Special Topics on Basic EECS I Design Technology Co-Optimization

Lecture 10

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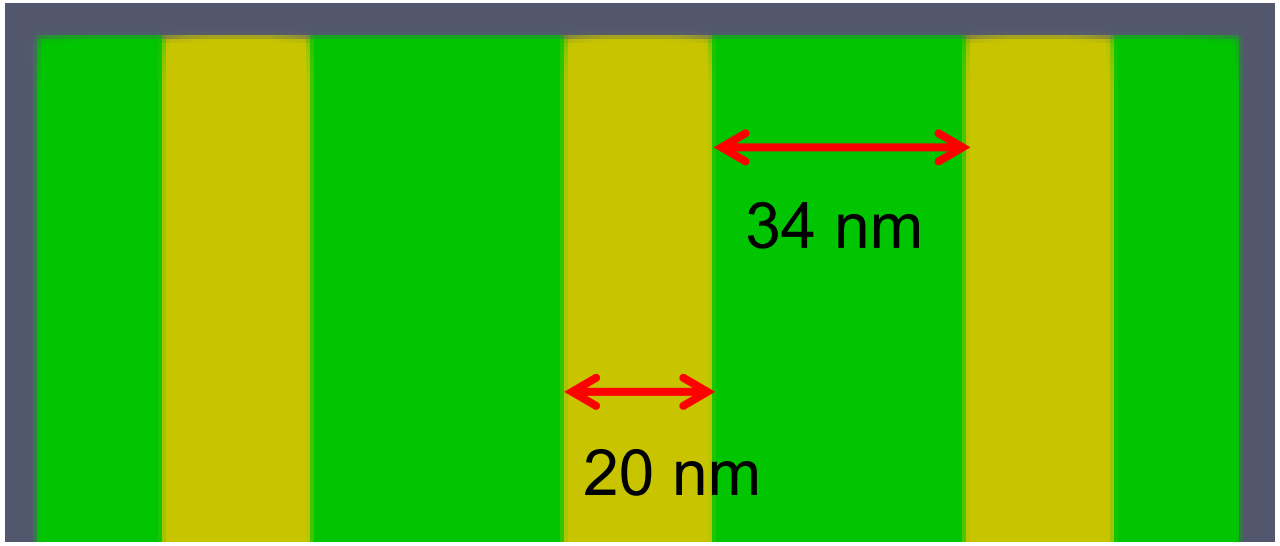
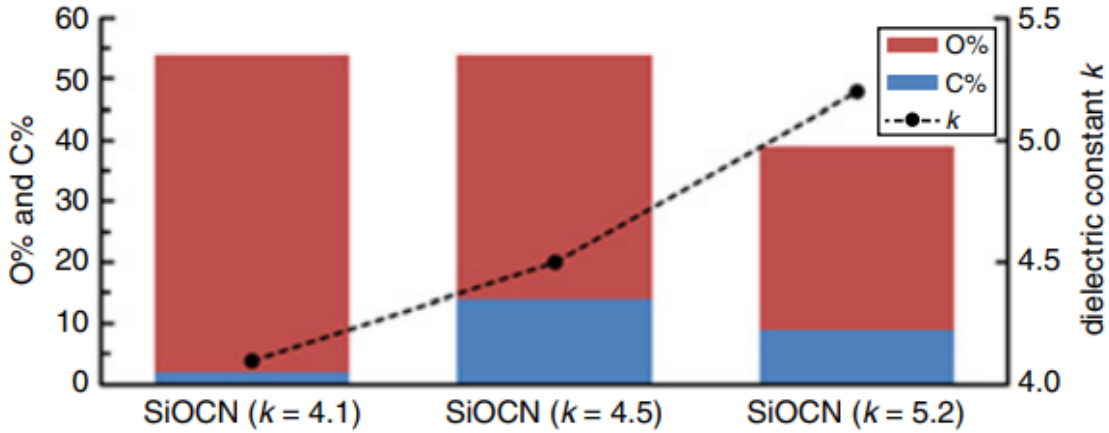
L10

Space between gates

- That is the place for source/drain regions.
  - However, separation between S/D and G is needed. *Spacer*
  - We need a low-k (not high-k) material.
  - Adding O and C to SiN ($\epsilon \approx 7.5$) ➔ SiOCN ($\epsilon \approx 3.8 - 5.0$)
  - Hybrid low-k spacer scheme? (We use only one layer.)

