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Radiation Testing on Biased Commercial AMD Microprocessor

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Abstract

When irradiating an Advanced Micro Device (AMD) Processor that is connected to the motherboard within a chamber, it is important to shield the motherboard from the gamma rays. In doing so I constructed a collimator with lead (Pb) bricks so that only the AMD processor is open to the gamma rays. While the motherboard was powered, the AMD processor experienced radiation. The results examined the effects that radiation had on an AMD processor and whether or not the processor could survive in the harmful radiation space environment.

Introduction

Gamma rays of 3.08 Krad/min are used to irradiate an AMD A43300 microprocessor, a device that is being considered to be used on space instruments such as satellites. It is very important to shield the motherboard from the harmful gamma ray spectrum, while irradiating a powered AMD microprocessor on a Biostar A55MLV motherboard. This is important because radiation emitted on the motherboard can cause certain experimental results to become inaccurate. The primary difficulty is to determine the perfect shielding technique, although it is fairly impossible to shield all of the unwanted energies. This experiment required different dose stages, with different time intervals per stage. There were several different test methods proposed for this particular project, such as, using high dose rates so that each stage would be shorter or moving the fan to the side of the motherboard so that the motherboard was not irradiated.

Is the current test method accurate?

Fig. 1. The Biostar A55MLV Motherboard.

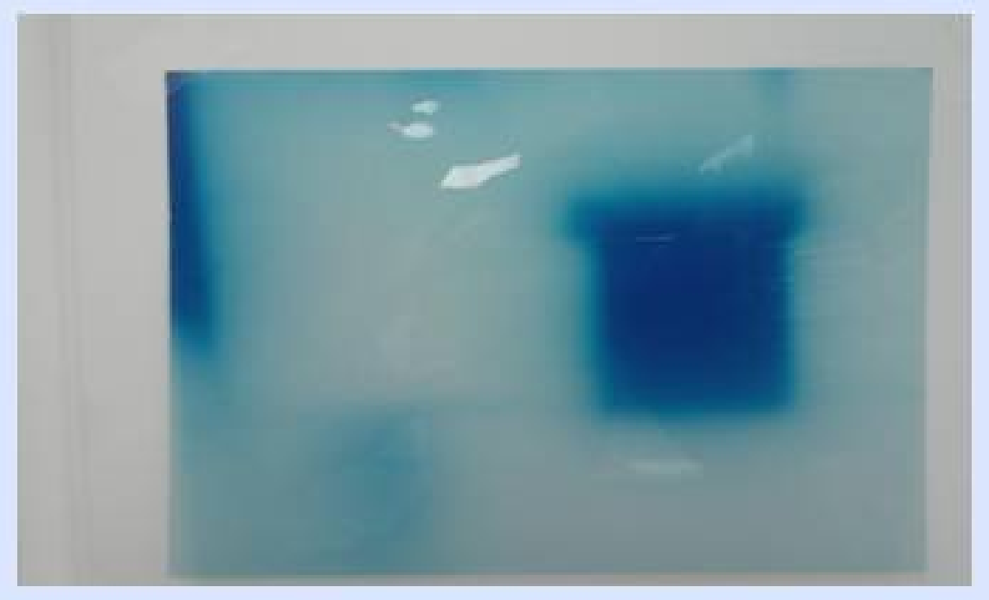


Fig. 2. Transparent film sheet that shows exactly where the gammas hit..

