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Comparison of Single Event Effects on 28-nm SoC Under Different Radiation Environments

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We conducted a number of experiments on Xilinx Zynq-7010 28-nm System on chip (SoC) , which was irradiated respectively with alpha particles, protons and laser, to study Single Event Effect (SEE) of SoC. In alpha experiments, 241Am α source at the energy of 5 MeV was used to irradiate the SoC chip. In proton experiments, 3 MeV, 5 MeV and 10 MeV mono-energetic proton beams were vertically irradiated on the SoC chip. In laser experiments, the external dynamic memory (DDR3) was vertically irradiated by 1064-nm laser because laser cannot be incident to the sensitive area in SoC, and DDR3, storing all testing program, is an important component of the test board. The plastic capsulation of SoC and DDR3 was removed in all the experiments. The results showed that Single Event Effect was induced in Xilinx SoC and DDR3. Single-bit event upset (SEU), Single Event Functional Interrupt (SEFI) and multi-bits upset (MBU) occured in different modules including PL, FPU, etc. The error types of all these experiments were similar, making experiments under different radiation environments as complement and verification to each other, which indicates that the test programs determine the test results under different circumstances. The SEU cross sections of different test modules in different experiments were obtained, and the variation trend of cross sections as functions of proton energy was explained. Comparing alpha and laser experiments, PL module was the most sensitive area while few errors happened in FPU in alpha experiments. But in laser experiments, things were completely the opposite. We found that errors were more easily to occur in FPU because FPU performed complex calculations and owned large amount of code; in contrast, few errors occurred in PL because PL completed most missions via hardware programmable logic, only using DDR for input and output values. Comparing alpha and proton experiments, the SEU cross section induced by 5-MeV α was greater than that induced by 5-MeV proton, since alpha particles have greater LET in this case. The comparison and explanation of SEE experiments utilizing different radiation sources were discussed.

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