signals are collected and sent to the

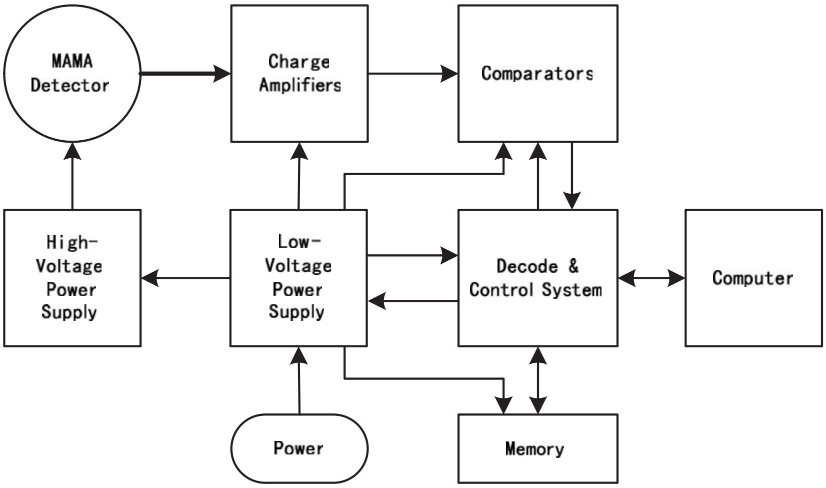

Fig. 3. Block diagram of the MAMA detector system.

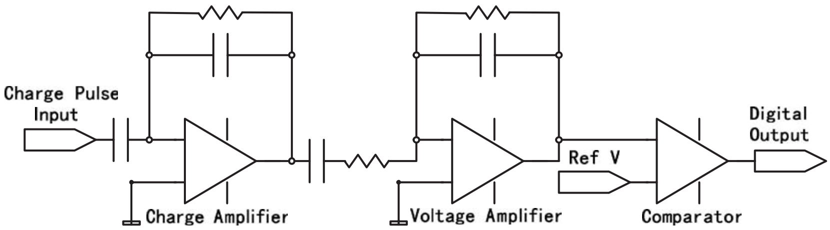

Fig. 4. Schematic of the amplifier and discriminator circuits.

associate electronics of the system(see Fig. 3). These charge signals are conditioned by amplifier and discriminator circuits and fed to digital logic circuits in a FPGA board which decode the location of the detected charge cloud from the coincident output signals. The controlling module and other digital logic circuits are also integrated in this FPGA board. The position and time data of the photon will be saved in the memory module and sent to the computer, which will then process the data and display the image and associated information.

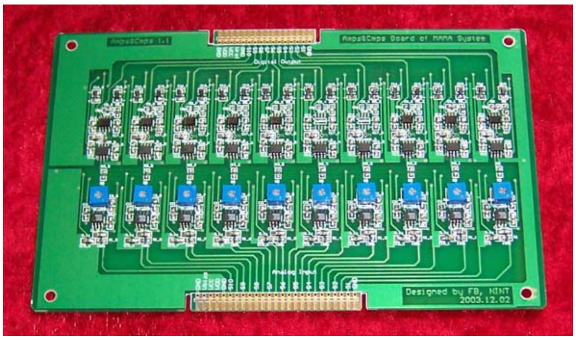

Fig. 5. The amplifiers and discriminators PCB board.

3. The progress of the project

We have completed a preliminary design of the MAMA detector charge amplifier and comparator system, which have successfully detected and conditioned the output signals generated by a MAMA detector. The schematic of the circuit is shown in Fig. 4 and the actual PCB board is shown in Fig. 5. The main chip of the charge amplifier is OPA657 [8], an 1.6 GHz, low-noise, FET-input operational amplifier. Our test shows that OPA657 is perfectly suitable for this application, so we don't have to design and use ASIC chips [9] which cost too much.

We are going to use a Stratix EP1S25 DSP Development Board [10] as the main digital part of the system. This Board have a powerful FPGA chip, more than 200 user I/Os, enough memory and other useful components. The decoder and the control unit will be implemented in the EP1S25 FPGA. Some of the I/Os of the board will be used to receive the digital signals from the discriminators and the others can be used to transfer other control and data signals. The memory of the board will serve as a memory buffer between the computer and the decoder to save the image data.

We developed a decoding method on computer which have successfully made high-resolution decoding in simulation. The algorithm is based on serial calculation, not based on parallel combinational logic [11]. We are going to implement it in the FPGA but we are not sure if it could run fast enough in a FPGA since it has not been tested in the FPGA.

The whole preliminary MAMA detector system would be finished before June, 2004 in schedule.

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