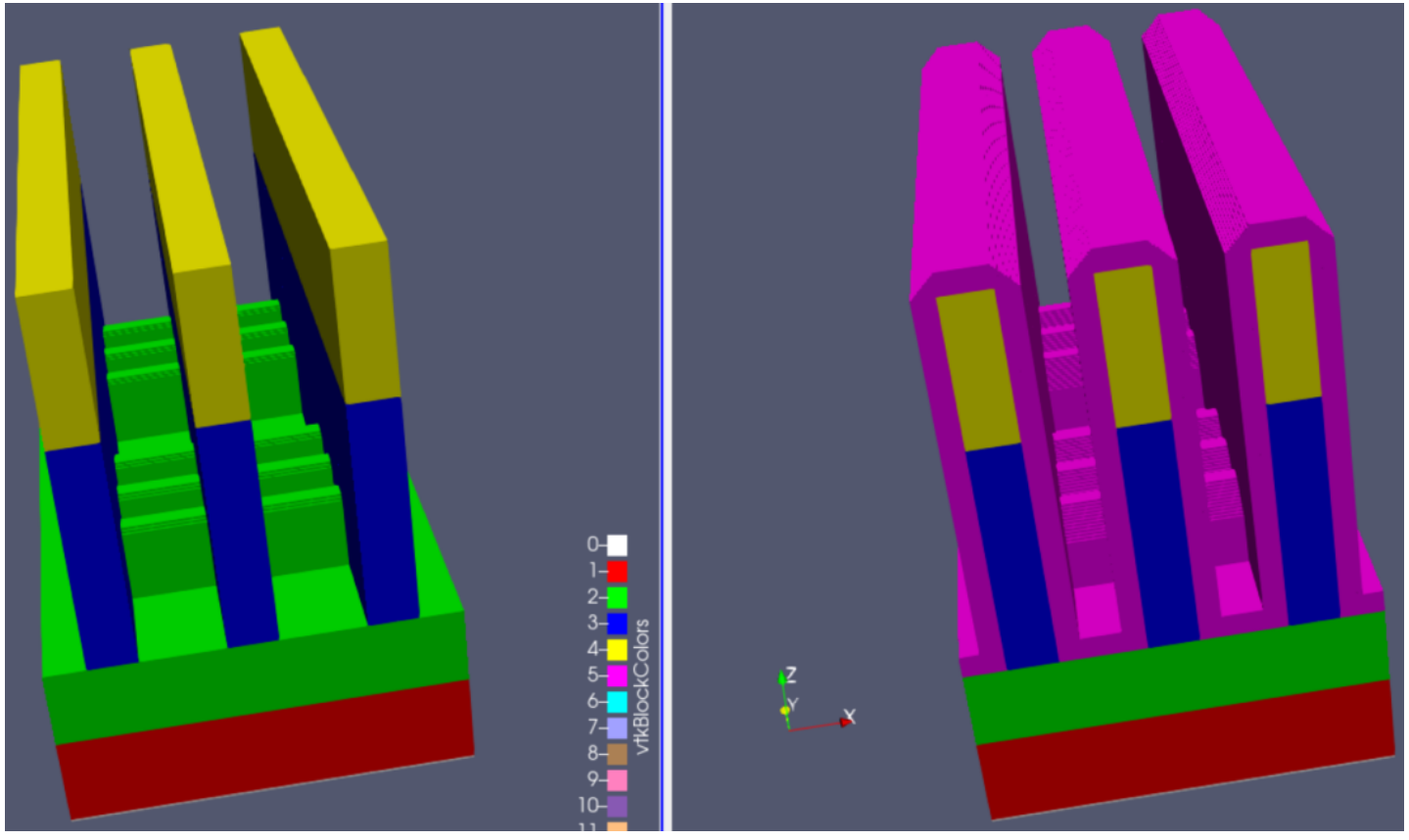




Various SiOCN films (GlobalFoundries)

