INFLUENCE OF ELECTROMAGNETIC POLLUTION OF THE ELECTRON BEAM GENERATOR AND HIGH-ENERGY RADIOACTIVE SOURCE ON THE MEMORY COMPONENTS

by

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The study considers the impact of the environmental contamination by the electromagnetic radiation of electron beam generator and high-energy radioactive source on the memory components. Electron beam generator can be used for injecting particle energy into the plasma of the fusion system based on a Marx generator, while radioactive source as a simulator of high-energy ionizing radiation that can be caused by the neutron-induced activation of plasma surrounding structures or released from deuterium-tritium fusion reaction. The effects of gamma radiation of high-energy radioactive source and electric field of the electron beam generator on EPROM and EEPROM semiconductor computer memory, were investigated. An older memory types were deliberately chosen for the reason that their more robust construction will better protect them from the effects of ionizing and non-ionizing radiation. The results obtained under well-controlled conditions show a high degree of non-resistance of the semiconductor technology to the expected electromagnetic pollution of the electron beam generator and high-energy radioactive source. This conclusion raises doubts on the possibility of simultaneous application of electron beam generator, consequently fusion system and nanotechnologies with the increasing need for miniaturization of electronic components.

Key words: electromagnetic pollution, electron beam generator, high-energy radioactive source, memory component

INTRODUCTION

Population growth in world countries and the development of new technologies have increased the need for energy. Today, countries that have relied on nuclear energy sources do not enter into any energy crises. However, conventional baseload power sources are limited due to greenhous gas and its negative impact to the climate change. Uranium, which is the fuel of both thermal and fast reactors, is present in nature in limited quantities as the last unstable element of the Periodic Table, originating from a supernova explosion that occurred before the formation of the Solar System. For this reason, it is considered that the definitive solution to the energy needs of the entire planet will be met by achieving economically acceptable, controlled nuclear fusion.

As one potential solution for significant source of energy with zero carbon emission is technology based on nuclear fusion in which a plasma is heated. Scientists organized on demanding projects emphasize the negligible impact on the human environment as one of the advantages of fusion reactors [1]. This statement, although partially true, ignores that fusion type reactors are a source of considerable electromagnetic (non-ionizing and ionizing) environmental contamination [2, 3].

Electromagnetic contamination of the environment causes consequences for the biosphere and the technosphere. The impact of electromagnetic contamination on the technosphere is particularly unpredictable, since the growing trend towards miniaturization of electronic circuits makes them very sensitive to overvoltages induced by ultra-fast electromagnetic fields generated in the fusion reactor. In order to examine the possible occurrence of electromagnetic pollution of the fusion system in the environment, a study was carried out on the influ-

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ence of the electromagnetic field, created in the electron beam generator which can potentially be a part of fusion machines for plasma heating, and gamma radiation, as a possible product of the neutron-induced activation of the surrounding plasma structures, on the memory components in its vicinity.

Several tests were performed on the plasma heating in the core of the generator with particle beams and their comparison with the plasma heating with an electromagnetic (laser) beam where, at high temperatures, there is considerable reflection of the laser beam and loss of energy [2]. A consideration of the before-mentioned problem is a continuation of previous research [4]. The electron beam generator, used in this study for plasma heating in the fusion system, is described in detail in the paper [5]. This generator in vertical part is a Marx generator, immersed in insulating oil to prevent sparking between capacitors and activated by three-electrode spark gaps insulated with a composition of SF6-N2 gases with a separate third electrode. Such a way of triggering gives minimal jitter when the percentage composition of the gas mixture is optimal [6-9]. For getting high plasma temperature, it is optimal to inject pulses of the order of 10 TW with a width of about 5 ns. Such a pulse cannot be obtained from one electron beam generator, so the plasma is heated by several electron beam generators that simultaneously fire into the plasma.

The goal of this study is to examine the influence of the fast electromagnetic field, created in the fusion reactor, on the technical-technological components in its vicinity, *i. e.*, the impact of electromagnetic contamination of the fusion reactor on the technosphere. It refers to the comparison of the damage of EPROM and EEPROM memories by gamma radiation and induced overvoltage due to the fast electromagmatic field that occurs in fusion reactors.

MATERIALS

The Marx generator was set to give a 1.2/50 s pulse shape by selecting resistors to charge and discharge the capacitor. In the horizontal part of the circuit there was a system of conductors and capacitors filled with deionized water. At the top of the horizontal part of the electronic generator there was a capacitive probe (or alternatively a Kerr cell) which was connected to the pulse conductor of the generator. This probe has the task of measuring the voltage form of the electronic pulse that is fired from the electronic generator and which injects energy into the plasma. The horizontal part itself serves to adjust the electronic pulse to the need, fig. 1 [5].