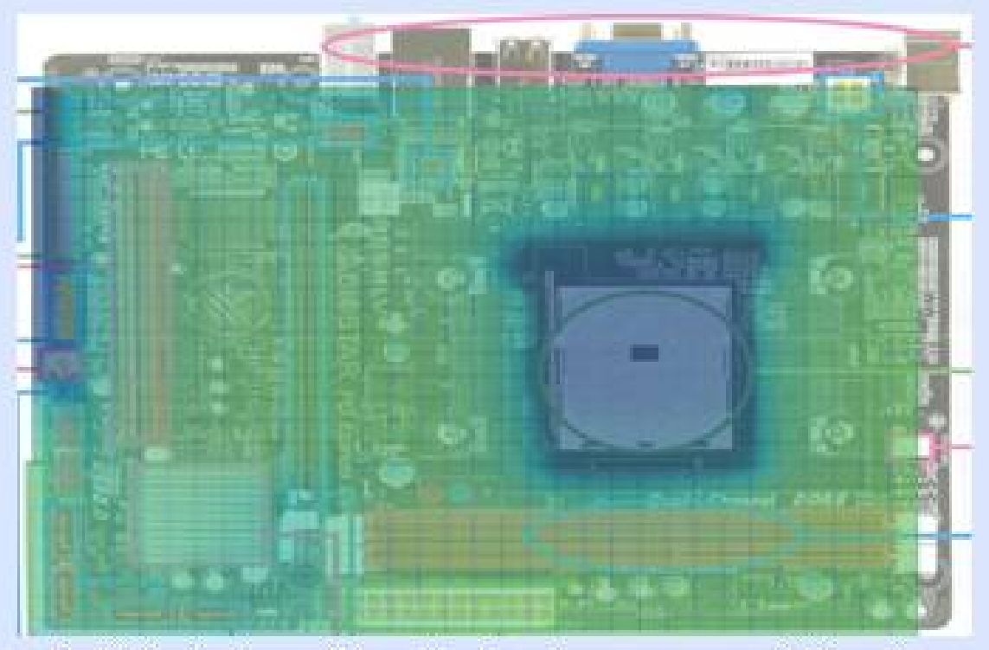


Fig. 3. Projection of where the Low dose gammas will hit on the Biostar A55MLV motherboard.

Device Under Test

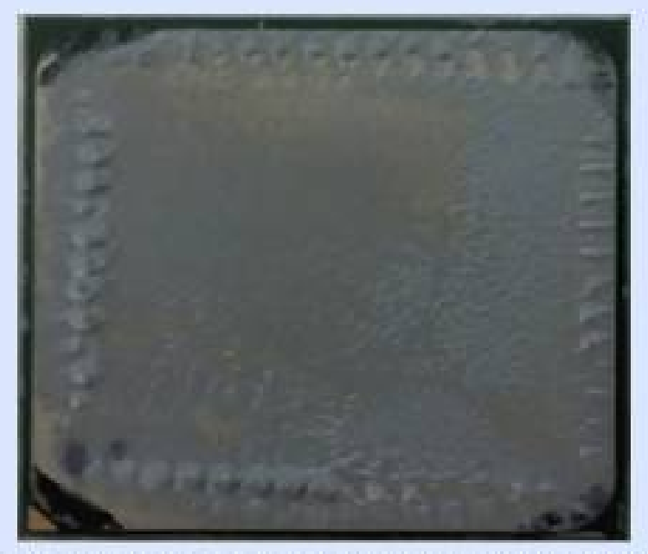


Fig. 4. Bottom of AMD A43300 Microprocessor

Fig. 5. Top of AMD A43300 Microprocessor

Table I. AMD A43300 Microprocessor Part information

Processor Type:	**AMD Dual-Core A4-Series APU for Desktops**
Model:	AMD A4-3300 APU with AMD Radeon™ HD 6410D
Part Number:	AD3300OJHXBOX
Socket Type:	FM1 uPGA
Power Wattage:	65
Frequency:	2500
Processor Bus Speed:	Not Specified
Processor L2 Cache Size:	1024
CMOS:	32nm SOI
Stepping:	Not Specified
Fusion Control Hubs:	D2/D3 FCH
DirectX Version:	Not Specified
GPU Clock Speed:	Not Specified

Experiment Methodology

The first step involved taking measurements of how the shielding collimator would be designed to get the best results possible from only irradiating the AMD A43300 microprocessor. The thickness of lead (Pb) it takes to attenuate high energy gamma rays almost completely is 4 inches. Designing a lead (Pb) collimator based on attenuating the gammas nearly one hundred percent from the Biostar A55MLV motherboard was a challenge.