Isotropic deposition of SiOCN

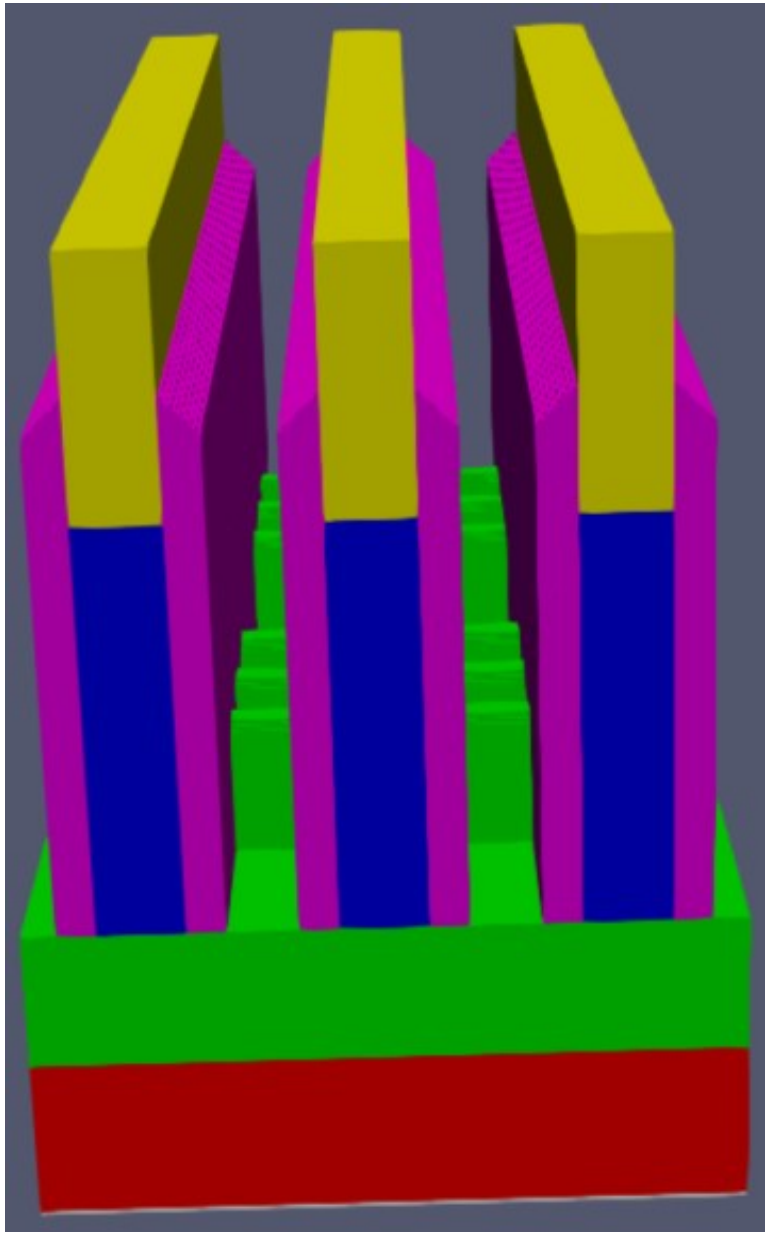
- Selection of its thickness (9 nm in our example)
  - Thick? Capacitance reduction (☺) Narrow S/D window (☹)
  - Thin? Capacitance increased (☹) Wide S/D window (☺)



Anisotropic etching of SiOCN

- Remove the low-k spacer covering fins.
  - But, keep the low-k spacer covering dummy gates.

