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Self-interstitial generation model at the SiO_2/Si interface

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Process simulators now widely used have not reached a level of sophistication which allows us to predict multi-dimensional dopant profiles, especially, in submicron devices because understanding of the underlying physical processes is still insufficient. In this paper, as one of such examples, we show unexpected experimental results which can not be explained by a widely used model.

(1) Experimental procedures and results

The CZ (100) wafers were implanted with boron at a dose of $1x10^{14}/cm^2$, at an energy of 80 KeV to introduce OSF nucleis. The wafers were oxidized at 1000 ℃ for 60 min. in dry oxygen ambient to grow OSF of 0.5 μm. Nitride film was deposited on the oxide and subsequently was photolithographically patterned into parallel stripes running across the wafer. Then, oxidation was carried out at temperatures in the range of 1050 - 1150 ℃ in wet oxygen ambients. The oxide was then etched off in buffered HF, and stacking fault features were revealed.

Figure 1 shows OSF's grown at the Si/SiO_2 interface near the edge of silicon nitride mask. The OSF length measured is plotted as a function of the distance from the oxidation mask edge in Fig. 2, which shows that OSF length decreases sharply with distance from the oxidation mask edge.

(2) Discussion

In a structure partially covered by nitride film, the self-interstitials generated at the oxidizing interface are expected to flow vertically into the substrate as well as laterally into the areas adjacent to the nonoxidized region. Consequently, the self-interstitial distribution is two-dimensional nature. By using the diffusion equation and self-interstitial generation model proposed by Hu[1)], we calculated the excess self-interstitial distribution at the interface as shown in Figure 3. By comparing experimental and theoretical results, we found that the best fit curve is in good agreement with the experimental data only for the OSF's of 1 um apart from the nitride mask edge (At each location, only maximum OSF length has physical meaning[2)]). Large discrepancy between the experimental and simulated results is observed in the oxidized region near the edge of the nitride mask. This indicates that the model now widely used in 2-D process simulation fails to explain the experimental results: The model predicts that the generated self-interstitials at the oxidizing interface adjacent to the nonoxidized region diffuse vertically as well as laterally into the bulk silicon so that the self-interstitial concentration should appreciably decrease near the edge of nitride mask. The experimental results reveals that the self-interstitial concentration at the oxidizing interface is uniquely determined by the oxidation rate regardless of the location of the nitride mask edge. While, at the non-oxidized interface, the flow of self-interstitials into Si/SiO_2 interface is proportional to the concentration of self-interstitials at the interface: The two boundary conditions described above should be used for the simulation of two-dimensional dopant diffusion.

References
1)S.M.Hu, Appl. Phys. Lett., 43, 449 (1983)
2)K.Taniguchi and D.A.Antoniadis, Appl. Phys.Lett.,42, 961 (1983)

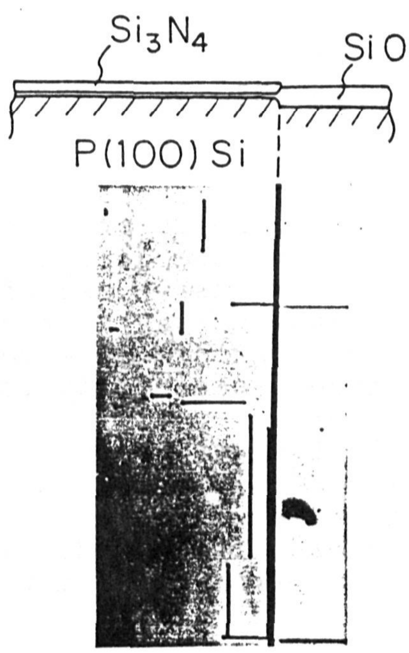

Figure 1 OSF's near the edge of silicon nitride mask.

