Multichannel femtocoulomb range Charge Measurement System for X-Ray Detector Applications

mgr inż. Michał Babij

Supervisor: prof. dr hab. inż. Karol Malecha

Auxiliary supervisor: dr inż. Piotr Pyrka

Department of Microsystems (K71W12ND02)

Faculty of Electronics, Photonics and Microsystems, Wrocław University of Science and Technology

Micro-Pattern Gaseous Detectors (MPGD), especially those based on Gas Electron Multiplier (GEM) structures, are currently one of the most commonly used types of detectors in large-scale High Energy Physics (HEP) experiments. These devices, after miniaturization and simplification, can also be used in much smaller scientific and industrial installations. The first miniature detectors based on GEM technology are beginning to be used also in space applications.

The first issue described in detail in the thesis is the miniaturization of the electronic charge measurement system for use in MPGD detectors, especially GEM. In the work carried out, dedicated components made out of Low Temperature Co-fired Ceramics (LTCC) were also used, which allowed for a significant reduction in the size of the device. The characteristic feature of the developed solution was the use of commercially available electronic components, including integrated circuits, which increases the availability of the solution and reduces costs.

To confirm the possibility of using LTCC ceramics in input systems with femtocoulomb charges, dedicated structures were developed and tested. They contain a matrix of resistors constituting the input system necessary for the correct operation of the systems used to convert the charge into a digital value. Due to the lack of high-resistivity pastes (over 1 MΩ/□) on the market compatible with the DuPont DP951 system and enabling the production of buried resistors, pastes for surface resistors were used. This required their characterization and validation of the possibility of their use.

As a result of the work carried out, LTCC structures with assumed parameters were developed and manufactured. These structures were integrated with a dedicated electronic charge measurement system within the functional GEM detector. A series of measurements were performed using the developed device and its parameters such as noise level, gain, and resolution were determined. They are comparable to other solutions and confirm the validity of the developed design, including the use of LTCC ceramic components.

The second research issue was to develop, test, and compare the parameters of readout boards made in different technologies. As part of the doctoral thesis, structures made of a composite of polyimide layers with FR4 laminate, LTCC ceramics, and FR4 laminate in classic Printed Circuit board (PCB) technology were compared. Based on the obtained results, the parameters of individual solutions, limitations of individual technologies, and potential applications and uses for a given type of reading plate were determined.

The research confirmed the possibility of using the developed charge collection structures (CCS) in miniature GEM detectors, also for space applications.

Michał Babij