From the aspect of electromagnetic pollution of the environment by the fusion systems, two components appear. The first component is electromagnetic radiation as a consequence of extremely fast pulses generated by electron beams injected into the plasma (conceived in this way). The second type is ionizing high-energy gamma radiation as consequence of neutron-induced activation of plasma surrounding structures (walls and components) [10]. Together, ionizing and non-ionizing radiation can affect electronic equipment used for protection, measurement and management control of the processes in a fusion system. Modern electronic equipment is especially sensitive, where the trend towards its miniaturization has caused an exceptional sensitivity to electrical noise induced by ionizing radiation [11-13]. Also, surge protection components can change their characteristics so, the entire control system could be compromised by overvoltage. Finally, ionizing radiation affects the low-voltage part of the sensor, which consists of a capacitor with an electronic type of polarization insulator (or some other material that has a frequency independent dielectric constant such as mica) and an adaptive resistance [14,

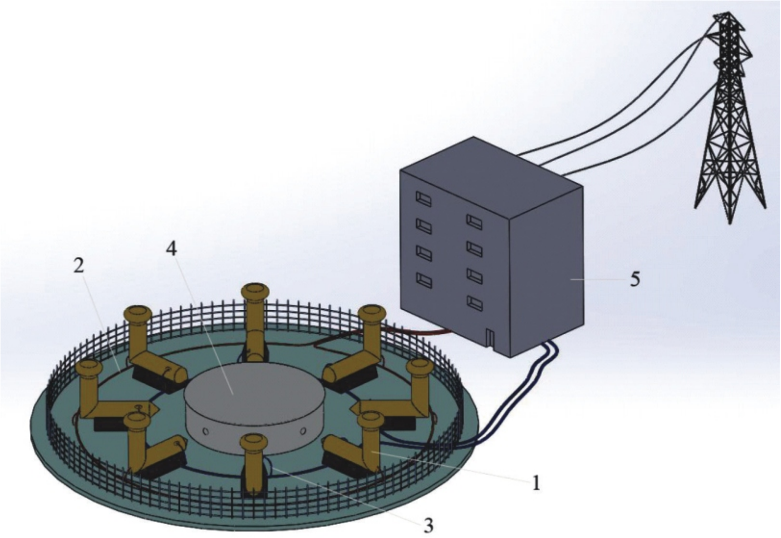

Figure 1. System of eight electron beam generators for injecting energy into the plasma by simultaneous triggering: (1) chamber with an oil-insulated Marx generator, (2) electrical assembly for beam formation, (3) entrance of the horizontal part for injecting electrons into the plasma, (4) space shielded by -metal with plasma, and (5) building for the conversion of heat energy into electricity (from [5])

15]. Even the smallest deviations from the set values of the system, especially the probe, can disrupt the fusion process and put the generator out of function.

EXPERIMENT

Estimation of the environmental pollution by a fusion system was conducted in two separate experiments: experiment on the influence of the gamma radiation field on electronic components and experiment of rapidly changing electric field on electronic components. The electronic components on which the experiments were carried out were EPROM and EEPROM. The older types of memories were chosen for reasons of more robust construction, so it could be expected that they have greater resistance to ionizing radiation and overvoltage [16].

Tests were performed on EPROM and EEPROM memories of various types and manufacturers. The obtained results presented in this study refer to JL 27C512 EPROM and 28C64C EEPROM memories manufactured by TMS, Singapore. The 100 memories of the same type were used for the test, which were divided into groups of five memories each.

The experiments with gamma radiation field were performed under well-controlled laboratory conditions. The gamma radiation field was realized by the IRPIK-B device. The thickness of the walls decreased the intensity of the source 1000 times. Beam shaping was done with a collimator of variable direction. The maximum dimension of the field at a distance of 1 m was 30 cm 30 cm. The used radioactive source was ^{60}Co (activity of 124.1 TBq; production date 2010). The ^{60}Co provides two gamma rays with energies of 1.173 MeV and 1.332 MeV.

Before the start of the test, the same memory content 1 was written in all memory samples. Memory content 1 was used because it is more energy stable. In doing so, constant voltage forms were used [17-20].

First, EPROM and EEPROM memories were tested on the effects of gamma fields. During the test with radiation from a gamma source, the size of the radiation field was 8 cm 8 cm. The distance between the source and the tested memory samples was 45.6 cm. The strength of the absorbed dose in air was 60 Gyh^{-1}, and 65.82 Gy^{-1} in Si material. Testing of the gamma field effect on memory components was performed at a temperature of 20 °C. Erasing the contents of the EEPROM components was done with a standard UV eraser. The effects of radiation on the examined memories were observed as: differential change in the number of defects as a function of the total radiation dose and cumulative change in the number of defects as a function of the total radiation dose. One series of measurements was performed with one irradiation on five memory components.

