SER/ALPEN Analysis System for Future Memories Technology

T.H.Kim, I.C.Kim, B.H.Rho,K.Y.Lee, C.G.Hwang, D.Chin and Y.E.Park

R & D Center, Sam-Sung Electronics
San#24 NongSeo-Lee, KiHung-Eup, YongIn-Gun, KyungKi-Do, Korea

1. Introduction

As a density of integrated circuits increases, device reliability induced by alpha particles emitted from plastic package has been issued. The ALPEN(alpha particle induced source/drain penetration) effect[1] is observed in MOSFET as the effective channel length(Leff) becomes below 0.4 um. Also it is reported that SER cannot be significant as the space between adjacent cells decreases down to 1um due to proximity effect[2]. However we observe serious SER problem as the space between n+ regions decreases below 0.6um down to 0.3um.

This paper describes 1) a systematic TCAD system to analyze the alpha particle induced device reliability and 2) simulation results for ASER and ALFEN using scaled cell and transistor structure for future memory products, respectively.

2. Integrated SER/ALPEN simulator

Fig. 1 shows an integrated SER/ALPEN modeling the alpha particle induced device reliability. MCASYS is a multi-channel analyzer system which determines the energy distribution of alpha particles emitted from radioisotope of Th-230 and Am-241. Fig. 2 shows the energy spectrum of alpha particles from Th-230, which discrete energies in energy spectrum will be used to simulate SER/ALPEN. EHPGEN is an enhanced Monte-Carlo simulator based on the TRiM-85[3] which determines the distribution of electron-hole pairs generated by alpha particle injected into silicon substrate. SINTERF receives SUPREM-4 data and generates the optimal and extensible geometry for SER/ALPEN simulation. SERMOD is a two-dimensional device simulator which calculates the amount of inflow or outflow of carriers through the electrodes as a function of time. Mathematical formulation of SERMOD is based on the drift-diffusion equation.

3. Results and Conclusion

Measurement and simulation results for transistor and cell structure of future memory products (from 16M DRAM to 256M DRAM) are discussed based on ALPEN and SER effects, respectively. Fig. 3a shows a structure of covered nMOS LDD(CLDD) device which can be used for 256M DRAM and Fig. 3b is surface plot of a doping profile obtained from SUPREM-4. Fig. 4 shows the Vds - Ids characteristics of CLDD with Lgate = 0.25um measured with HP4145B. The incidence of alpha particle increases the leakage current level by 3 orders of magnitude compared to leakage current level without alpha particle as shown in Fig. 4. However the punchthrough effect has not been observed for new optimized 0.25um drain structure(CLDD). This phenomena can be explained by comparing simulation results for CLDD and conventional LDD devices. In the CLDD structure, charges collected from each electrode are effectively reduced by introducing energy barrier from covered implantation as shown in Fig. 3. However, charges on source electrode causes punchthrough in the conventional LDD structure with ever larger gate length(Lgate=0.6um).

Fig. 6 is a simulation geometry to analyze the cell mode ASER for various design rules. Fig.7 shows the simulation results of charges collected at electrode A and C varying V_B as a function of space when alpha particle of the 217KeV is incident on the electrode A. As the space between n+ regions is reduced, charges collected on electrode A and C are significantly increased due to punchthrough in the bulk with Vc equal to 0V. The charges collected at each electrode for Vc equal to 3.3Vare significantly decreased compared to those with Vc = 0V. The significant collected charges are observed as the design rule of cell structure decreases from 0.6um to 0.3um as shown in Fig. 7 for several substrate bias conditions. In conclusion, the transistor and cell structure are key issues to improve SER/ALPEN effect for future high density memory.

Simulation for a sample ALPEN (with 2450 grid points) and a cell mode ASER (with 4900 grid points) are spent about 3 CPU hours and 2.5 CPU hours on the IBM-RiOS 6000/540 workstation respectively.

4. Acknowledgment

The authors wish to express their appreciation to Ph.D. Y.W.Hwang for measuring the Th-230 energy spectrum.

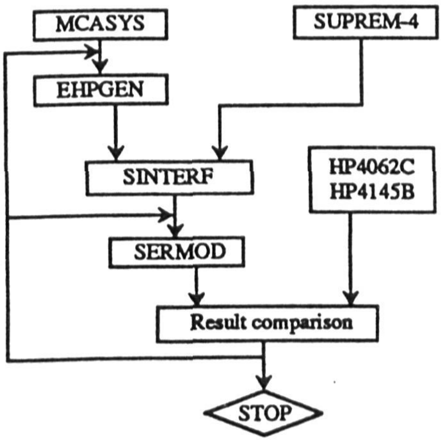


Fig. 1. Block diagram of SERMOD system.

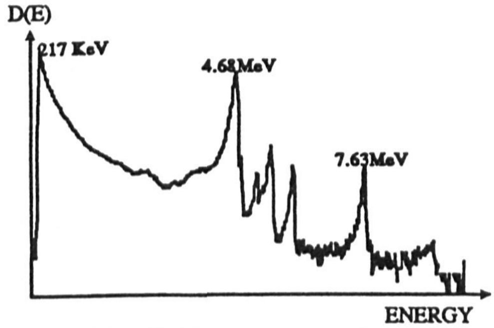


Fig. 2. Th230 Energy spectrum in vaccum measured with MCASYS.

