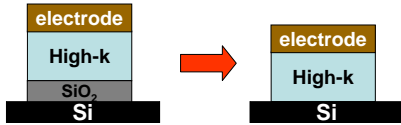


Effect of Rare Earth Oxide Capping for La-based Gate Oxides

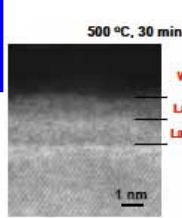
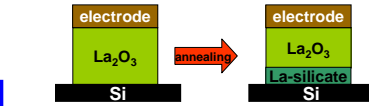
T. Kaneda¹, M. Kouda¹, K. Kakushima², P. Ahmet¹, K. Tsutsui², A. Nishiyama², N. Sugii²,
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Back ground

To achieve an EOT below 1 nm, high-k gate insulators should be directly in contact with the Si substrate.



No SiO₂ interfacial layer



La-silicate is also high-k material

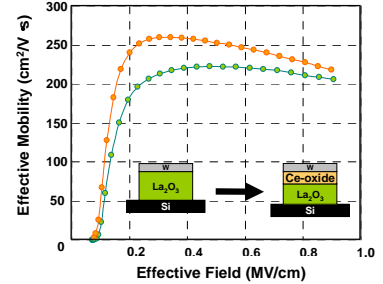
High-k/Si-substrate direct contact is achieved

La-silicate : dielectric constant = 9~12

→ EOT~0.5nm physical thickness is so thin

→ Electrical properties were degraded

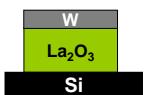
Capping a thin Ce-oxide layer on a La₂O₃ gate dielectric



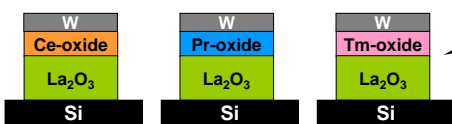
Electrical characteristics were improved

Purpose of this work

Examined the effects of rare-earth oxide as a capping material to further scale La₂O₃ dielectrics toward 0.5 nm in EOT.



La₂O₃ material is base layer
CeO_x, PrO_x, TmO_x capped on
La₂O₃ gate dielectric

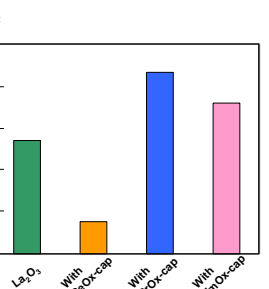
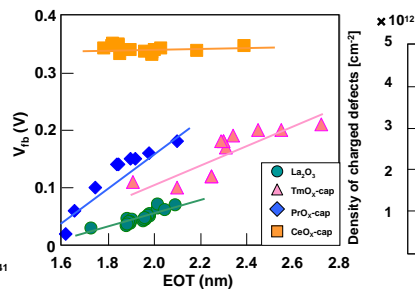
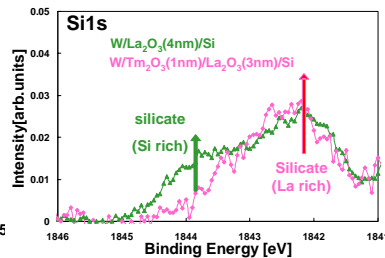
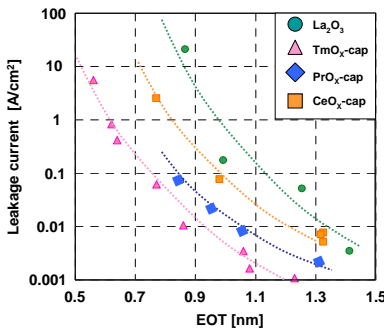


Rare-earth material capping

Fabrication of device

- n-type Si substrate (MOS capacitor)
p-type Si substrate (MOSFET)
 - SPM, HF last treatment
 - High-k materials deposition (La₂O₃, Ce-oxide, Pr-oxide, Tm-oxide)
 - Tungsten (W) metal gate electrode deposition by RF sputtering
 - PMA (Post Metallization Annealing) 500 30min (FG:3%H₂)
 - Source, Drain Al interconnection
 - Bottom electrode Al deposition
- In situ*
-

Result and discussion



Leakage current can be suppressed with rare-earth oxide capping, especially, with Tm-oxide

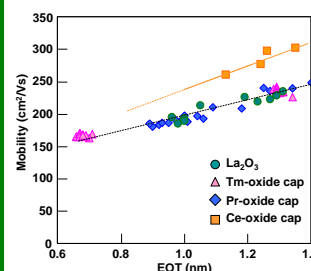
Formation of the silicate layer can be suppressed by XPS Si1s spectrum

Achieving a higher overall dielectric constant after annealing

Further device-scaling was achieved

The density of charged defects in the film was reduced only with Ce-oxide capping

Conclusion



Ce-oxide cap

charged defects reduction

→ Improvement of mobility

Tm-oxide cap

Higher dielectric constant

→ Small EOT was achieved