After that, EPROM and EEPROM memories were tested for high-frequency electric field (voltage rise field 50 kV(ns)$^{-1}$. During the testing of the resistance of the memory components to overvoltages induced by fast voltage pulses, they were placed at a distance of 50 m, 100 m, 500 m, and 1000 m (these tests were performed in a clean area without reflections) from the model of the electron fusion injector in the horizontal plane, in which the previously described electric field is established at all points. The examination of the effect of the fast electric field was performed in the same way as in the case of irradiation with gamma photons. EPROM and EEPROM memory components, from the same manufacturer, were used for all the measurements. Those components were tested for stochastic identity and were chosen among the most stable components for the tested effect in the gamma field. The two effects of a fast electric field on the tested memories were observed: the direct effect of a fast electric field on the memory and the effect of a fast electric field on memories protected from overvoltage by a fast protective hybrid circuit according to the standard IEC 77.C1, as shown in fig. 2 [21].

During the examination of the non-ionizing radiation impact on one memory component, the number of triggering reps of electronic generator model were: 100, 200, 300, 400, 500, 600, 700, 800, 900, and 1000. Between two consecutive triggering, a one-minute break was made. The process of one measurement series was automated. After the completion of a series of triggering, the number of errors, caused by the action of a non-ionizing electromagnetic impulse, was determined. An error was considered if logical content 1 from a memory component cell is lost, *i. e*., logical content 0 in a cell was considered as an error. The reading of the memory component cells was performed with equipment and software obtained from the manufacturer of the tested component. The number of destructive errors after one series of non-ionizing electromagnetic pulses was recorded and then the content of the measured semiconductor component was cleaned and logical content 1 has been set. If the contents of the memory component cell in which the entry of the logical content 1 failed, it was considered destroyed. Memory component was considered de-

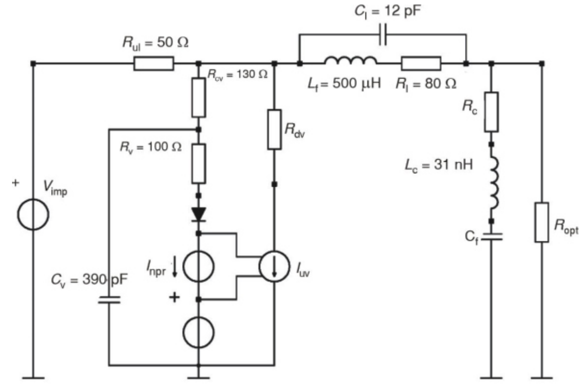

Figure 2. Scheme of the protective hybrid circuit made according to IEC 77.C1 standard

stroyed if the writing of the logical content 1 to memory cell failed.

The measurements were performed under well-controlled laboratory conditions. The used instrumentation was certified by licensed laboratories. The semiconductor components measured were identical and new. The combined measurement uncertainty was for all the measurements less than 8 % [22, 23].

RESULTS AND DISCUSSION

Figures 3 and 4 show the differential change and the cumulative change in the number of EPROM component defects depending on the received radiation dose, respectively, where N_{i+1} is number of defects for (i + 1) component, Ni is number of defects for i component, N_{tot} is total number of defects, and N_0 is initial number of defects (for figs. 3-16).

Based on figs. 3 and 4, it can be concluded that gamma radiation leads to a significant damage to the contents of EPROM memories.

A change occurs when the total radiation dose exceeds 1300 Gy. The resulting changes are reversible. After deleting the content by UV radiation previously irradiated with a dose of over 1300 Gy, all functions are restored 100 %.

The re-irradiation of EPROM memories after erasing and restoring all records to state 1 shows that there has been a decrease in the stability of memories in relation to radiation, figs. 5 and 6.

The effect observed in figs. 5 and 6 is a consequence of the cumulative effect of radiation. The main physical effect that leads to damage to the contents of EPROM memories is the generation of electron-hole pairs in the insulating SiO_2 layer. In addition, gamma radiation leads to the formation of surface states on the Si-SiO_2 boundary surface. Both of these effects are successfully canceled by deletion, but there is always a memory effect caused by the significantly lower mobility of the holes.

Figures 7 and 8 show the differential change and the cumulative change in the number of EEPROM component defects depending on the total received radiation dose, respectively.

