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A Segmental 2D readout board for GEM detectors

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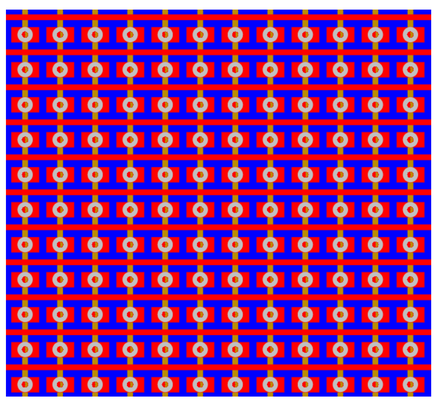
The aim of the research

The main goal of this work was to design, test, and validate a 2D cartesian readout board for Gas Electron Multiplier (GEM) detectors manufactured with standard Printed Circuit Board (PCB) technology. The proposed readout boards can be manufactured without margins, so it is possible to connect the individual segments (readout boards) into a bigger panel. This board design can be manufactured by commercial PCB manufacturers, which should guarantee a low price and short lead time. The next advantage of this solution is the ability to further increase the size of a readout by using additional segments. Readouts manufactured using this technology should be reliable and robust. These readout boards could be also used in other Micro Pattern Gaseous Detectors (MPGD).

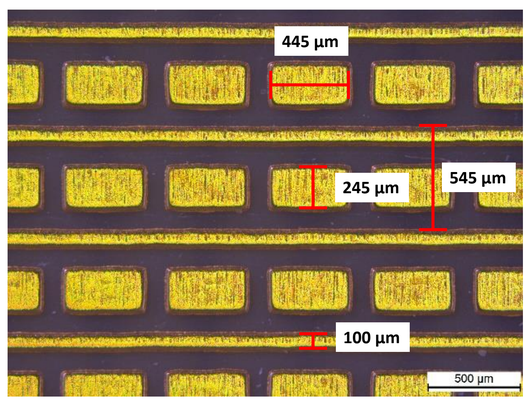
The 2D readout board design

The main design consideration was to achieve a readout board, with all electrodes in a single plane without 3D structures, like in standard CERN readout boards. The 2D readout boards consist of lines in the X direction (horizontal) and a series of pads in the Y direction (vertical). The pads are located between the X lines and are connected together by the lines located on a second layer, that are perpendicular to the X lines on the top layer. The connected pads form the Y-axis. Two additional layers were utilized to connect the signals to connectors located at the bottom of the readout. The connectors are Hirose FX10A-140 used currently in Techtra and CERN readout electronic designs. The lines pitch was chosen to be 545 µm, so standard PCB manufacturers can manufacture this board. The standard CERN readout has 390 µm pitch which is only 28% smaller than the proposed design, which shouldn't affect much the detector X-Y resolution.

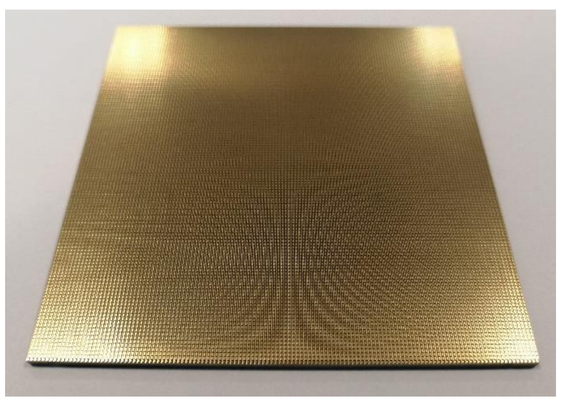
PCB parameters:
- **Active area: 70 x 70 mm^2**
- **Line numer: 128 x 128 lines**
- **Pitch: 545 µm**
- **Board stack: 4-layer PCB**



