LOW DOSE RATE EFFECTS IN BIPOLAR DEVICES DURING LONG-TERM OPERATION SPACE ELECTRONIC SYSTEMS

Viacheslav PERSHENKOV*, Alexander BAKERENKOV, Vladislav FELITSYN, Alexander RODIN, Vitaliy TELETS, Vladimir BELYAKOV, Alexander ZHUKOV

National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe shosse, 31, Moscow, Russian Federation

*Corresponding author: Viacheslav Pershenkov, vspershenkov@mephi.ru

The maintenance of uninterrupted successful operation space system for navigation and investigation of different astronomic objective (planets, universes, nebulas) demands the development of on-board electronic systems which have possibility for long-term working in radiation ionizing space environments. During impact of the long-term radiation the two kinds low dose rate effects were observed: enhanced [1] and reduced [2] degradation of electrical characteristics of bipolar devices at the same total absorbed dose. It denotes as ELDRS (Enhanced Low Dose Rate Sensitivity) and RLDRS (Reduced Low Dose Rate Sensitivity). In given work the physical mechanisms of these low dose rate effects are considered. This kind of investigation can serve as the base for development of the testing methods for input control of bipolar microelectronic devices for on-board electronic system application.

Our approach is based on the conversion hydrogen-electron model of the SiO_2/Si interface traps buildup [3]. There are two types of traps located in the oxide near the silicon/dioxide interface—shallow traps (near conduction band border) and deep traps (near the middle of the forbidden gap). The probability of thermal excitation of the oxide positive center up to the conduction band depends on its energy depth in the oxide relative to the Si forbidden gap. The shallow oxide traps with energy near the conduction band are converted to interface traps in a short period of time and are responsible for the degradation at high dose rates, whereas the deep traps, whose energy levels are near the middle of the Si forbidden gap, require more time for conversion and determine the increase in excess base current under long-time irradiation, i.e., at low dose rates.

The case of ELDRS devices the acceptor-like traps are neutral while the donor-like traps are positively charged. The recombination rate of injected from emitter electrons connects with their capture on the positively charged traps with relatively large capture cross section (10^{-14} - 10^{-13} cm^{-2}). Therefore the excess base current is relatively large. The increasing of dose rate (the reducing of the irradiation time) leads to decreasing of the interface trap concentration and the excess base current reduces. For RLDRS devices the acceptor-like and donor-like traps are neutral. The recombination rate of injected from emitter electrons relatively small (capture cross section 10^{-15} cm^{-2}). For this reason at low dose rate irradiation the excess base current is relatively small in spite of all trapped oxide charges are converted to interface traps during long time irradiation. The increasing of dose rate (the reducing of the irradiation time) leads to increasing of the non converted trapped positive charge and the increasing of the excess base current.

Keywords: *interface traps, low dose rate, conversion model, bipolar device, ionizing radiation.*

References

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