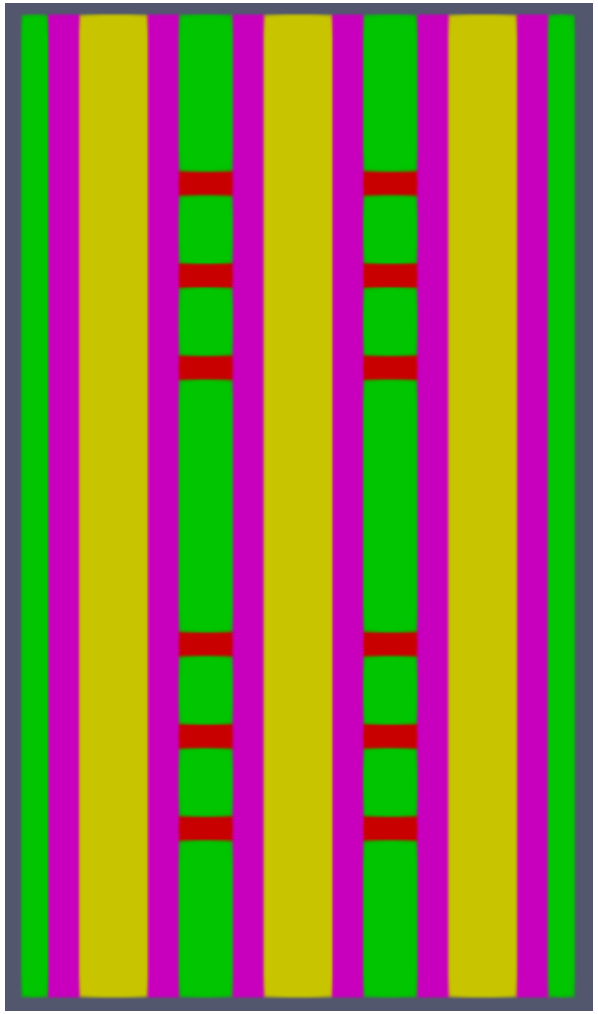
  (What is the etch depth required for this profile? Find it.)

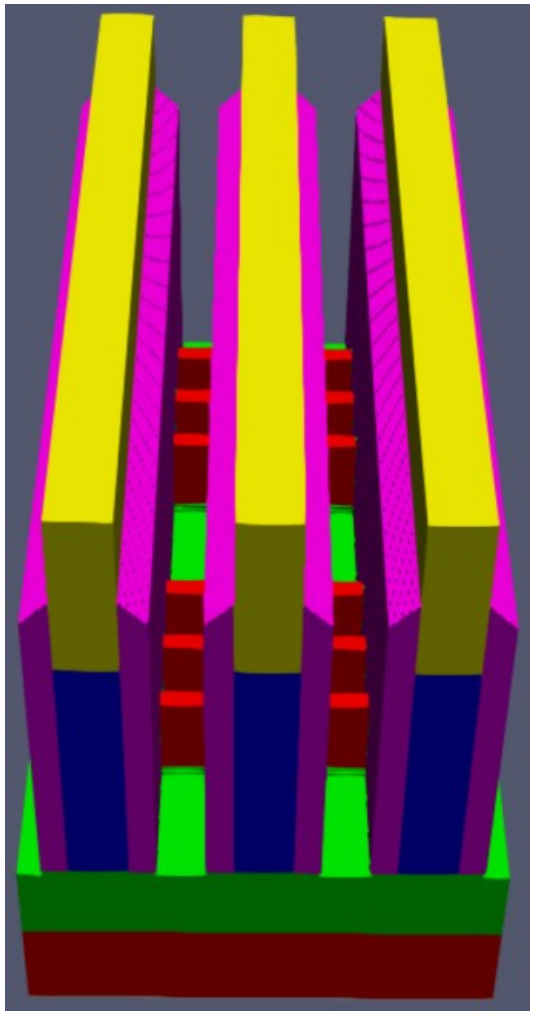


Prepare the source/drain epitaxy.

- First, remove the oxide.
  - The thickness of dummy SiO_2 layer is 2 nm.
  - How to do the isotropic etch? Specify `iso` in the spec. (Its default bahavior is the anisotropic etch.)