Based on figs. 7 and 8, it can be concluded that gamma radiation leads to a significant damage to the content of EEPROM memory. The threshold for EEPROM memory damage is at doses of 100 Gy. With the increase of the total received dose, the number of damages to the content of EEPROM memory increases. In contrast to the behavior of EPROM memories, the influence of gamma radiation on EEPROM memories is irreversible. Therefore, once the EEPROM memory has been damaged by the influence of gamma radiation,

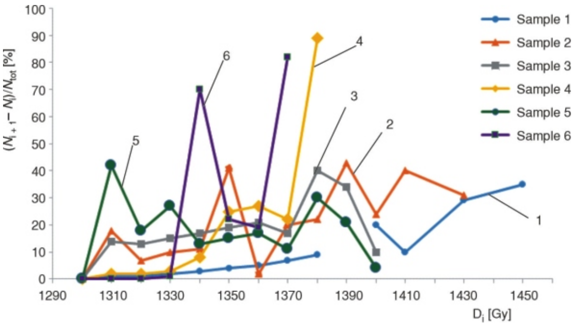

Figure 3. Differential changes in the number of defects as a function of the total received radiation dose of the EPROM memory samples irradiated for the first time

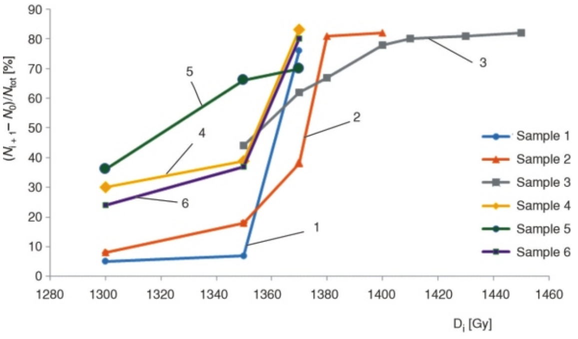

Figure 4. Cumulative changes in the number of defects as a function of the total received radiation dose for the first-time irradiated EPROM memory samples

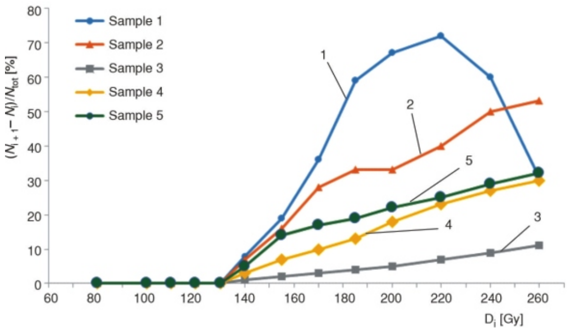

Figure 5. Differential changes in number of defects as a function of total received radiation dose for reprogrammed re-irradiated EPROM memory samples

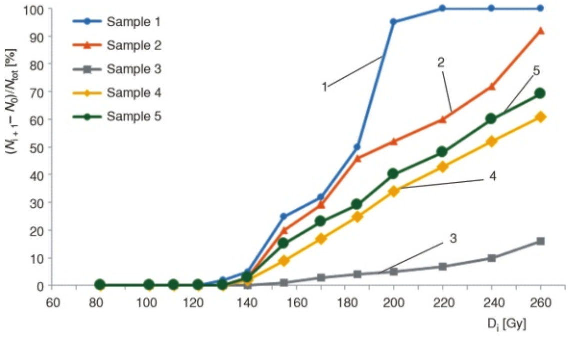

Figure 6. Cumulative changes in number of defects as a function of total received radiation dose for reprogrammed re-irradiated EPROM memory samples

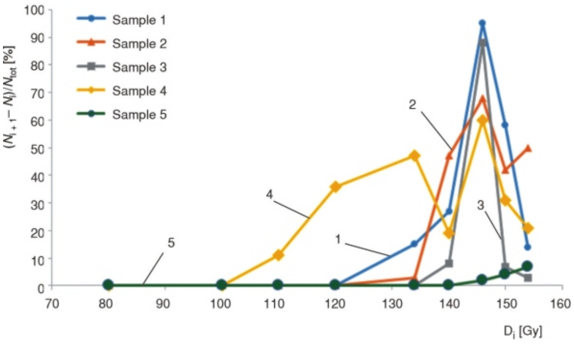

Figure 7. Differential changes in the number of defects depending on the total received radiation dose for EEPROM memory samples

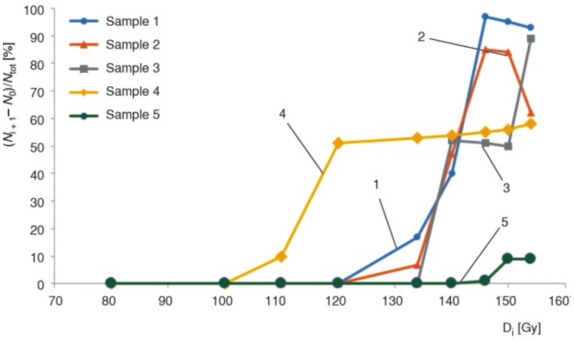

Figure 8. Cumulative changes in the number of defects depending on the total received radiation dose for EEPROM memory samples

it can no longer be overwritten by the application of UV radiation, *i. e*., cannot be reprogrammed again. This difference between EPROM and EEPROM memories from the aspect of the effect of gamma radiation is in the retention of holes created by ionization in the insulating layer due to a higher value of the electric field. In addition, there is an accumulation of holes on Si/SiO_2 surfaces. The impact of both of these effects increases with a decrease in oxide thickness, which confirms the expectation that further miniaturization of electronic components decreases their resistance to ionizing radiation.