Since the DUT was 3.5 inches from the bottom of the motherboard we decided it would be better to allow to spectrum of the source to lead up to the DUT. So we started with a 2X4 wooden block and made a ramp that had a height of 1.5 inches. The design of the lead (Pb) collimator was built on top of the ramp so that the spectrum from the source would follow through a tunnel like opening (Fig. 6-7).

After the shielding design was complete, we used a Fluke Biomedical dosimeter to see the dose amount that certain parts of the board received (Shown in Fig. 8). The AMD A43300 microprocessor received 3.08 Krad/min to confirm that the microprocessor would indeed be exposed to radiation. To insure the test results were accurate, a transparent film sheet was then placed over the motherboard. This film sheet turned blue where radiation was targeting the motherboard (Fig. 2-3).

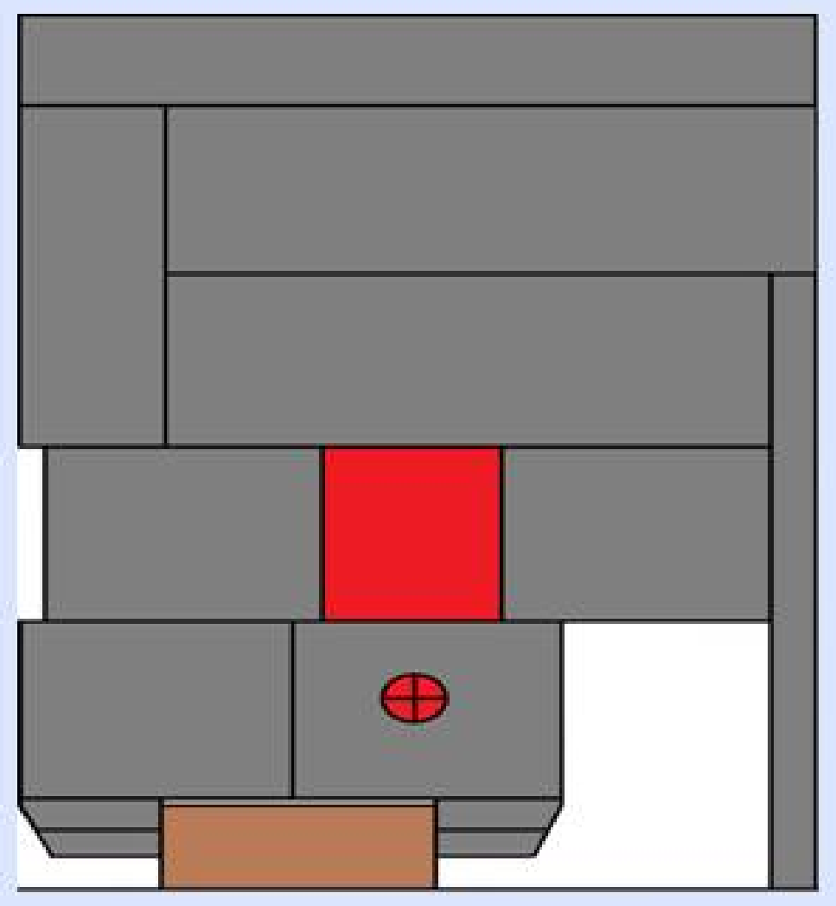


Fig. 6. In this image you see an illustration of the front face of the shielding design we used when performing the experiment.

