decrease of upset cross section of angled ion strikes is attributed to the edge effect. When a particlestrikes at the edge of sensitive volume withatitled angle, the pathlength in the sensitive volume is decreased. This-results in the deposited charges decrease. Theedge effect is more obviouswith the angle increasing.

In conclusion, the experiment result reveals that the SEU cross section obtained by angled incidenceis underestimated. So it is necessary and important to furthercorrect the SEU cross section of titled incidence on SOI SRAM.

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3 - 34 Effects of Heavy Ion Accumulated Dose Irradiation on Single Event Upset Sensitivity

Gu Song, Liu Jie, Zhang Zhangang, Zhao Fazhan, Liu Tianqi, Sun Toumei, Hou Mingdong Geng Chao, Xi Kai, Yao Huijun and Luo Jie

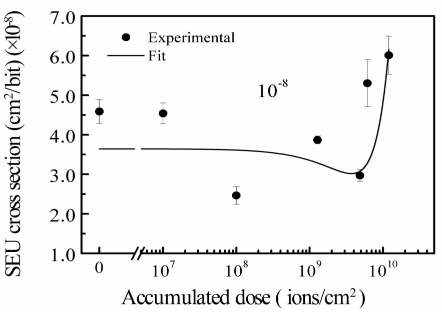

Fig. 1 SEU cross section as a function of ^{112}Sn irradiation accumulated dose. The error bars represent the standard deviation.

At space, large dose gamma and proton irradiation produce interface states and trapped charges in the device's gate oxide[1]. Interface states and trapped charges will alter the electrical characters of the device, such as the threshold-voltage shifts, leakage current increase and so on. Those phenomena are commonly referred to as total ionizing dose (TID) effects. On the other hand, heavy ion irradiation mainly produces single event effects (SEE) through direct ionization on devices. For example, single event upset (SEU), one of the SEE, is very common in SRAM, which seriously threaten device reliability in orbit. The synergistic effects of total ionizing dose on SEU sensitive in SRAM has also been investigated[2-3]. However, the synergistic effects appears two opposite trends at different type devices[4]. No rigorous explanation for this phenomenon was given, and it is also not clear that heavy ion accumulated dose exposure effects SEU sensitivity in SOI SRAM. Therefore, an experimental investigation about the synergistic effects of the heavy ion accumulated dose on SEU sensitive in SOI SRAM was performed.

In this experiment, the previous heavy ion accumulated dose irradiation and SEU testing were carried out using the initial energy 3.7 MeV/u^{112}Sn beam from the HIRFL facility. The SOI SRAM including 1Mb (128 k×8 bit) was exposed to a series of dose level with a power supply bias of 5 V and subsequently subjected to identical tests for SEU cross section. The experiment was conducted in the vacuum and at room temperature.

The experiment result that SEU cross section changes with ^{112}Sn accumulated dose is shown in Fig 1. It is clear that the SEU cross section remains unchanged at less than 1×10^7 ions/cm^2, decreases with the accumulated dose increased, and increases at 5×10^9 ions/cm^2 accumulated dose. The reason for this phenomenon is discussed below. When the heavy ion accumulated dose is at low of 1×10^7 ions/cm^2, few ions strike at the gate oxide areas. Hence, the low dose irradiation doesn't affect the SEU cross section. With the accumulated dose increased, the SEU cross section decrease is attributed to the memory imprint effects[3]. But when the accumulated dose approaches to 5×10^9 ions/cm^2, increased leakage currents decreases the critical charge for upset[4], which leads to the increase of SEU cross section. In conclusion, the sensitivity of single event upset is impacted by heavy ion accumulated dose.

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3 - 35 Large Dispersion of Deposited Energy in Devices with Different Active Film Thicknesses

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Hou Mingdong and Sun Youmei

The Linear Energy Transfer (LET) is known as an average metric to study Single Event Effects (SEE) in electronic devices, characterizing a given ion beam. Yet because of the stochastic nature of particle-matter interactions, each incident particle has a different path though matter and thus deposits a different amount of energy in the sensitive volume of a device. That brings an error source to the experimental data, in which LET is used as a main parameter, ignoring this intrinsic dispersion of deposited energy. As technology scaling, devices are becoming more and more sensitive to this dispersion phenomenon. By using Geant4[1] Monte Carlo simulation, we investigated the dispersion in deposited energy as a function of sensitive silicon film thickness. During the simulation, 25 MeV/u krypton and 9.5 MeV/u bismuth ions, which are most commonly used in the SEE experiments performed at HIRFL, were chosen to incident in devices with three different silicon film thicknesses: 17 μm, 0.8 μm and 150 nm. For each ion, the charge it induced in the sensitive volume was recorded and analyzed.

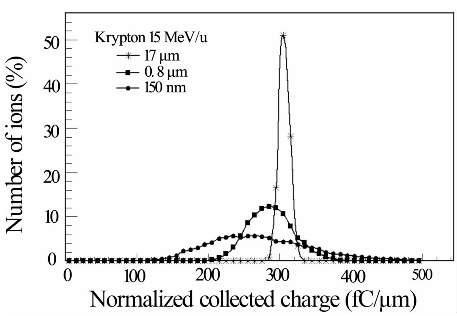

Fig. 1 Simulated number of ions as a function of the deposited charge, normalized to the silicon film thickness, for 25 MeV/u krypton ions in devices with different silicon film thicknesses.

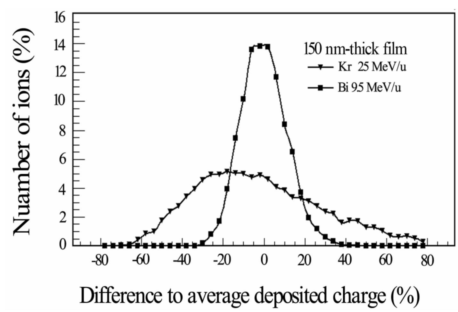

Fig. 2 Proportion of ions as a function of the difference of their normalized deposited charge value to the average value of the distribution for the 25 MeV/u Kr and 9.5 MeV/u Bi ions.

Fig. 1 shows the simulated number of ions as a function of charge, normalized to the silicon film thickness, induced by the energy the ion deposited in the sensitive volume. The simulated trends are consistent with the experimental observation in[2]. Since the LET increases with the decrease of the ion energy while it penetrates matter, the thinner the silicon film, the smaller the value of the average deposited charge per micrometer. As shown in Fig. 1, the energy dispersion, marked by the variation taken at half maximum, clearly increases with decreasing silicon film thickness, starting from a variation of ±1% for the 17 μm thick film up to ±50% for the 150 nm one. The variability in deposited energy is directly related to the stochastic scattering mechanisms of ions in matter. In a thick film, scattering events are obviously more numerous and thus smoothing out the variations in total deposited energy. Therefore, the dispersion phenomenon should be considered especially in devices with thin sensitive volumes.

The dispersion of deposited energy induced by 9.5 MeV/u bismuth ions is smaller than that induced by 25 MeV/u krypton ions when they are penetrating a device with a 150 nm thick active film. Fig. 2 shows the number of ions as a function of the absolute difference to the mean value of the generated charge. For 9.5 MeV/u bismuth ions, the difference to the average value is around ±20%. The average