Figures 9 and 10 show the differential change and the cumulative change in the number of EPROM component defects unprotected from induced overvoltages, depending on the number of triggering of the electronic generator, respectively.

Figures 9 and 10 depict that overvoltages induced by a fast electromagnetic field, caused by the triggering of an electronic generator, led to a significant number of defects of EPROM components. The number of defects of EPROM components, caused in this way, is significantly higher than the number of defects caused by the received radiation dose. Also, unlike the effect of gamma radiation, EPROM components unprotected from induced overvoltages, do not show the existence of a threshold, *i. e*., the effect of the damage occurs already at the first trigger. In addition to the above, it was found that defects, caused in EPROM memories due to overvoltage, cannot be removed by erasing the contents and reprogramming again, which is also an important difference compared to the effect of gamma radiation.

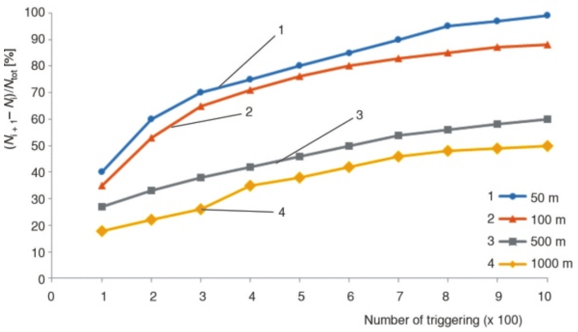

Figure 9. Differential change in the number of defects of EPROM components unprotected from induced overvoltage depending on the number of triggering of the electronic generator (distance from the electronic generator)

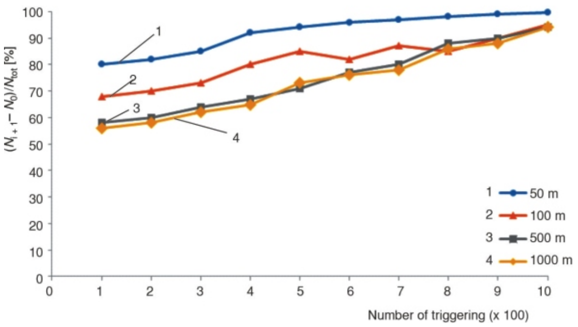

Figure 10. Cumulative change in the number of defects of EPROM components unprotected from induced overvoltage depending on the number of triggering of the electronic generator (distance from the electronic generator)

Figures 11 and 12 show the differential change and the cumulative change in the number of EPROM component defects, protected against induced overvoltages, depending on the number of triggering of the electronic generator, respectively.

Figures 13 and 14 show the differential change and the cumulative change in the number of EEPROM component defects unprotected from induced overvoltages depending on the number of triggering of the electronic generator, respectively.

Figures 13 and 14 depict that overvoltages induced by a fast electromagnetic field by triggering of an electronic generator led to an extremely large number of defects in EEPROM components. The number of EEPROM component defects is noticeably higher than the corresponding number of EPROM component defects. It was also found that the number of defects in EEPROM components is twice as high as the number of defects caused by the received dose of gamma radiation. The EEPROM component could not be overwritten and the component could not be reprogrammed. The EEPROM component defects, unprotected from overvoltage, had no threshold number of

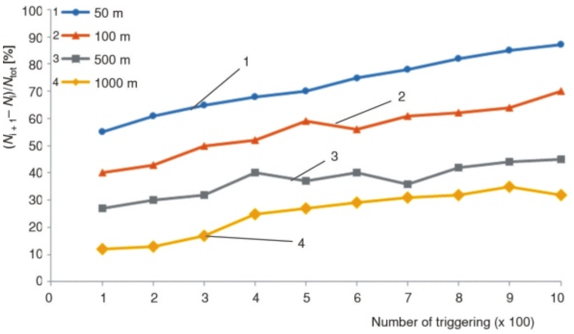

Figure 11. Differential change in the number of defects of EPROM components protected against overvoltage depending on the number of triggering of the electronic generator (distance from the electronic generator)