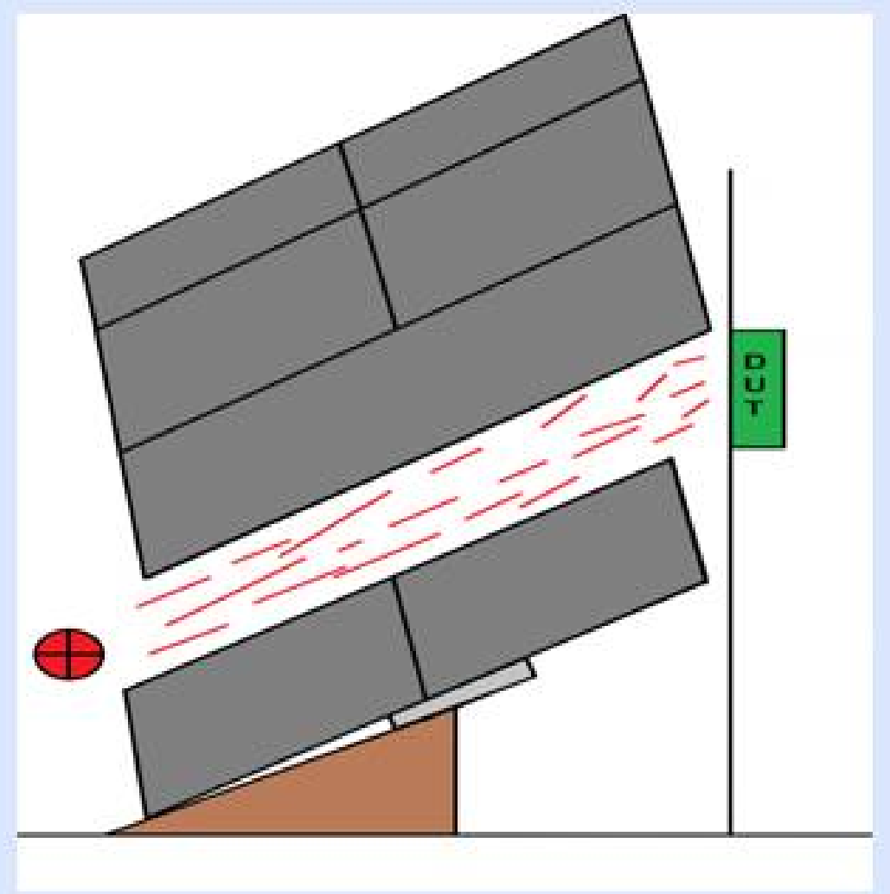


Fig. 7. In this image you see another illustration of a side view of the shielding design we used when performing the experiment.