A section of 2D readout PCB project



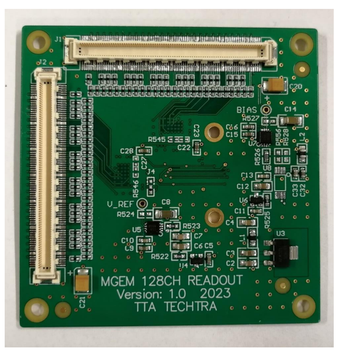
Microscope view of the readout structure

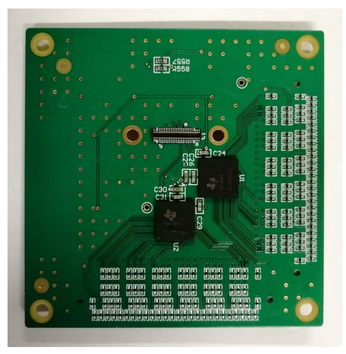


A 70 x 70 mm^2 2D readout board (128 x 128 ch.)

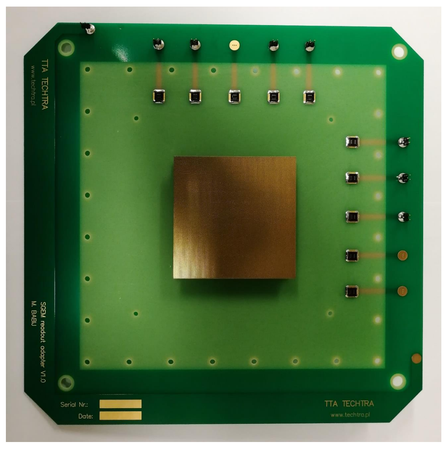
Measurement setup

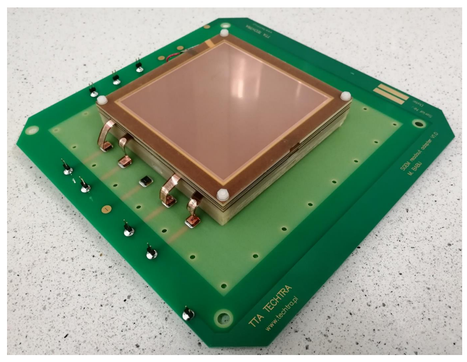
The readout board was tested using a dedicated measurement setup. The 2-layer PCB main board was used to mount the detector components. The readout board is connected directly to the readout electronics, which are mounted on the main board. The DAQ electronic is located on the other mainboard side. The standard 3-2-2-2 GEM stack arrangement was used. GEM stack is covered with Gas-box with polyimide window. In this first measurement, the 64 x 64 px. readout electronics was used.





