Total Ionising Dose Studies of the QFW ASIC

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Introduction

In 2004 the ASIC design group of the GSI Experiment Electronics department (EE) has developed a full custom designed Application Specific Integrated Circuit (ASIC) called *QFW*[1]. This chip, based on a former development of a charge to frequency converter [2], provides a dynamic range of more than 7 decades without any range switching (1 pA. . . 10 μA respectively 10 pA. . . 100 μA).

A typical application for which the chip can be used is the signal readout of ionisation chambers or multi wire detectors. Therefore, for a good readout performance the *QFW* chip has to be mounted maybe very close to the GSI accelerator or near the beam pipe somewhere in the experiments. In these environments there are often very harsh radiation conditions to the semiconductor devices. Special effects like the Total Ionising Dose (TID) play a very important role and therefore prior to the selection of a chip must be carefully tested. In cooperation with the GSI Beam Diagnostic group a research project has been launched 2008 for testing to test these TID effects of the *QFW* ASIC.

Total Ionising Dose Studies

In July 2009 a Total Ionising Dose test was performed at the X-ray irradiation facility of the Institute of Experimental Nuclear Physics (IEKP)[3] at Forschungszentrum Karlsruhe (FZK)[4]. In total two *QFW* test chips mounted on the *QFW* board of the Beam Diagnostic group [5] have been irradiated. A picture of the test setup inside the irradiation chamber is shown in Fig. 1. During the beam tests the X-ray operation settings were held constant at 60 kV and 30 mA tube current. In order to change the irradiation dose rate the distance between X-ray source and test setup could be changed.

Measurements and Results

The first chip was irradiated up to 3.2 kGy (SiO_2), the second chip up to a total dose of 17.2 kGy (SiO_2). For all four channels of the *QFW* chip the current to frequency characteristic was measured for positive as well as negative test currents. The lower limit for the injected currents was 50 pA, the upper limit 10 μA respectively 100 μA.

Both chips were fully functional after irradiation with X-rays. The measured increase of leakage current was in the order of 70 pA per kGy (SiO_2), constant over the complete dynamic range of the *QFW*. Only one channel of one chip showed a significant higher increase in leakage current. After a total dose of 6 kGy (SiO_2) the average increase of leakage current of this channel was 1940 pA per kGy (SiO_2).

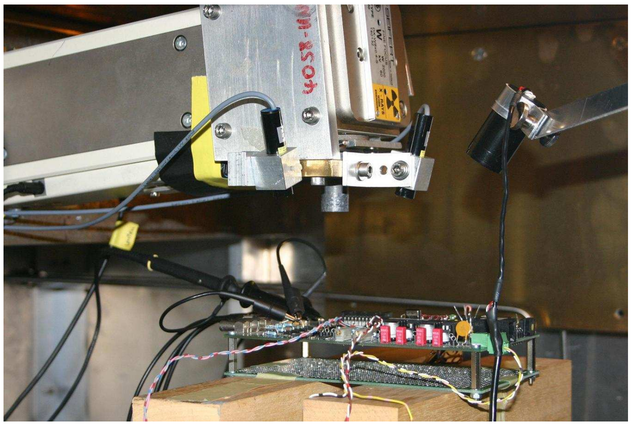

Figure 1: *QFW* test setup inside the X-ray irradiation chamber. The collimator output of the X-ray tube is shown at the top, underneath one of the both test PCB with a *QFW* chip is located.

Immediately after irradiation the annealing of the induced leak currents was observed. After two months of annealing at room temperature no leakage currents were measured for both chips.

Summary

The first Total Ionising Dose test of the *QFW* has shown that the chip can withstand higher radiation doses, although it was not designed for it. The chip also showed a very good annealing performance after the X-ray beam was switch off. It is therefore highly unlikely that failures due to TID effects will occur during normal beam operation conditions.

References

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