Experiment

A goal of this test was to investigate correlation of the excess Idd current in the ABCD3TA chips after proton irradiation at PS and high dose rate X-ray irradiation. A working assumption was that the excess Idd current was caused by ionisation effects in the oxide, so we could expect that X-rays would cause similar effects as protons. Though, in terms of absolute values of the excess current we expected differences between the results from PS irradiation and X-ray irradiation due to difference in dose rates between the two experiments. From PS experiments we have evidence that some annealing (short and long term) takes place.

In the X-ray experiment eleven ABCD3TA chips from the batches used in the modules irradiated before at PS have been irradiated with X-rays up to a total dose of 10Mrad. The dose rate was 36.6 kRad/min so that 10 Mrad was delivered to the chips within a period of 4.5 hour. During irradiation the chips were clocked and exercised in a similar way as in the PS irradiation. Temperature of chips could not controlled and it was in the range of 40 to 50 C. The results of digital tests and the power consumption in of the analogue and the digital part of the chip for both modes of operation (Master and Slave) were monitored continuously. Note that the chips were operated during irradiation on a probe station and were biased with Vdd of 4.5 V in order to ensure reliable operation of the I/O circuits. After irradiation in correct electrical environment the chip passed all digital tests at 50 MHz and minimum Vdd of 3.3 V. For two chips only the minimum Vdd increased slightly up to 3.5 V.

Given high dose rate used in the X-ray test it would be desirable to perform some annealing of the irradiated chips. Due to limited availability of the equipment this was done only in limited range. For three chips we have followed annealing of the excess current immediately after irradiation for about 3 hours at room temperature. Other three chips have been annealed at 100 C during periods from 30 to 60 hours.

Results

The plots with the results are shown at http://mic-jk.web.cern.ch/mic-jk/ (follow the links there or go directly to:

http://mic-jk.web.cern.ch/mic-jk/PSIrrad/Irrad/IrradReport1.htm and

http://mic-jk.web.cern.ch/mic-jk/PSIrrad/AnnealHTemp/AnnealReport1.htm.

Figures 1-1 to 1-11 show the records of the Idd current in the Slave and the Master mode take during irradiation. The experimental facts are:

- the excess current does not depend on whether the chip works in the Slave or in the Master Mode, it is not generated to I/O circuits,
- the excess current starts after 1 – 2 Mrad (25 to 60 min),
- absolute values of the excess current are higher after the X-ray test, as expected,
- short term annealing occurs at room temperature,
- there is a clear correlation (Fig. 1-12) between the PS data and the X-ray data for the chips from the same wafers. Note that the strange case of wafer 03 from batch Z36459 is conformed by X-ray data.
- the correlation looks even better for the chips which have been annealed at 100 C (Fig. 1-13) although one should note a low statistic in this case.

- there is no correlation between the excess Idd current and switching performance of the chips.

Figures 2-1 to 2-16 show the results of high temperature annealing test. Between end of irradiation and start of annealing the chips were kept at room temperature unbiased. The observations are:

- some short term annealing occurs in the chips unbiased and stored at room temperature, compare the values at the end of irradiation and start of annealing,
- the excess current depends strongly on the temperature, unlike the "normal switching" current; this temperature dependence is about 15mA/70C and does not change after annealing,
- in the chip which exhibits low excess current (Figs 2-4 and 2-5) there is no significant short term annealing at 100 C,
- in the chips which exhibit high excess current there is still significant short term annealing at 100 C.

Preliminary conclusions:

1. A correlation with respect to the excess Idd current between PS irradiation and high dose rate X-ray irradiation has been confirmed.
2. High dose rate X-ray irradiation can be used as a screening method.
3. Excess Idd does not influence switching performance and operation of the chips.