The 64 x 64 channel simplified readout electronics

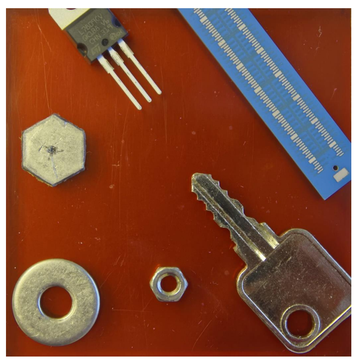




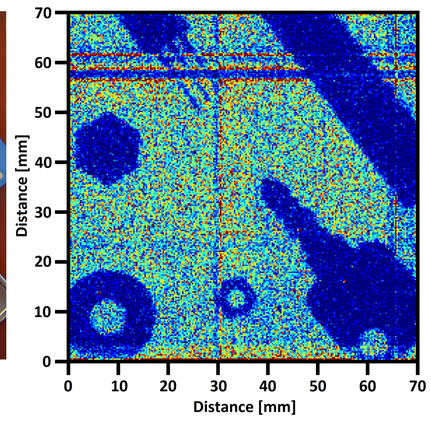
The test detector with GEM stack

The first results

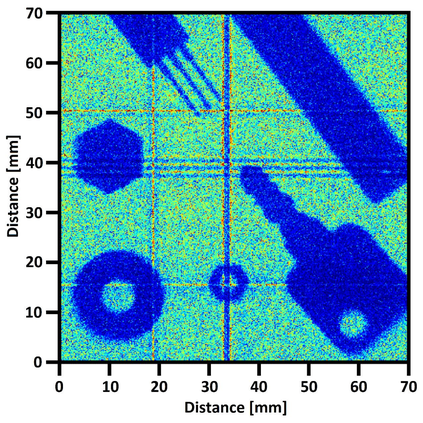
The 70 × 70 mm^2 PCB 2D readout board was characterized by visual inspection and using the X-ray method. The Surface of the metallizations looks very clean and flat, and the dimensions of the features are according to the project specification. No short circuits or gaps in the traces were observed. This will be further validated using electric measurements, as well as noise and charge distribution measurements. To validate the ability to imaging using a detector with tested boards, an X-ray test was performed. A few metal and ceramic parts were placed on the detector window, and the detector was irradiated using the Cool-X source for about 2 hours.



The test objects placed onto the detector



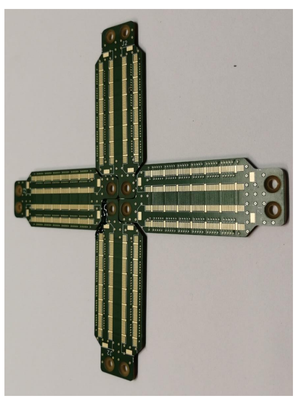
Radiograph measured using 2D PCB readout (64 x 64 px.)

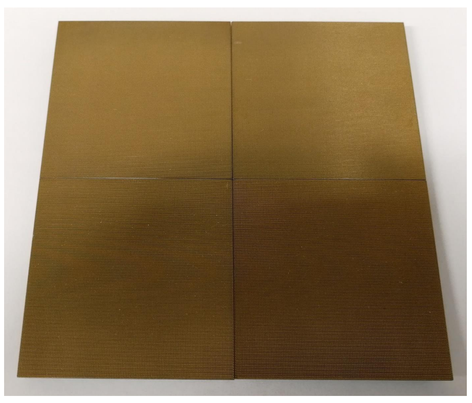


Radiograph measured using CERN readout (180 x180 px.)

Segmental readout boards

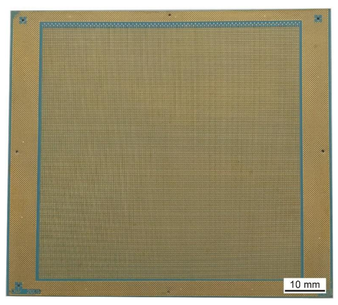
The 2D readout bards can be manufactured almost without dead area, using PCB or LTCC technology. Each readout segment can be connected together, to achieve a bigger active area of the detector. The margin between boards can be as small as 200 µm or even less.

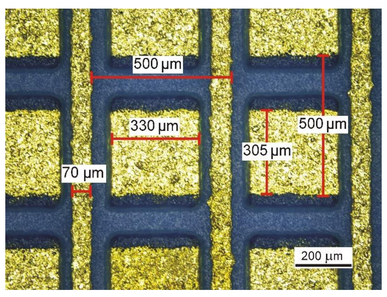


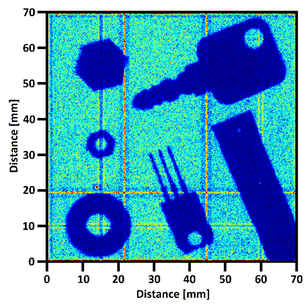


LTCC readouts (ceramic)

The Low Temperature Co-fired Ceramics can be a suitable technology for MPGD readout board manufacturing.
We designed, manufactured and tested the 70 x 70 mm^2 ceramic readouts. These boards can be used in special applications like aerospace.







Results and conclusion

The presented results prove, that a 2D cartesian readout board manufactured with standard Printed Circuit Board (PCB) technology can be used in the MPGD, especially GEM detectors. The first radiographs look promising, considering the fact, that readout electronics used in the first tests have 3 times fewer ADC channels. The technology will be further tested using 128 x 128 ch. readout electronics. The noise characteristics, charge distribution etc. needs to be also measured and compared.

Acknowledgement

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