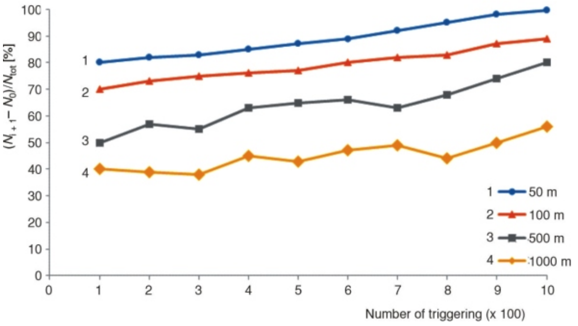

Figure 12. Cumulative change in the number of defects of EPROM components protected against overvoltage depending on the number of triggering of the electronic generator (distance from the electronic generator)

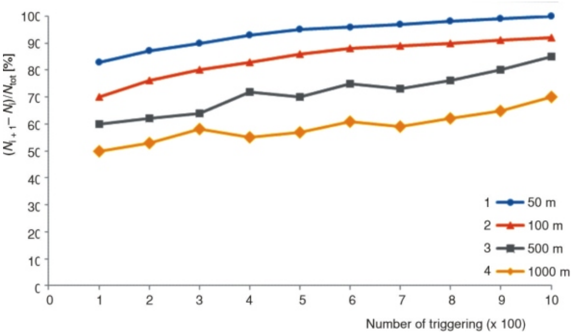

Figure 13. Differential change in the number of defects of EEPROM components unprotected from overvoltage depending on the number of triggering of the electronic generator (distance from the electronic generator)

triggering of the electronic generator, but at the first trigger defects occur.

Figures 15 and 16 show the differential change and the cumulative change in the number of EEPROM component defects protected against induced overvoltages depending on the number of triggering of the electronic generator, respectively.

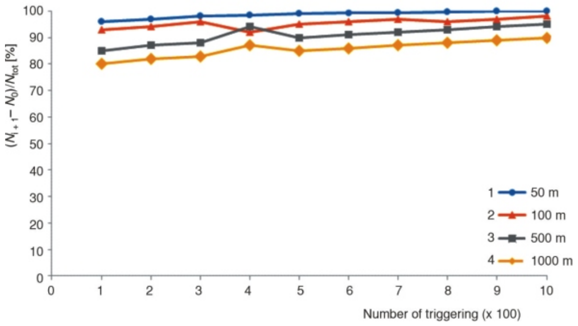

Figure 14. Cumulative change in the number of defects of EEPROM components unprotected from overvoltage depending on the number of triggering of the electronic generator (distance from the electronic generator)

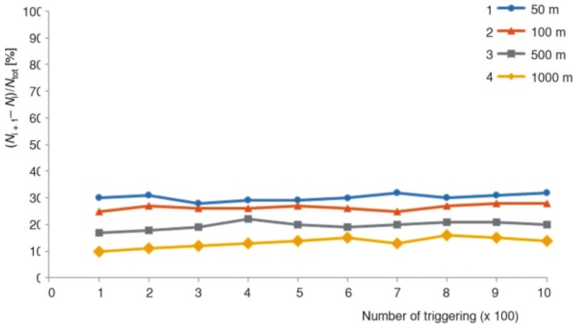

Figure 15. Differential change in the number of defects of EEPROM components protected against induced overvoltage depending on the number of triggering of the electronic generator (distance from the electronic generator)

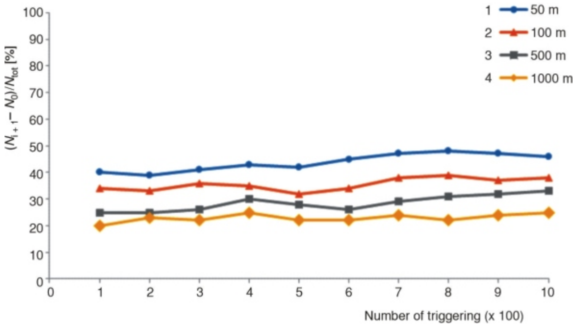

Figure 16. Cumulative change in the number of defects of EEPROM components protected against induced overvoltage depending on the number of triggering of the electronic generator (distance from the electronic generator)

Figures 15 and 16 depict that the protection against induced overvoltages of EEPROM components is more effective than the protection of EPROM components. EEPROM components with a protective hybrid circuit have a noticeably lower number of defects compared to the effect of radiation overvoltage for the same type of components. This result can be related to the frequency range of the applied filter which removes the frequencies to which the EEPROM component is most sensitive.

