INFLUENCE OF RADIATION EXPOURE ON THE PROPERTIES OF DIELECTRIC LAYERS BASED ON ANODIC ALUMINUM OXIDE

S. Biran, D. Korotkevich, A. Korotkevich, K. Garifov, A. Dashkevich
Belarusian State University of Informatics and Radioelectronics, 6 P. Brovki str., Minsk, Belarus

biran@bsuir.by

I. INTRODUCTION

Anodic aluminum oxide films are widely used in various fields such as biomedical, nanophotonics, microelectromechanical systems and aerospace industry. In space, electronic equipment is exposed to various types of radiation including electrons, protons, neutrons and heavy ions. Devices with a high degree of integration can be sensitive to natural radiation even at the surface of the Earth. Radiation can affect electronic equipment, degrading performance and resulting in loss of data. Degradation of characteristics occurs due to the formation of electron-hole pairs in the gate and insulating dielectrics. Anodic aluminum oxide film shows good resistance to radiation because captures a significant number of electrons, which compensate for hole traps. In addition, Al_2O_3 has several levels of traps in the band gap, which facilitates easy tunneling of electrons from the dielectric to the substrate [1]. Exposure by medium energy hydrogen and helium ions can lead to delamination of the anodic alumina film. Oxide delamination is caused by residual stresses resulting from oxide growth and irregularities in the substrate [2].The effect of radiation exposure on thin-film structures depends not only on the chemical composition of the films, but also on mechanical stresses at the interfaces. In order to increase the radiation resistance of thin-film structures based on Al_2O_3, it is necessary to improve the technology of forming the interface between layers.

II. EXPERIMENT

The study of the effect of radiation on the dielectric properties of anodic aluminum oxide films was carried out using capacitor structure in which aluminum base was used as the lower plate and sprayed contact pad as the upper plate. Aluminum 1 mm thick was used as a material for the test structures. Anodizing was carried out in a solution based on oxalic acid with constant stirring of the electrolyte in a galvanostatic mode. The electrolyte temperature was maintained at 15˚C. The thickness of the obtained anodic oxide films of aluminum was 60 µm. 1 µm thick aluminum film was deposited on the surface of the anodic aluminum oxide. Electric capacitance of the samples was measured using an R, L, C meter at a frequency of 1 MHz. The temperature dependence of alumina substrates was studied in a helium cryostat in the range from 4 to 300 K. After measuring the temperature dependence of the electrical capacitance of unirradiated samples, they were irradiated with α-particles with energy 5 MeV from source ^{239}Pu with dose $3,1 \cdot 10^{14}$ sm^{-2}. Measurement was repeated after irradiation. Temperature dependence electrical capacity of samples before and after irradiation presented on figure 1.

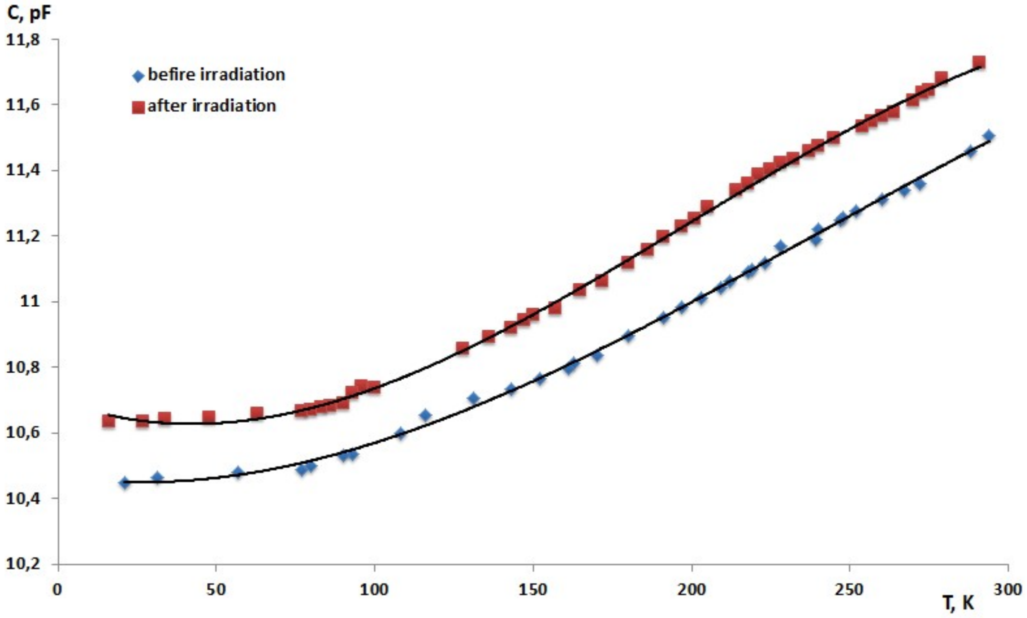

Figure 1. Temperature dependence electrical capacity of samples before and after irradiation with α-particles

III. CONCLUSIONS

Temperature dependence of the electrical capacitance for unirradiated and irradiated samples has the same form in the entire temperature range. This indicates the absence of any significant changes in the internal structure of the investigated dielectric layers. Quantitative differences in the capacity of unirradiated and irradiated samples are 2%, formation of radiation defects in a dielectric leads to a decrease in its dielectric constant. Taking into account the high ionizing ability of α-particles, their high energy, it can be concluded that capacitor structures are resistant to this radiation effect.

REFERENCES

[1] E. Harari, B.S.H. Royce, " Trap structure of pyrolytic Al2O3 in MOS capacitors " Appl. Phys. Lett., Vol. 22, pp. 106-107, 1973.

[2] Meng Li, De-Gang Xie, Evan Ma, Ju Li, Xi-Xiang Zhang, Zhi-Wei Shan " Effect of hydrogen on the integrity of aluminium–oxide interface at elevated temperatures", Nature Communications volume 8, Article number: 14564, 2017.