Micro-R Well
Undergraduate Research

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1 Objective

To study and understand how the Micro-Resistive Well functions and to build a functioning Micro-R well detector, as well as complete the quality control testing for the detector.

1.1 Definitions

MPGD The Micro Pattern Gaseous Detector.

PCB The Printed Circuit Board.

DLC Diamond-like carbon. This is a resisitive material.

Araldite Araldite is a glue that is utilized in construction and assembly.

HV High Voltage.

2 Introduction

The micro-R well is a form of the MPGD that is similar to the GEM detectors previously studies in the high energy particle physics laboratory at Florida Tech, however, it is has only a single amplification stage. This amplification stage is in the resistive layer of the PCB readout board, hence its name micro-resistive well detector. A drift cathode sits above the resistive layer and readout electrode seperated by the drift gap. The micro-R well was first designed at the Frascati Laboratory in Italy and first built by the TE- MPE-EM workshop in 2009 at CERN. The detector is thin and sturdy, which is extremely suitable for large scale . It is also suitable to function in strongly irradiated environments.

3 How the Detector Works

It is first important to mention the structure of the detector. Starting at the bottom the detector beings with a honeycomb lattice structure for stability, where the micro-R well PCB is attached to. On top of that is the PCB readout electrode which has the DLC (diamond-like carbon) resisitve layer on top. The wells are then formed out of kapton and a copper layer rests on top of the wells. Above that is the drift gap which sits beneath the drift cathode. A kapton window will finish off the design. The detector works when a charged particle enters the detector through the drift cathode, where it then enters a single stage amplification as it passes through the drift gap. The charge is then collected in the wells and induces the signals to appear on the PCB readout.

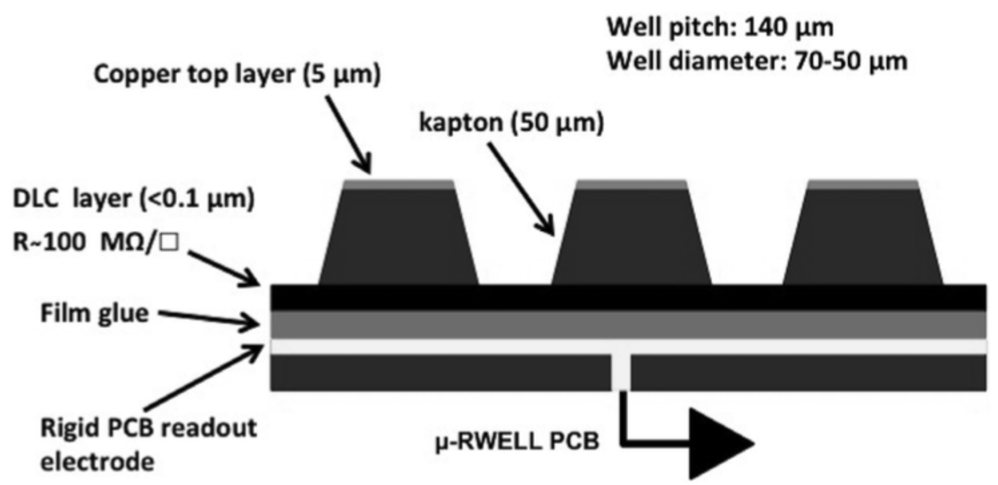

Figure 1: Figure 3.1 Design of the well system

4 Assembling the Detector

The detector parts were shipped from the laboratory at CERN. The assembly process is to be completed in a clean-room environment, ensuring that all materials are thoroughly cleaned before each and every step. The first step is to take a roller and clean the PCB readout board and then test the connection between all of the grounds (i.e. the board's ground, the grounding ring, and the ground strips). The next connection to test is the connection between all of the tabs. It is important to check these connections because once the detector is closed the active region, drift, and ground will be connected to these tabs and these tabs will be how they are accessed. Next it is recommended to test the connection between the active region and the strips, this will ensure that they are indeed connected, if they are not connected then the micro-R well detector will not function properly. The next step is to solder a connection from the active region to one of the aforementioned tabs. Check the connection again and do a visual inspection under the microscope to ensure the solder did not damage the wells. Next, solder a connection from the grounding ring to a separate tab. Do not solder the grounding ring connection to the same tab that the active region connection is attached. The two aforementioned connections can be accomplished with a small piece of copper tape. Again, inspect the wells and check the connection to ensure everything is still properly working, and that the solder did not damage anything. Next solder the grounding tab to the boards ground, please note that this connection will most likely need an high voltage wire to connect them. Once again, do a thorough cleaning of the detector and all the pieces using the roller and sticky pad. This is especially important to do after the soldering steps, as it is imperative that no loose particulates from the solder remain on the detector and most importantly: the active region.