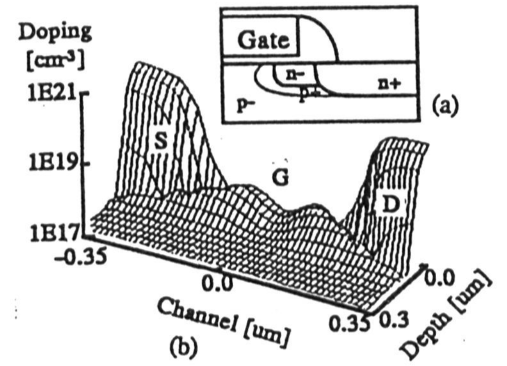


Fig.3. a) A structure of Covered nMOS LDD
b) Surface plot of a doping profile obtained from SUPREM-4.

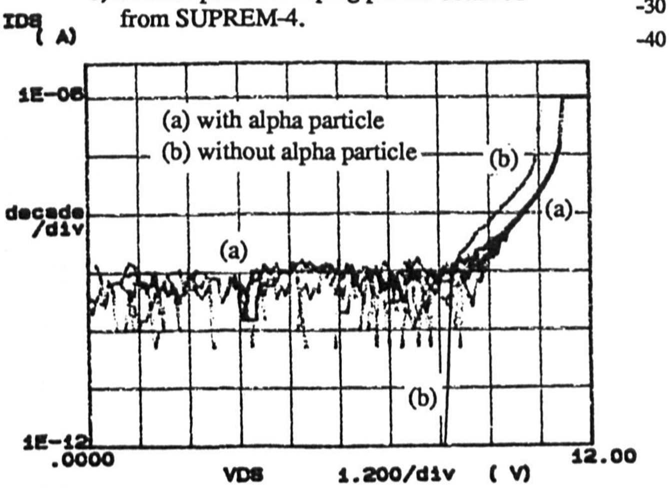


Fig. 4. V_{DS} - I_{DS} characterististics of CLDD with Lgate=0.25 um measured with HP-4145B.

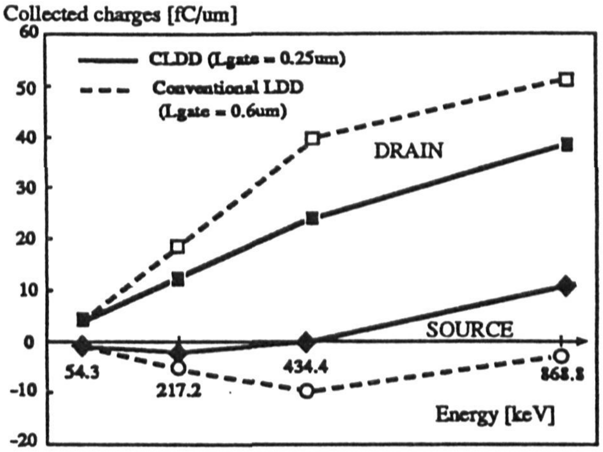


Fig. 5. Charges collected at drain and source electrode as a function of alpha particles energy.

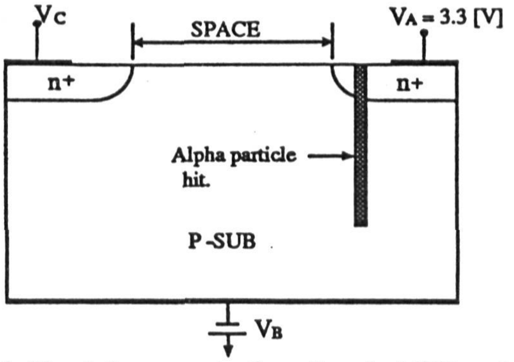
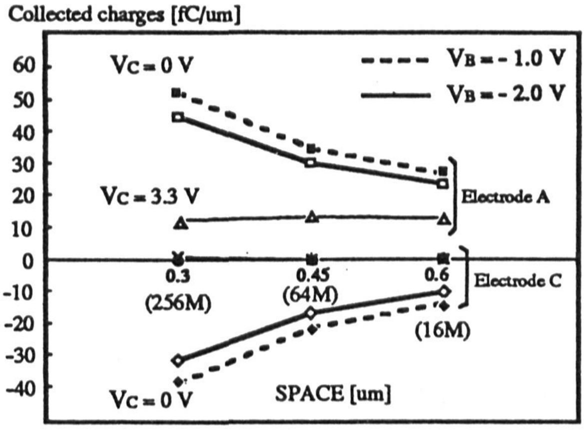


Fig. 6. Simulation geometry for cell mode ASER analysis.



	V_B = - 1.0		V_B = - 2.0	
Vc	0	3.3	0	3.3
Electrode A	■	▲	□	△
Electrode C	◆	●	◇	×

Fig. 7. Charges collected at electrode A and C varying V_B as a function of space. Alpha particle energy is 217 KeV.

References

[1] E. Taketa, at al., " A new soft-error phenomenon in VLSIs - The alpha particle induced source/drain penetration (ALPEN) effect", SSDM, 1988

[2] E. Taketa, at al., "Key factor in reducing soft error in mega-bit DRAMS -- Funneling and Scalability", IEEE/IRPS, p207, 1987

[3] J. F. Ziegler, "The stopping and range of ions in silicon", 1985