

Advanced Defect Engineering in Pre-amorphized Si Substrate with Laser Pre-Irradiation Optimization

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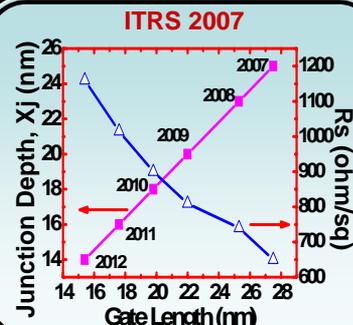
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Introduction

In nano-scale dimensions, defect engineering techniques becomes significant to realize highly activated ultra-shallow junctions.

Laser pre-irradiation on Si substrate is reported to generate excess vacancies at the maximum depth.[1] This excess laser induced vacancies can be engineered to annihilate the end-of-range (EOR) defects that are created inevitably by the pre-amorphization implant (PAI).[2] These EOR defects release excess Si interstitials that causes dopant deactivation and B enhanced diffusion.

In this study, we perform excimer laser pre-irradiation on Si substrate prior to the Si⁺ PAI and B implant. The effects of vacancies generated by pre-irradiated laser on dopant diffusion and activation in pre-amorphized silicon substrate are reported.



Results

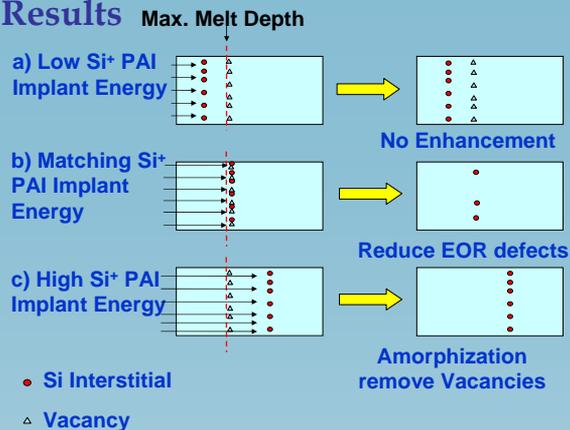


Fig. 1: Schematics showing the mechanism associated with the interaction of [V] with the free [I] from the EOR defects. The PAI depth of the Si⁺ interstitials (a) is shallower than the max. laser melt depth. (b) coincides near the region of the max laser melt depth. (c) falls beyond much deeper than the max. laser melt depth.

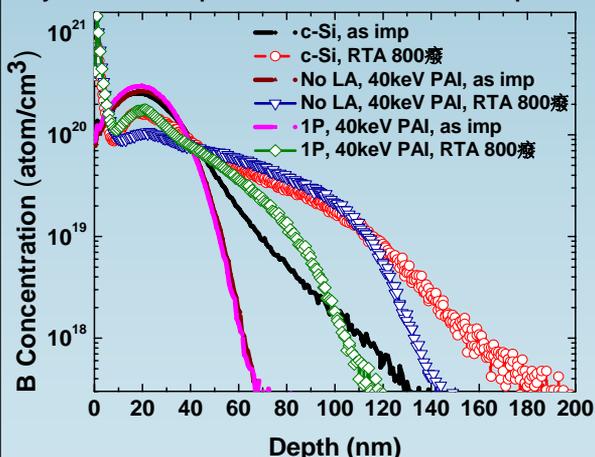


Fig. 2: B SIMS profile of c-Si and 40 keV PAI Si both subjected to laser pre-irradiation and without, followed by RTA of 800°C for 60s.

Summary

By matching the pre-irradiated laser melt-depth with the PAI depth, the laser induced vacancies will recombine with the excess Si interstitials created by the PAI, reducing the excess Si self-interstitials from the EOR defect band.

With the reduction of the EOR defects, highly activated and shallow junction profiles can thus, be obtained.

