Research Article

Zhanhan Hu*, Danaysa Macías Hernández, and Silega Nemuri Martinez

Analysis of radiation effects of semiconductor devices based on numerical simulation Fermi–Dirac

Abstract: To study the radiation effect of Fermi–Dirac (F–D) semiconductor devices based on numerical simulation, two methods are used. One is based on the combination of F–D statistical method and computer simulation. The method discusses the influence of temperature and light energy on the carrier number by starting from an intrinsic silicon semiconductor and carries out computer simulation on the carrier number in intrinsic silicon semiconductor. TID Sim, a three-dimensional parallel solver for ionizing radiation effects of semiconductor devices, is developed. The ionization radiation damage of typical metal oxide semiconductor (MOS) FET NMOS and bipolar transistor GLPNP is simulated. It was proved that the variation trend was close to a straight line in the temperature range (278–358 K) studied in this article. The results are consistent with those of the statistical distribution of semiconductor carriers. This method is suitable for calculating the number of semiconductor carriers, and it is an effective method to study the problems related to carrier distribution.

Keywords: F–D statistical method, semiconductor, radiation effect

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1 Introduction

Metal oxide semiconductor (MOS) will degrade its performance parameters when exposed to high-energy ionizing radiation; the typical phenomena are threshold voltage drift and off-state leakage current increase. This is a long-term effect; that is, the phenomenon of effect cannot be eliminated after the device is powered off [1]. The cause of the long-term radiation effect of MOS devices is the formation of trapped charges that are difficult to move in the gate oxide or isolation oxide; this makes the channel surface form an inversion or a leakage path between the source and the drain when no bias is applied. Therefore, the generation of trapped charges, the transport, and final distribution have an important influence on the long-term effect of the device [2]. The Monte Carlo method and the coupling method of the finite volume method are used to simulate the long-term radiation effect caused by the oxide trap charge in the MOS tube. Using the Monte Carlo method to track the random transport process of incident particles, the ionization energy deposition distribution can be obtained, and this distribution is coupled to the drift-diffusion model equation as a source term [3]. To discretize the governing equation using the finite volume method and solve the Poisson equation in gate oxide and silicon together, the carrier continuity equation and the trapping rate equation of gate oxide, in this way, the threshold voltage drift and off-state leakage current of a typical MOS tube after being irradiated can be calculated. Gamma irradiation is a key environmental factor that causes the performance degradation and even permanent failure of satellite electronic systems. There are two basic effects of semiconductor device ionization radiation damage: Total ionizing dose effect, that is, the damage of the device, increases cumulatively with the increase in the total radiation dose, and the enhanced low dose rate effect (enhanced low dose rate sensitivity [ELDRS] effect) [3]. That is, under the condition of a fixed total radiation dose, the damage to

Numerical Analysis For Semiconductor Devices

RD Boyd

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