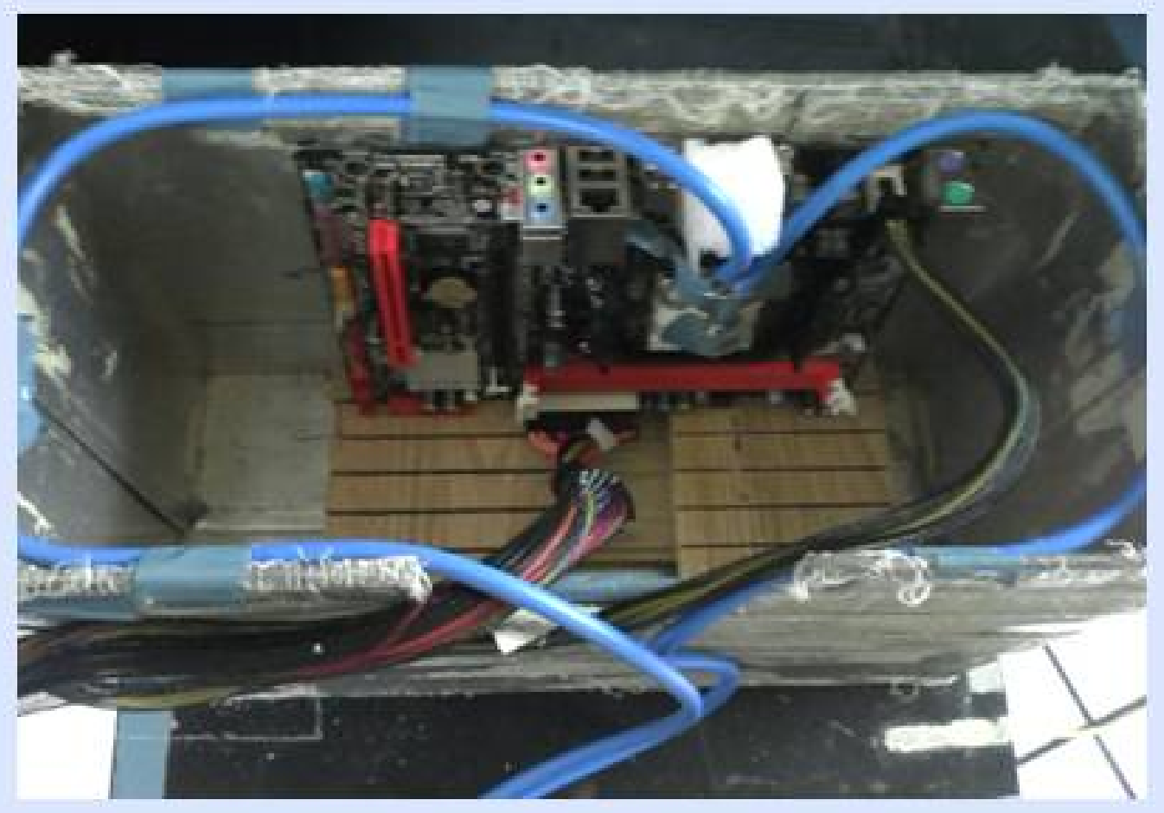


Fig. 8. Biomedical Dosimeter Test setup. In this image you can see the placement of the dosimeters probe that reads the amount of dosage a particular spot is receiving.

Experiment Methodology (con't)

After all pre testing was complete, we removed the dosimeters and connected the actual AMD microprocessor and the cooling fan on the motherboard. We ran extended cords from the inside to the outside of the radiation chamber that allowed control of the operations of the motherboard from outside of the chamber. We examined with a virgin motherboard with a virgin DUT before every irradiation stage to ensure that nothing had changed concerning the virgin board and virgin DUT output. We then examined the output of the irradiated motherboard with the irradiated DUT to see the difference in the irradiated parts and the virgin parts. Next we examined the output of the virgin motherboard with the irradiated DUT to see if there were any experimental errors or where the irradiated motherboard may have lost functionality or power due to radiation. We did this for each dosage stage: 100 Krad/min, 250 Krad/min, 500 Krad/min, 750 Krad/min, and 1000 Krad/min.

