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Optimization of STI bottom corner rounding by In-situ Steam Generation process in 50nm device

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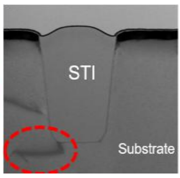
Introduction

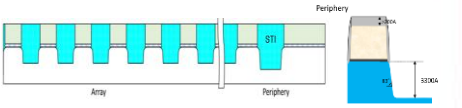
Ensuring the smoothness of the bottom corners of the STI area is of great significance for the device. The bottom sharp corners can lead to excessive concentration of local stress, causing silicon dislocations in the substrate.



- ISSG is by combining hydrogen (H2) and oxygen (O2) in the process chamber at high temperatures and low pressures, a mix of water vapor, OH radicals, O radicals and other species is formed at the wafer surface.
- This paper explores the method of of achieving improved bottom rounded corners while maintaining the roundness of the top corners through the adjustment of ISSG process parameters. The results show that a high proportion of hydrogen significantly improves the bottom rounded corners, but is not beneficial for the top rounded corners.

Methodology

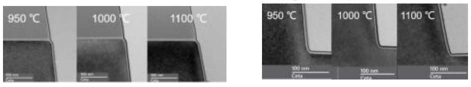
- Use 50nm NOR-flash memory device STI structure wafer.
- After STI etch, the wafer then processed in an Applied Materials Radiance Plus 300mm Centura RTP chamber with ISSG process to grow STI liner oxide.
- TEM was used to analyze the morphology of the STI corner.



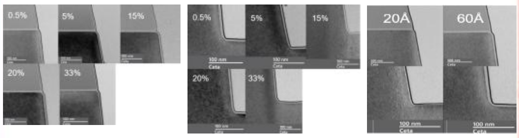
Condition	Temperature (°C)	H_2 Ratio(%)	Thickness(Å)
Baseline	1100	5	60
A	1000	5	60
B	950	5	60
C	1100	0.5	60
D	1100	15	60
E	1100	20	60
F	1100	33	60
G	1100	0.5	20

Result & Discussion

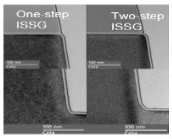
- **Temperature:** A higher temperature will make a more rounded top corner, but lead to facet formation of bottom corner. Such faceting at the bottom corner may induce dislocation formation under the stress from subsequent layers



- **H_2 Ratio:** An excessively high H_2 ratio will cause a depression at the top corner, but it is beneficial for the bottom corner.



- **Oxide Thickness:** A thinner liner oxide layer is unfavorable for the top corner but can suppress interfacial faceting of the bottom corner even under hydrogen-lean conditions.
- **Sacrificial Oxide Layer:** Two-step ISSG process maintains favorable rounding at both the top and bottom corners, whereas the one-step process leads to a slight depression at the top corner.



Summary

1. A higher temperature improves the rounding of the top corner but degrade that of the bottom corner.
2. A higher H_2 ratio helps suppress faceting at the bottom corner yet may induce depression at the top corner.
3. Increasing the oxide thickness improves the top corner profile but adversely affects the bottom corner morphology.

- An optimized process combining a high temperature of 1100 °C, an H_2 ratio above 20%, and a two-step ISSG approach is proposed, which achieves well-rounded profiles at both the top and bottom corners.