CONCLUSIONS

In the present study, it was proven in an exact way that ionizing and non-ionizing radiation destroys the record of relatively robust memory components (for this reason, components of older production were used). In addition, the miniaturization of memory components led to faster destruction of their contents under the influence of ionizing (gamma) and non-ionizing (fast electromagnetic field) radiation. It was concluded that a fast electromagnetic field leads to the destruction of the memory component due to the breakdown of the insulating layer SiO_2. Gamma radiation destroys the functioning of memory components by changing the microelectronic circuits in the gate, increasing the surface electron density. The changes caused by the effect of fast electromagnetic fields lead to physical destruction and the memory component can no longer be reprogrammed. Changes in memory components caused by gamma radiation can be reversed by UV radiation, after which they can be reprogrammed again. However, this reversibility after the effect of changes due to gamma radiation is of no practical importance. Since once the content of memory components is disturbed by ionizing radiation, it generally becomes the cause of irreparable damage.

It was established that moving away from the electronic generator reduces the differential effects of ionizing and non-ionizing radiation, but that the integral memory effect increases them and can bring them up to 100 % on an annual time scale. At the same time, in the case of the destructive effect of a fast electromagnetic field, the most sophisticated overvoltage protection enables a partial differential effect, but in a longer time (*e. g.*, several days), the protection effect is lost and the memory components lose all protection effects. The experiments with redundancy of memory components also did not yield useful results. Under normal conditions, moving away the tested components only prolongs the time of their functional and physical destruction.

By testing an electronic components and densely integrated electronic components, it is shown that there is a correlation between the increased degree of their miniaturization and non-resistance to ionizing and non-ionizing radiation. At an extreme degree of miniaturization, there is a reduced resistance to secondary cosmic radiation, which absolutely disqualifies them from application (unless they are made in high redundancy with logic OR and NOR gates, which cancels the miniaturization effect). Since these effects are expected in the vicinity of a fusion reactor model, it can be concluded that this source of energy, which is considered the definitive solution to energy problems, is dangerous from the aspect of electromagnetic contamination of the environment.

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AUTHORS' CONTRIBUTIONS

N. M. Kartalović gave the idea for the experiment which was carried out by U. D. Kovačević and D. P. Nikezić. A. R. Jusić analyzed the results and participated in preparation of the final version of the manuscript.

REFERENCES

[1] Cakar, N. D., *et al.*, Nuclear Energy Consumption, Nuclear Fusion Reactors and Environmental Quality: The Case of G7 Countries, *Nuclear Engineering and Technology, 54* (2022), 4, pp. 1301-1311

[2] McCracken, G., Stott, P., *Fusion – The Energy of the Universe*, Academic Press, Elsevier, Amsterdam, The Netherlands, 2nd ed, 2012

[3] Szewczak, K., Jednorog, S., Radiation Hazards in PF-1000 Plasma Generator Fusion Research (part 3), *J Radioanal Nucl Chem., 309* (2016), 3, pp. 1169-1174

[4] Vujisic, M., *et al.*, Gamma Irradiation Effects in Programmable Read Only Memories, *J. Phys. D: Appl. Phys., 40* (2007), 18, 5785

[5] Arandjelović, N., *et al.*, Comparison of Measurement Reliability of Nanosecond Rectangular Voltage Pulses by Kerr Effect and by High-Speed Voltage Probe, *Fusion Science and Technology, 78* (2022), 5, pp. 369-378

[6] Song, F., *et al.*, A Compact Low Jitter High Power Repetitive Long-Pulse Relativistic Electron Beam Source, Nuclear Inst. and Methods in Physics Research, A, Accelerators, Spectrometers, *Detectors and Associated Equipment, 919* (2019), Mar., pp. 56-63

[7] Osmokrović, P., *et al.*, Numerical and Experimental Design of Three-Electrode Spark Gap for Synthetic Test Circuits, *IEEE Transactions on Power Delivery, 9* (1994), 3, pp. 1444- 450

[8] Osmokrović, P., *et al.*, Mechanism of Electrical Breakdown of Gases for Pressures from 10^{-9} to 1 bar and Inter-Electrode Gaps from 0.1 mm to 0.5 mm, *Plasma Sources Science and Technology, 16* (2007), 3, pp. 643-655

[9] Osmokrović, P., *et al.*, Validity of the Space-Time Enlargement Law for Vacuum Breakdown, *Vacuum, 85* (2010), 2, pp. 221-230

[10] Rubel, M., Fusion Neutrons: Tritium Breeding and Impact On Wall Materials and Components of Diagnostic Systems, *Journal of Fusion Energy, 38* (2019), pp. 315-329

[11] Vasić, A., *et al.*, Aging of Solar Cells Under Working Conditions, *Journal of Optoelectronics and Advanced Materials, 9* (2007), 6, pp. 1843-1846