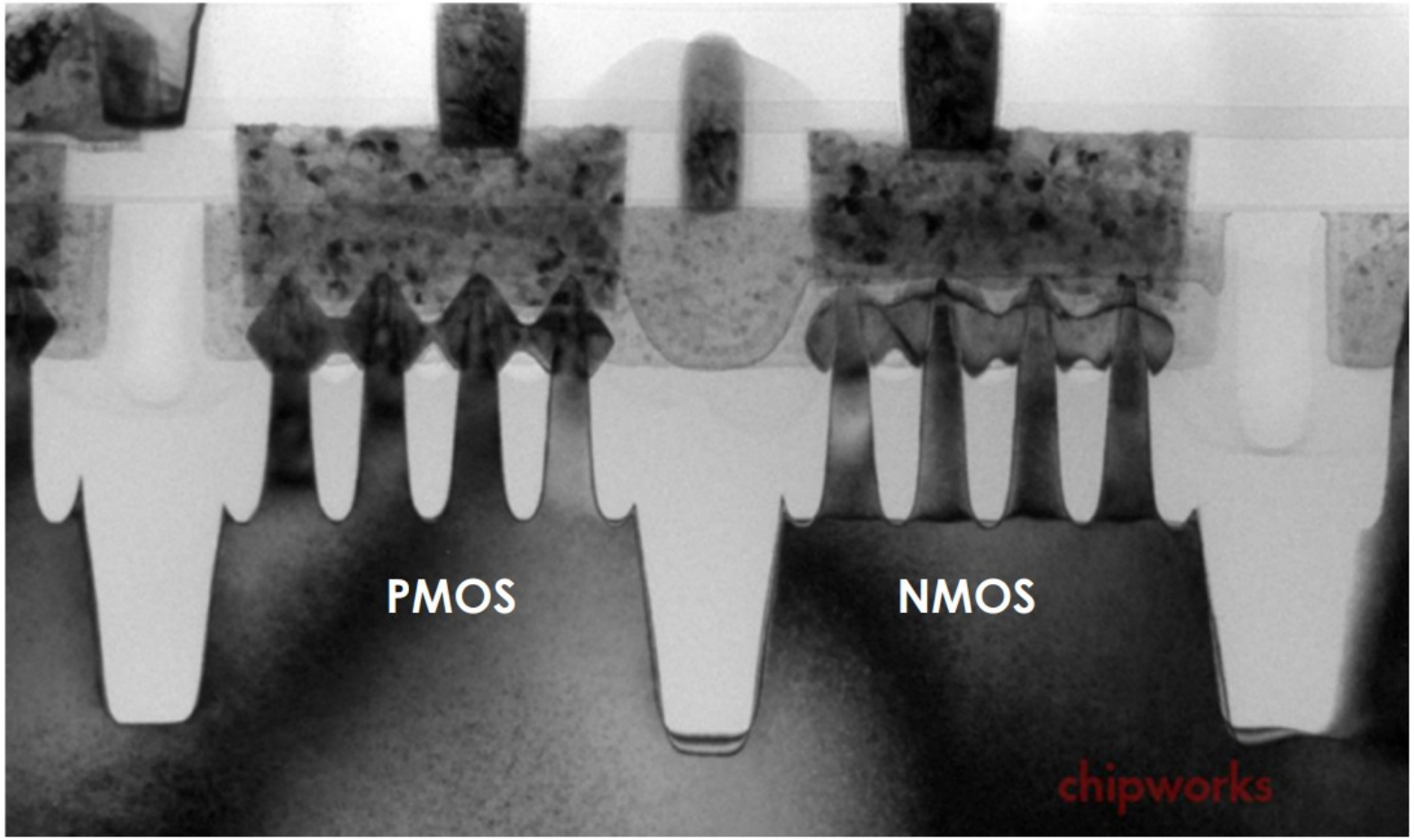
```
model (name="model_sourcedrain_SiO2") {
   select (region="SiO2")
}

etch (iso,model="model_sourcedrain_SiO2",thickness=2)
```

