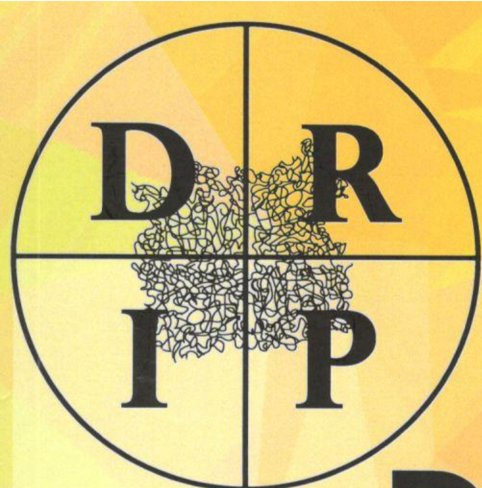

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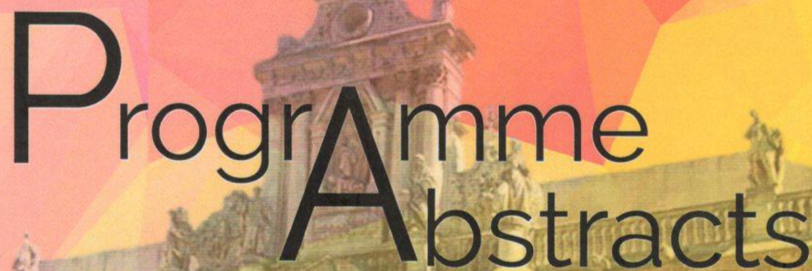

Programme Abstracts

Electrical characterization of defects created by γ-radiation in HfO_2-based MIS structures

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Advanced microelectronic devices are used in a variety of applications, and some of them are to work in harsh environments, such as space navigation, radiology equipment, instrumentation for nuclear energy plants and detectors for high-energy physics experiments. MOS transistors are often exposed to a flux of particles or photons, and the ionizing radiation effects can give rise to defects inside the insulator, which may degrade device performance and reduce lifetime [1].

In this work, we present an electrical study of the effect of gamma radiation on the electrical properties of $Ni/HfO_2/n^+$-Si MIS structures. These capacitors are to be used as resistive switching devices in ReRAM memories. The high-k gate insulator (hafnium oxide) thickness is 20 nm and it was deposited by atomic layer deposition (ALD) technique. The capacitors were subjected to a γ-ray (^{60}Co) irradiation using three different doses: 16 KGy, 96.6 KGy and 386.4 KGy.

One permanent effect due to the irradiation of the devices is a high number of defects inside the bulk insulator. High frequency capacitance-voltage characteristics were measured. Figure 1 (a) shows the flat-band voltage obtained as a function of the irradiation dose. In this case, the flat-band voltage values move towards lower values, indicating that γ-irradiation has given rise to positive charge inside the insulator. The hysteresis amplitude in C-V curves is shown in Figure 1 (b). The hysteresis amplitude increases with the irradiation dose, which means that radiation has created defects inside the HfO_2 insulator, which has also been observed in a previous work [2]. These defects can lead to instabilities in the devices and enhance the leakage current. In addition, we have observed higher flat-band voltage transients amplitudes for irradiated capacitors.

Figure 2 shows interfacial state densities (D_{it}). The density value increases when samples are irradiated. We observed this behavior for higher radiation doses (2.5 MGy) using electron irradiation, although it was not observed for doses of about 250 KGy [3].

Finally, the conduction mechanisms were studied. Figure 3 shows the current – voltage curves of the sample irradiated using the highest dose, measured at different temperatures, ranging from liquid nitrogen temperature and room temperature. The curves fit well to the defect assisted Poole-Frenkel mechanism, as we can see also in Figure 3, where the β_{PF} parameter values are also listed.

References

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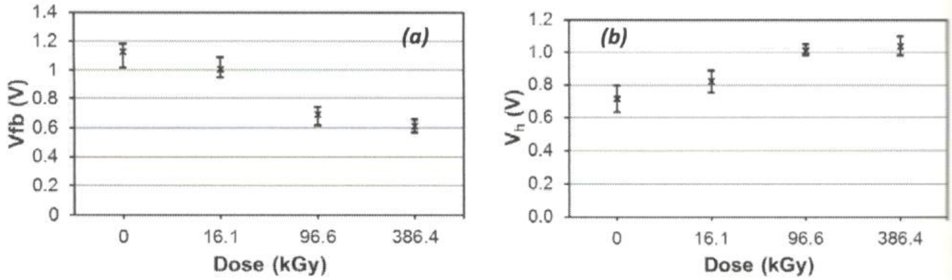

Figure 1. Flat-band voltage (a) and hysteresis amplitude (b) in high-frequency C-V curves as a function of the irradiation dose.

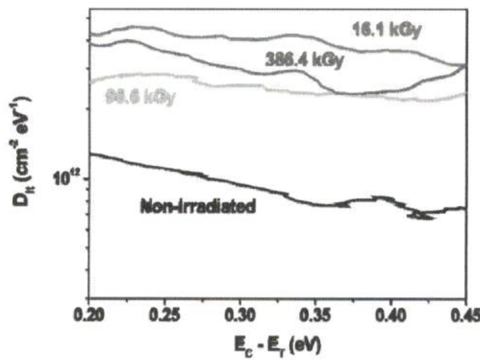

Figure 2. Interface state densities (D_{it}) measured by deep level transient spectroscopy (DLTS).

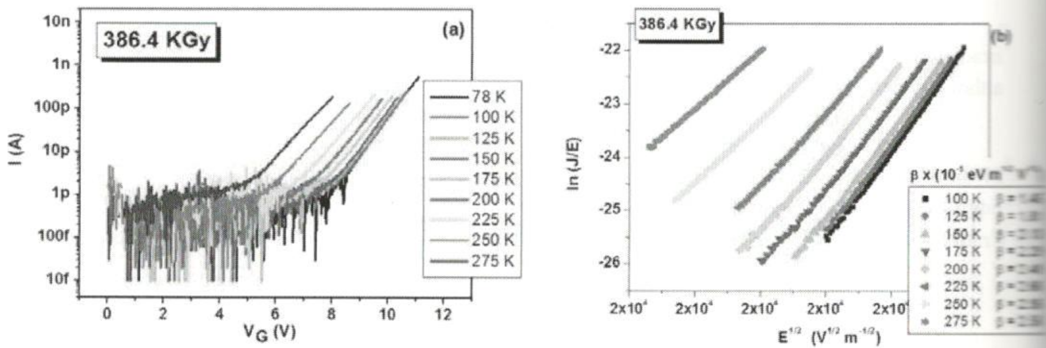

Figure 3. Current voltage characteristics measured at several temperatures (a) and Poole-Frenkel mechanism fit (b) of the sample irradiated with 386.4 KGy.