CERN Summer School

Summer student report

Installation of a TCT set-up for characterization of novel HV-CMOS planar silicon sensors

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Introduction

For future upgrades of the LHC it is necessary to develop new tracking detectors: more radiation hard and cost efficient pixel detectors with high spacial resolution are required for the planned high luminosity version of the LHC (HL-LHC). For future tracking devices HV-CMOS active pixel sensors are great candidates since they fulfill all the demands mentioned above. First prototypes of these sensors are assembled on custom test boards and together with FE-I4 readout chips they make up the first test pixel detectors. One approach for testing these chips is through using lasers to induce electron-hole-pairs into the depletion zone of the sensor chip diodes to simulate an ionizing particle crossing through the bulk. Comparison measurements of irradiated/non-irradiated sensors are used to explore the radiation hardness of the sensors.
TCT-Measurement Setup

The main part of my summer student project was the initiation of a TCT-measurement setup (TCT - Transient Current Technique), the laser system needed for testing the chips. Therefore all the separate parts had to be installed and implemented.

![TCT-measurement setup inside a Faraday cage](image)

The Faraday cage basically consists of a grounded copper box attached to an aluminum frame, inside which part of the TCT-setup is constructed. The setup comprises of two laser systems (IR $\lambda=1060$ nm and Red $\lambda=660$ nm) by PicoQuant consisting of the laser heads and a PDL 880-B laser driver (outside of the box) as the basic components. The driver is additionally
connected to a function generator to produce pulses at different frequencies. Through the laser optics the beam is then focused to a spot with a diameter in the µm scale in the focal point of the system. Since the movement of the sensor is much easier to realize than the movement of the optical system, the detector is placed on a high precision XYZ-stage by Newport, which allows measurements of signals induced by the laser beam at specific positions on the detector surface.

**Installation of the experimental set-up**

A workstation for controlling the set-up had to be established.

![Workstation for the TCT-setup](image)

*Figure 2: Workstation for the TCT-setup*
The computer is used for communication with the controller of the XYZ-Stage. This is achieved through the USB-Port of the controller using a C++ program on a Windows operating system. Also, the computer is needed to run the software STcontrol that is used for the read-out of the FE-I4 front-end chip. The laser is operated via the PM 5135 function generator by Philips (for triggering) and the laser driver PDL 800B by PicoQuant.

Due to a manufacturing error there were complications with the doors of the copper box in which the experimental setup was placed. On account of safety reasons both doors were removed and new parts had to be ordered. The mounting of the doors was improved to prevent future complications, no measurements could be taken during that time since the laser used is a class 3B laser ($P \leq 500$ mW) and the system has to be closed off during operation. This is achieved through interlocking the doors using magnetic switches, which immediately power off the laser driver if the doors are opened while the system is operated.

A first initiation of the lasers could be made, all parts were connected and a laptop camera and digital camera were put in place to record the laser beam (660 nm). No beam could be observed using these methods up to now.
Follow-up work

For full functionality of the TCT-setup further work steps are required. For the communication with the controller of the XYZ-Stage it is necessary to adjust the C++ program for the Windows operation system (Visual C++). It has only been tested on Linux and Unix systems. Also the program needs to be enhanced and further developed for the specific requirements. The goal is to ultimately include the program into the STcontrol software. To ensure unobstructed movement of the XYZ-stage, the cables connected directly to the motion system should be replaced by ribbon cables. The functionality of the laser has to be verified. First attempts with cameras and the visible laser were not successful. It is advisable to use a photo diode or the pixel detector for a more precise examination of the laser beam. The characteristics of the laser beam, like beam width and position of the focal point have to be determined. For very sensitive measurements further insulation and cooling of the copper box or the sample directly should be considered.

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