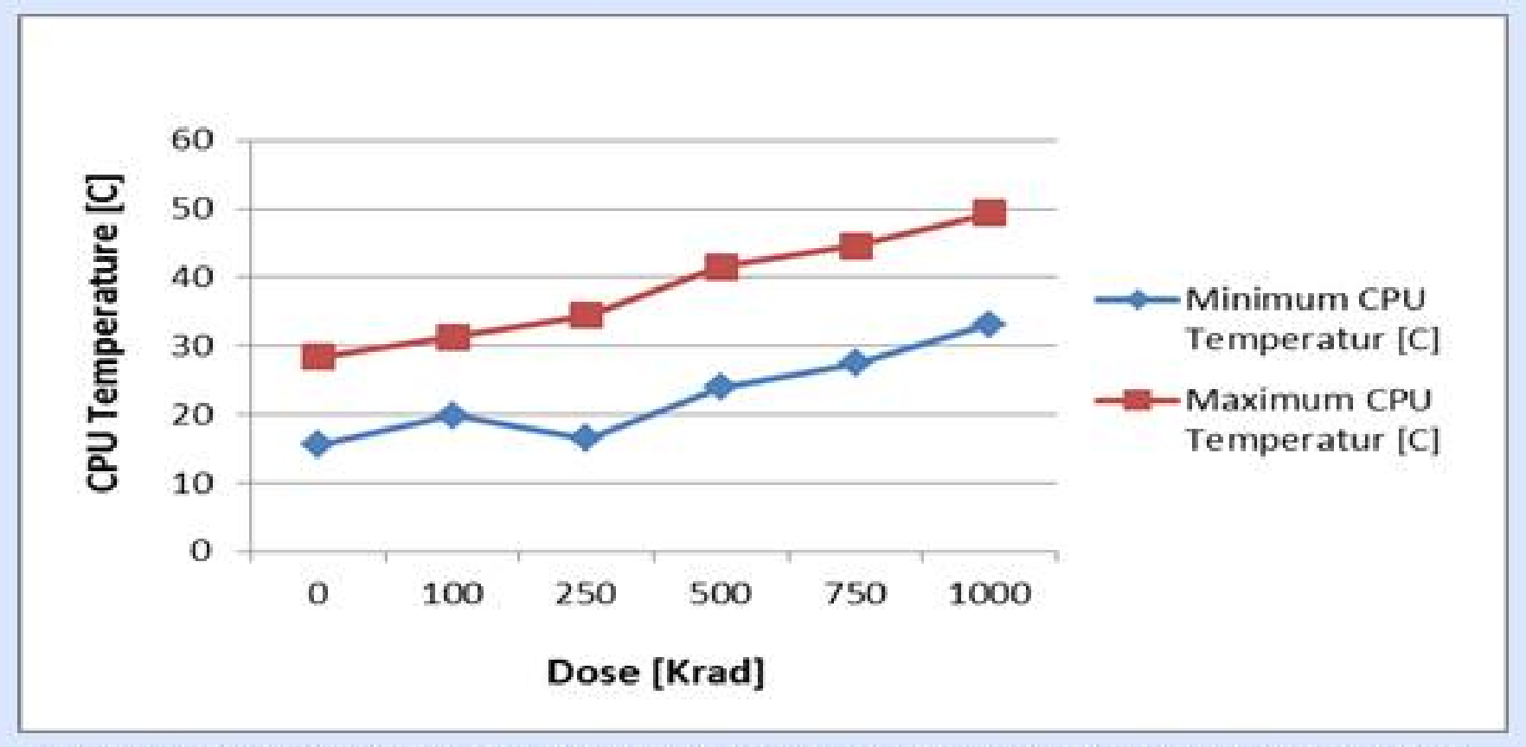
So is the current test method accurate enough?

Fig. 9. In this image you see the actual front face of the shielding design we used when performing the experiment.