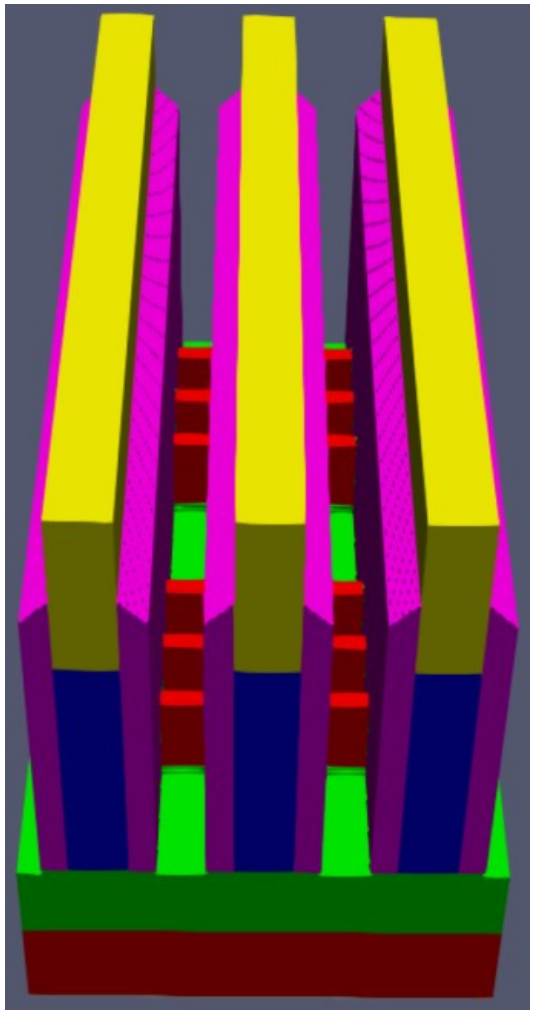




One TEM image of S/D region

- Samsung 14 nm FinFET S/D
  - Merged S/D region





TEM image (chipworks)

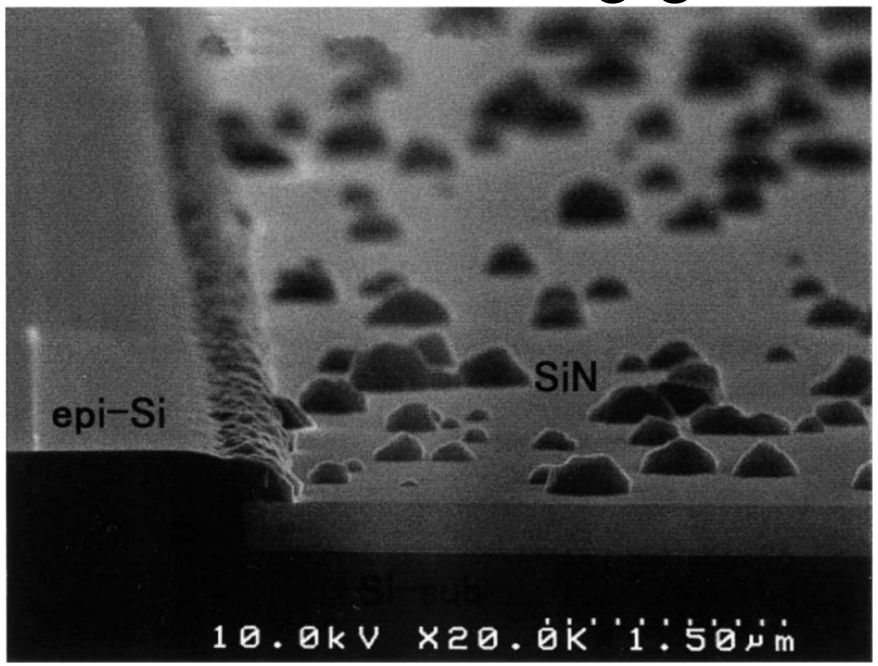
Selective epitaxial growth

DCS, dichlorosilane

- S/D regions are grown by the selective epitaxial growth.
  - For silicon growth, SiH_2Cl_2-HCl-H_2 gas system is used.

