SIMULATION OF RADIATION DAMAGE OF THE SEMICONDUCTOR DEVICES

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I. INTRODUCTION

Semiconductor devices are extensively used in many sectors of modern electronics. Operation under irradiation can be impossible through their high radiation sensitivity. To forecast their radiation hardness it is important to develop efficient models of radiation effects on semiconductors. In this paper, the model of integral *n-p-n* BJT operating in radiation environment is considered.

II. MODEL OF BJT RADIATION DEGRADATION

Bipolar junction transistors (BJT) are mostly affected by the accumulated defects in semiconductor lattice which are generated by high-energy particles. BJT operating characteristics such as the current gain and the output current decrease mostly as a result of the decrease of minority-carrier lifetime in the base [1].

Model of space-time evolution of minority charge carriers in BJT base includes the equation of continuity of electrons (in case of n-p-n BJT) [2]:

$$\frac{\partial n(x)}{\partial t} = -\frac{\Delta n(x)}{\tau_n(x)} + D_n(x)\frac{\partial^2 n(x)}{\partial x^2} - \mu_n E(x)\frac{\partial n(x)}{\partial x} - n(x)\mu_n\frac{\partial E(x)}{\partial x}, \quad (1)$$

where n is concentration of non-equilibrium (minor) electrons, τ_n is lifetime, Δn is difference between the concentrations of non-equilibrium and equilibrium electrons, $D_n(x)$ is diffusion coefficient, μ_n is mobility, $E(x)$ is intensity of electric field induced by the impurity uneven distribution in the base.

The electron lifetime dependence on the radiation dose is defined as [3]:

$$\frac{1}{\tau_{\Phi}} = \frac{1}{\tau_0} + k_{\tau}\Phi \quad , \tag{2}$$

where τ_0 is the initial lifetime, τ_{Φ} is the irradiated lifetime, Φ is the absorbed radiation dose, k_{τ} is the radiation factor depended on the type and energy of radiation. In [2], k_{τ} is calculated for the 0.2 – 5 MeV electron and 1.4 MeV neutron radiation.

The model details, difference approximation of (1), border conditions and numerical solution [4] are presented in [5]. The software (Fig. 1) was developed. Results are shown in Fig. 2 - 3.

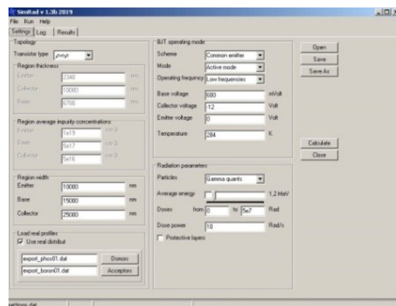

Figure 1. Control panel

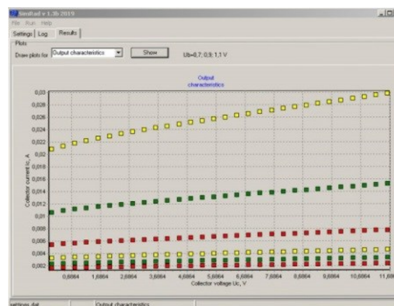

Figure 2. Output characteristics

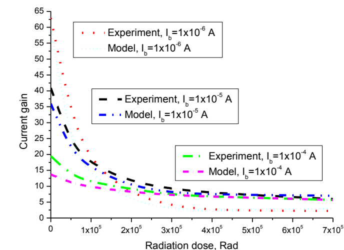

Figure 3. Current gain

III. CONCLUSIONS

Calculated results demonstrate the significant fall of BJT characteristics that is confirmed experimentally.

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