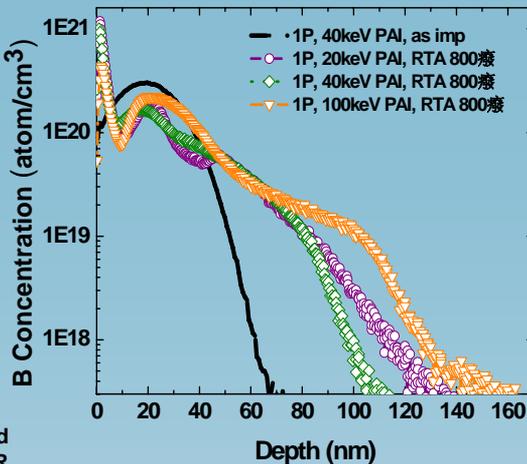


Fig. 3: B SIMS profile in the single-pulse 0.72 J/cm² laser pre-irradiated Si, subjected to various Si⁺ PAI energies of 20 keV, 40 keV and 100 keV, followed by RTA of 800°C for 60s.

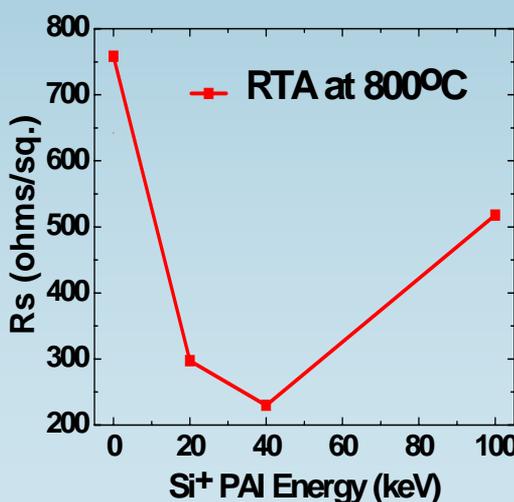


Fig. 4: Plot of R_s against the Si⁺ PAI energies.

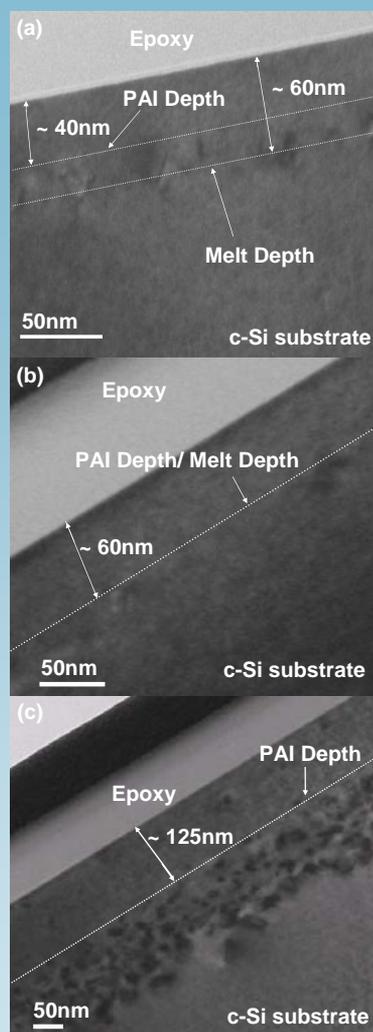


Fig. 5: XTEM showing EOR Defects for (a) 20 keV, (b) 40 keV and (c) 100 keV PAI conditions.

References

- [1] G. Mannino, V. Privitera, A. L. Magna, E. Rimini, E. Napolitani, G. Fortunato, and L. Mariucci, "Depth Distribution of B implanted in Si after Excimer Laser Irradiation", Appl. Phys. Lett., vol. 86, 051909 (2005).
- [2] D. X. M. Tan, K. L. Pey, K. K. Ong, B. Colombeau, C. M. Ng, S. H. Yeong, A. T. S. Wee, C. J. Liu, and X. C. Wang, "Vacancy Engineering by Optimized Laser Irradiation in Boron-Doped, Pre-amorphized Silicon Substrate", Appl. Phys. Lett., vol 92, 2 (2008).