[12] Kartalović, N. M., *et al.*, Influence of the Synergy of Neutron and Gamma Radiation and Functional Aging

on the Efficiency of a Hybrid Protection Circuit, *Nucl Technol Radiat, 37* (2022), 3, pp. 201-206

[13] Arandjelović, N. M., e*t al.*, The Efficiency of Gas-Filled Surge Arresters in The Environment Contaminated by Non-Ionizing Radiation of Fusion Reactors, *Nucl Technol Radiat, 37* (2022), 1, pp. 51-56

[14] Vujisić, M., *et al*., Simulated Effects of Proton and Ion Beam Irradiation on Titanium Dioxide Memristors, *IEEE Transactions on Nuclear Science, 57* (2010), 4 PART 1, pp. 1798-1804

[15] Stanković, K., *et al*., Reliability of Semiconductor and Gas-Filled Diodes for Over-Voltage Protection Exposed to Ionizing Radiation, *Nucl Technol Radiat, 24* (2009), 2, pp. 132-137

[16] Lončar B., *et al.*, Radioactive Reliability of Programmable Memories, *Proceedings*, 13th International Conference On High-Power Particle Beams, BEAMS 2000, (2000), pp. 992- 995

[17] Vujisić, M., *et al*., Comparison of Gamma Ray Effects On EPROMS and E2PROMS, *Nucl Technol Radiat, 24* (2009), 1, pp. 61-67

[18] Stanković, K., Osmokrović, P., The Model for Calculating the Type a Measurement Uncertainty of GM Counters from the Aspect of Device Miniaturization, *IEEE Transactions on Nuclear Science, 61* (2014), 3, pp. 1316-1325

[19] Osmokrović, P., *et al*., The New Method of Determining Characteristics of Elements for Overvoltage Protection of Low-Voltage System, *IEEE Transactions on Instrumentation and Measurement, 55* (2006), 1, pp. 257-265

[20] Osmokrović, P., *et al*., The Influence of the Electric Field Shape on the Gas Breakdown under Low Pressure and Small Inter-Electrode Gap Conditions, *IEEE Transactions on Plasma Science, 33* (2005), 5 I, pp. 1677-1681

[21] ***, IEC TC 77 – Electromagnetic Compatibility, International Electrotechnical Commission, Geneva, Switzerland, 2022 https://www.iec.ch/dyn/www/f?p=103:7:::::FSP_ORG_ID:1265

[22] ***, Evaluation of measurement data - Guide to the expression of uncertainty in measurement, First edition September 2008, JCGM 100:2008, Joint Committee for Guides in Metrology, Pavillon de Breteuil, F-92312 Sèvres Cedex, France, 2008 https://www.bipm.org/documents/20126/2071204/JCGM_100_2008_E.pdf/cb0ef43f-baa5-11cf-3f85-4dcd86f77bd6

[23] Kovačević, A., *et al*., Evaluation of Measurement Uncertainty Using Mixed Distribution for Conducted Emission Measurements, Measurement: *Journal of the International Measurement Confederation, 44* (2011), 4, pp. 692-701

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УТИЦАЈ ЕЛЕКТРОМАГНЕТНОГ ЗАГАЂЕЊА ОД ГЕНЕРАТОРА ЕЛЕКТРОНСКОГ СНОПА И ВИСОКОЕНЕРГЕТСКОГ ИЗВОРА ЗРАЧЕЊА НА МЕМОРИЈСКЕ КОМПОНЕНТЕ

У раду се разматра утицај контаминације животне средине електромагнетним зрачењем, генератора електронског снопа и високоенергетског радиоактивног извора, на меморијске компоненте. Генератор електронског снопа може да се користи за убризгавање енергије честица у плазму фузионог система заснованог на Марксовом генератору, док радиоактивни извор као симулатор високоенергетског јонизујућег зрачења може бити изазван неутроном индукованом активацијом плазма околних структура или ослобођен из реакције фузије деутеријум-трицијум. Испитивани су ефекти гама зрачења, високоенергетског радиоактивног извора и електричног поља генератора електронског снопа, на ЕПРОМ и ЕЕПРОМ меморије рачунара. Намерно су изабрани старији типови меморија из разлога што их њихова робуснија израда боље штити од дејства јонизујућег и нејонизујућег зрачења. Резултати добијени под добро контролисаним условима показују висок степен неотпорности полупроводничке технологије на очекивано електромагнетно загађење генератора електронског снопа и високоенергетског радиоактивног извора. Добијени резултати доводе у сумњу могућност истовремене примене генератора електронског снопа, а самим тим и фузионих система и нанотехнологија са све већом потребом минијатуризације електронских компоненти.

Кључне речи: електромагнетно загађење, генератор електронског снопа, високоенергетски радиоактивни извор, меморијска компонента