The inner screws will need to be trimmed down in order for them fit underneath the outer frame and top window. This can be done with a small blade and a file. The inner screws will then need to be placed in an ultrasonic bath for a minimum of five minutes, although ten minutes is recommended to ensure the cleanliness of the parts. Once the inner screws have been cleaned and dried with nitrogen gas, they can be placed in their position on the detector. It is now important that the inner screws be glued in place, from the bottom of the detector, in order to secure them in place and ensure a gas tight detector. This step can be completed with the Araldite glue. This should dry for at least one day, this will ensure that the glue is not wet or tacky when the stack is assembled. Once again, please note that the entire set-up and all components should be cleaned with the roller and sticky pad frequently and between all steps. Next, decide on a drift gap size, this version utilized a three millimeter drift gap. Now, because the drift foil is framed on both the top and the bottom, and has a total thickness of one millimeter, five frames pieces stacked on top of each other are needed to form the gap. This is because the frames are each half of a millimeter. It is important to note that the active region is a square, and that the frames are each half of a square, so ten frame pieces total will be utilized for a three millimeter drift gap, five being used for each side. Clean and stack each frame piece by threading them through the inner frame screws. Next carefully, place the drift foil onto the stack by threading it through the inner screws and screwing down the nuts to secure the stack in its position. Ensure that it is positioned in a way such that the drift foil tab aligns with a tab on the PCB readout board. Please note that the tab on the readout board should not be the tab that the active region is attached to nor the tab that attaches to the grounding ring. The next step is to solder the drift foil tab to the tab on the PCB readout board that it lines up with. The drift foil should now be connected to the readout board.

Now it is time to tap the holes into the frame to place the gas plugs. First choose the placement for the gas plugs, then ensure that the placement will not hinder any of the soldered connection tabs on the readout board or any of the strips on the readout board. After the frame is tapped for the gas plugs, thoroughly clean the frame, and coat the inside of the frame with a resin. When coating the frame with resin take care not to get any resin where the o-ring belongs, as this affects the seal and could mean that the detector is no longer gas tight. Let the resin dry for a minimum of twenty-four hours to ensure that it is completely dry before any further steps are taken. Next clean the frame again and glue in the gas plugs. The Araldite glue can be utilized for this part as well, but ensure that it has a long enough time to dry so that it is not wet or tacky when assembly continues. Ensure that the frame is thoroughly cleaned before the assembly process is continued. The next step is to place the kapton window and the top lid piece onto the frame taking care to line up the outer screw holes on every material. Thread the closing screws into their holes from the bottom of the PCB readout and all the way through the frame, window, and lid. Tighten the screws into place with their corresponding nuts to help ensure that the chamber is gas tight.

5 Quality Control Testing

The next steps are to complete the quality control tests (or QC in short hand). Please note that this has not yet been completed, but is on the agenda to be completed very soon. QC3 is the first quality control test that needs to be done. This is the gas test. The detector is filled with $ArCO_2$ gas until it reaches five millibar, where the chamber is then closed off from the gas source and the surrounding environment. The detector is then observed for a few hours to determine if any gas has left the chamber, and at what rate it does so. This test determines if the detector is gas tight or if the detector will leak. Ideally the detector should be gas tight and should not leak.

QC4 is the second quality control test that needs to be completed. This is the high voltage test. This test is used to determine possible malfunctions, and any faults in the HV circuit. The chamber is first flushed with CO_2 gas and then current is applied. The detector is then observed for any unusual activity in the current, as well as any possible leaks, and finally for sparking. This test measures the current drawn against the applied voltage as well as the current drawn against the rate.

QC5 is the third and final quality control test that will be completed after assembly. This is the gain calibration test, and is completed in a radiation box. The first goal to measure the gain as a function of the voltage. This is the voltage that is applied on the divider. The second goal is to measure whether or not the detector has a uniform response. This is accomplished by applying high voltage to the detector and measuring certain outputs that are produced.

6 Difficulties

As with any part of research there were difficulties. One such difficulty being the DLC layer. A lot of time and inspection went into determining whether or not the DLC layer was accessible in order to obtain a direct measurement of the resistance of the layer. It turns out that the DLC is not accessible as it is completely coated with a polymide.

7 References

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