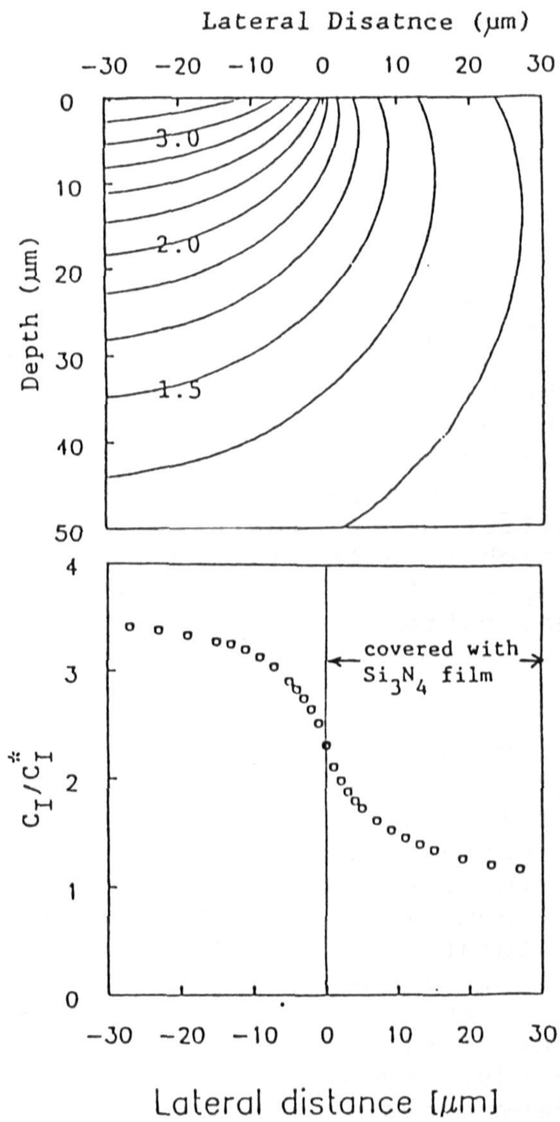

Figure 3 Excess self-interstitial concentration at the interface.

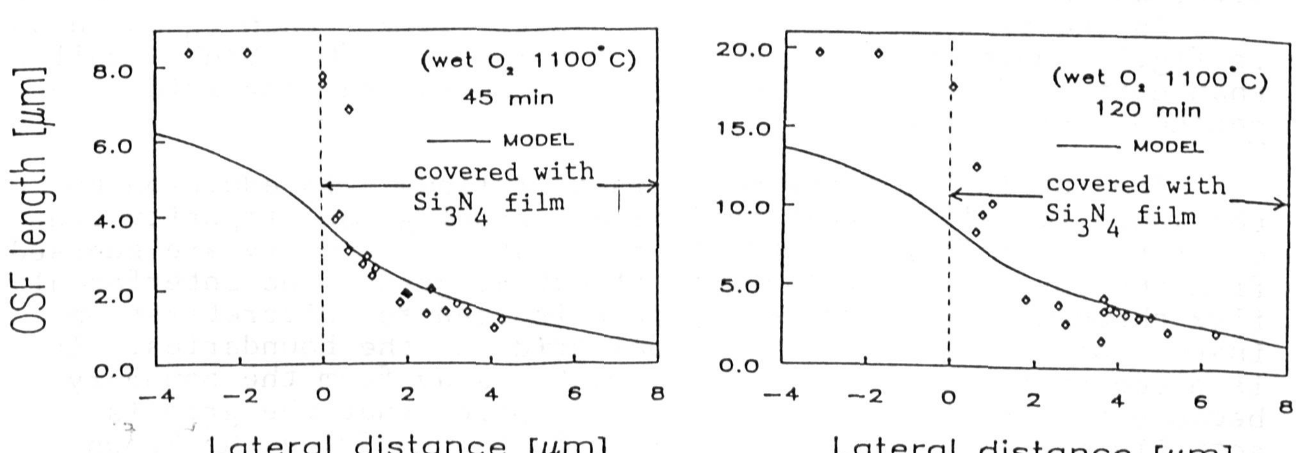

Figure 2 OSF length vs. lateral distance from nitride mask edge: (a) 45 min. and (b) 120 min. oxidation.