Results

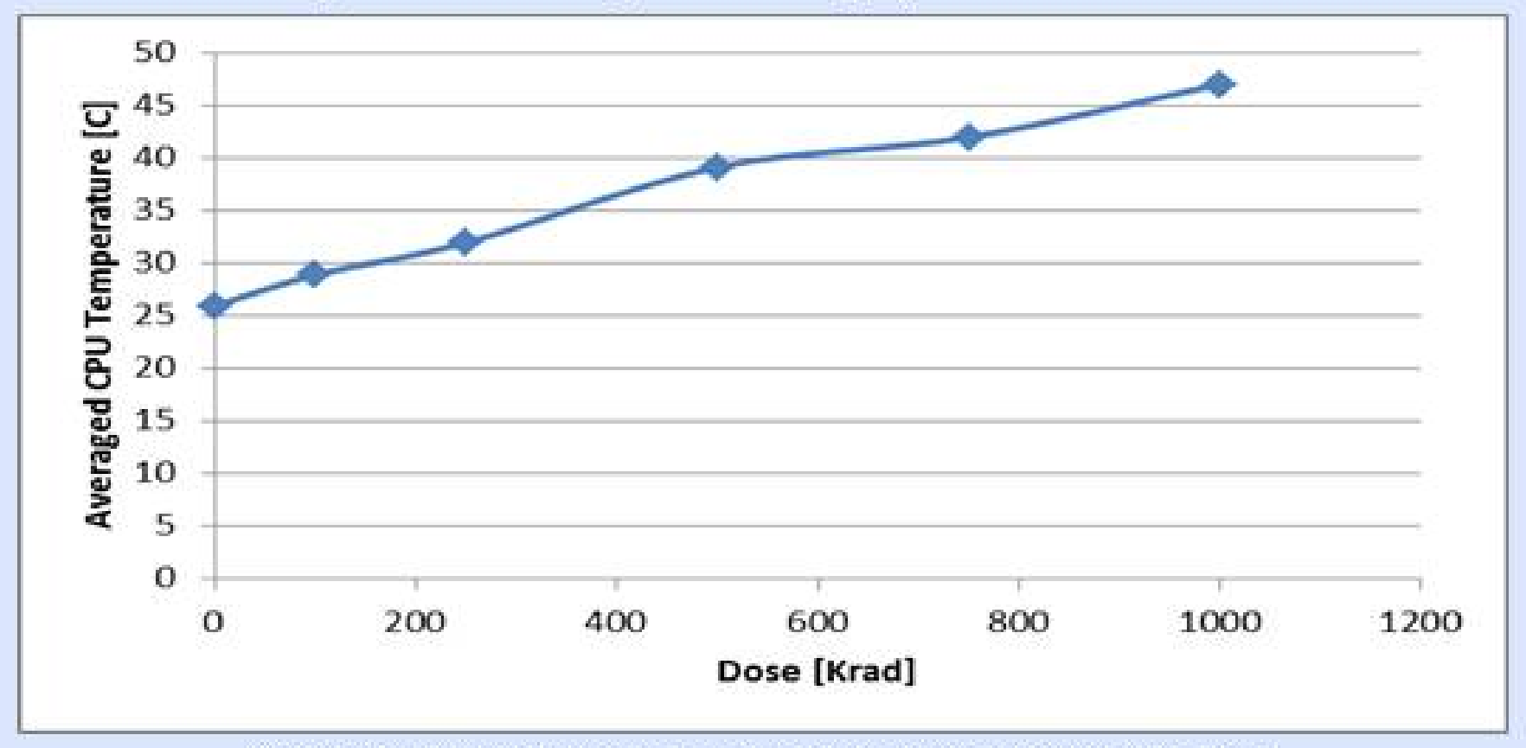
During one of the irradiation stages, I had a problem with the initial cooling fan. It was to be biased over the weekend in the radiation chamber between stages 100Krad/min and 250Krad/min. When we opened the chamber and went in to check the fan, it had overheated and the fan speed was significantly low. I changed the fan with a virgin fan and continued to do so throughout every stage. It is possible that since the fan was positioned perfectly on top of the AMD A43300 microprocessor, that radiation caused the fan to overheat. As a result, a new test method was proposed for future references. The fan was moved to the side of the DUT so that it was not in the path of harmful radiation. We could also conduct high dose rate tests that last longer periods of time to examine the effects that radiation has over days of exposure. During our current test method, nothing changed dramatically except for the temperature of the CPU. We believe this has a lot to do with the fan being directly over the DUT and exposed to radiation, as the temperatures increased with every dosage stage.

Maximum & Minimum CPU Temperature [C] of irradiated DUT



Graph 1. In this graph you can see the temperature differences at various dosage stages during the experiment on the DUT.

Average CPU Temperature [C] of irradiated DUT



Graph 2. In this graph you can see the average temperature of the DUT.

Conclusions

I have shown results of the effects of applied radiation on a commercial AMD microprocessor at a dose rate of 3.08 Krad, whereby the temperature increases with increasing dose rates. The fan issue became a bigger problem than expected. After the cooling fan overheated, I assumed that the temperatures would continue to climb. I believe that the current test method was a great start towards showing what type of results we would get from an almost perfectly designed lead (Pb) collimator using simple geometry. Low dose TID testing has its ups and downs but I believe that higher dose rates will show a lot more change in the results. The higher rates could help determine if the AMD microprocessor is really able to withstand the harmful radiation in the space environment. Lead bricks are used in this experiment because it is a very dense material versus concrete or aluminum. The key aspect of this experiment is being able to operate and control the Motherboard from outside the source chamber while the parts are actually experiencing harmful radiation. All proposed test methods will be considered for this project.

Acknowledgment

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