CERN Summer Student - Report

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Abstract.

The high luminosity upgrade of the LHC will push the limits for detectors, especially the silicon trackers which are closest to the interaction point. The ATLAS CMOS Sensor R&D effort is investigating a new technology using high-voltage CMOS processes for producing pixel and strip sensors. In contrast to the currently used technology these devices implement active electronics on the sensor itself, offering a multitude of tuning parameters for achieving the best performance. My summer project revolved around characterising existing samples along with assembling and debugging hardware required for their improvement and functionality. Other tasks involved writing communication protocols using pyBAR to remotely control injection circuitry on a GPAC card, and helping various members of the group with data collection and analysis. Through the summer student programme I have had the opportunity to be part of a vibrant scientific community at the forefront of research, to create bonds with fellow students from universities across the world and to further my understanding in particle physics.

1. Introduction

HVCMOS (High Voltage CMOS) pixel detector technology is a novel idea that has been gaining a lot of attention for the past years. The design consists of a traditional hybrid pixel design (i.e. bulk Silicon connected to front end readout electronics (Fig.1)) but with some additional improvements that vastly increase the functionality, flexibility and relaibility of the chip, as well as decrease production cost.

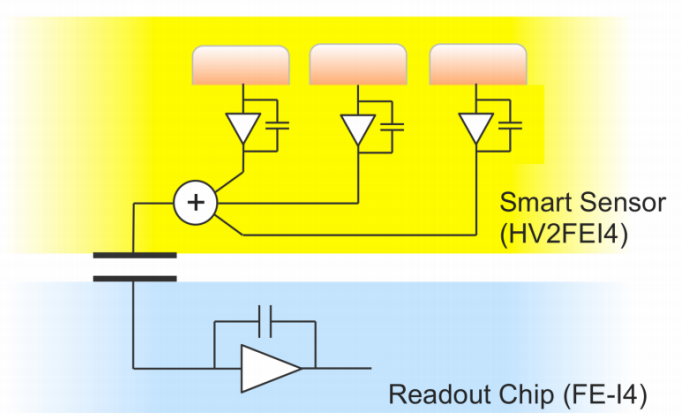

Figure 1: Si sensor schematic including front end logic [1]

The HVCMOS sensor benefits from a series of implants in the Si bulk (Fig. 2) that increase the charge collection sensitivity due to ionising radiation. Analogous to existing pixel detectors our samples require a high voltage bias to operate accordingly. Along with the increase in charge sensitivity the HVCMOS design provides a series of other benefits such as :

- readily available HVCMOS mass production capabilities that are associated with low costs
- eliminating the expensive and delicate bump bonding procedure (required to connect the front end readout electronics with the Si bulk material) through gluing with special adhesives (this being permitted due to the capacitive design of the signal transmission) thus further reducing cost, pixel charge sharing and improving manufacturing complexity.
- HVCMOS technology has been shown to be radiation hard and looks very promising in comparison to similar types of pixel technologies regarding performance after radiation and long exposure to radiation.

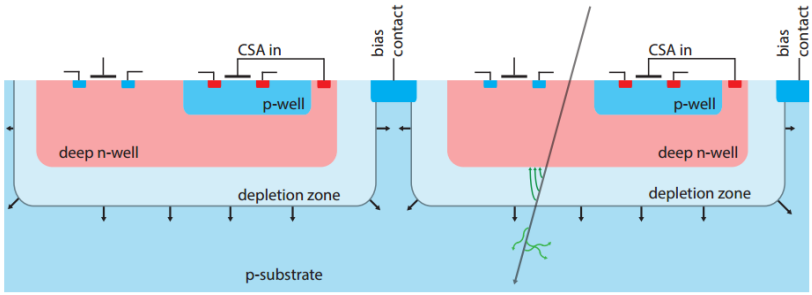

Figure 2: Cross-section of HVCMOS pixel cells [1]

2. Project work

The main section of my work has been comprised of assembling and testing components required for the functionality of the HVCMOS samples as well as data collection for various measurements parametrisations and characterisations. The tasks that were assigned to me comprise of the following:

- Performing a series of measurements on individual pixels on a number of HVCMOS prototypes to understand and parametrize the functionality of the modules as a whole. Tests were also performed to estimate the threshold levels in the boards.
- Soldering components onto auxiliary boards used to power HVCMOS modules via 5 V channels and onto HVCMOS boards; soldering was done both manually and using preset solder paste and pick and place machines.
- Debugging boards using an infrared camera.
- Making various types of cables required for different power and board connections for HVCMOS samples as well as auxiliary instrumentation required to run them.
- Checking the functionality and mapping of cables required to power staves, modules, etc.
- Taking a series of noise measurements via oscilloscope readings to determine peak to peak signal values
- Log, process and interpret calibration values for remotely controlled power supplies.
- Writing a small communication script to control an injection circuit using a multi IO board paired with a GPAC power card read out via an USBPix readout board via python based readout under the detector control framework pyBAR.

3. Working as part of the group

I was able to integrate successfully into our research group. I constantly took part in the group meetings to get up to date with what was going on in the group, and worked with various members of my team as well as working alone for the most of the time. Work was assigned to me primarily by my supervisor, with various other tasks form other members of our research group. This in turn provided the opportunity to closely collaborate with my colleagues allowing me to gain experience and insight in a series of matters concerning our detectors. Through this I've extended my ability to give and receive feedback and contributed to the functionality and overall work load of the group.

4. Being part of the CERN community

One of the biggest parts of the summer was undoubtedly the social aspect associated with being a CERN summer student. One of the more important sides has been forming international networking bonds with other fellow students through attending the various events and gatherings organized by the HR team and some of the students.

In addition attending the lectures held by various members of the scientific community , that were at the top of their research field, has offered me a great deal of insight across a variety of fields related to high and low energy particle physics. In turn this has provided me a broader understanding with the challenges associated with the CERN experiments and to a certain degree will influence me in my future career choices.

5. Conclusions

Through this internship I've had the opportunity to create new networking bonds in the scientific community, to experience first hand the working environment of an active research facility, to attend lectures held by experts of their respective fields and to contribute to the new set of future detectors which will be used in the future ATLAS upgrades. Finally I hope I've been an asset to my research group by contributing where possible with my help in collecting data, measurements and debugging.

Bibliography

[1] Ristic B. 2014 *Measurements on HV-CMOS Active Sensors After Irradiation to HL-LHC fluences* CERN Geneva Switzerland 2-3