$$SiH_2Cl_2 \rightarrow Si\ (solid) + 2HCl\ (gas)$$

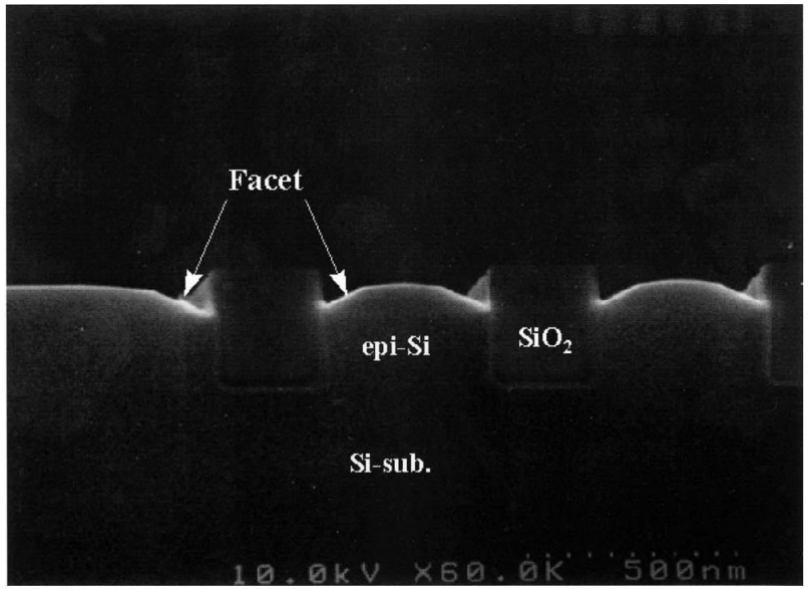
  - RPCVD (reduced pressure chemical vapor deposition)
  - HCl is added as an etching gas.



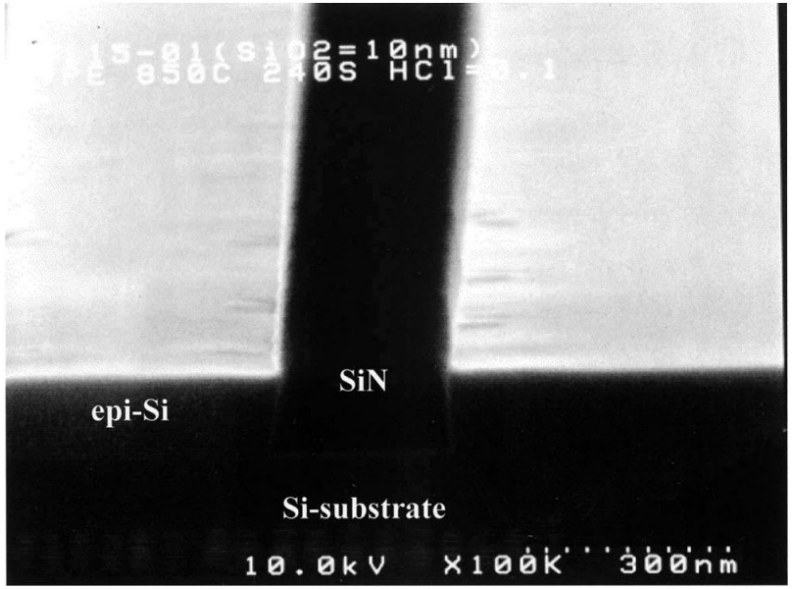
SiN patterned sample after SEG
(K. Miyano et al., Toshiba)

Facet

- Depending on the sidewall, the SEG result is heavily affected.
  - For SiO_2, facets are observed.



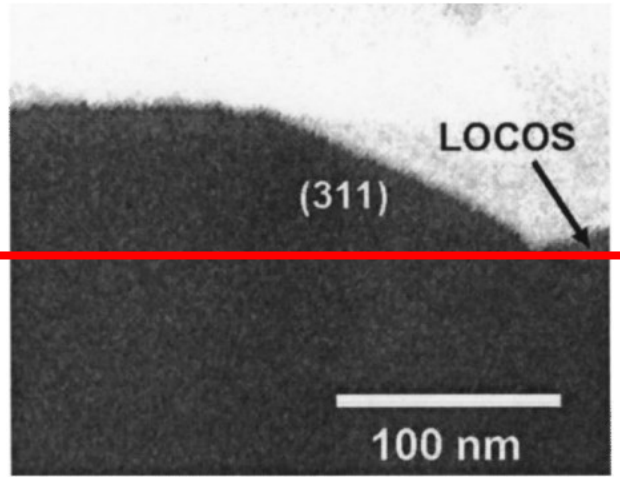
SEG result peformed on SiO_2 patterned wafer (K. Miyano et al., Toshiba)

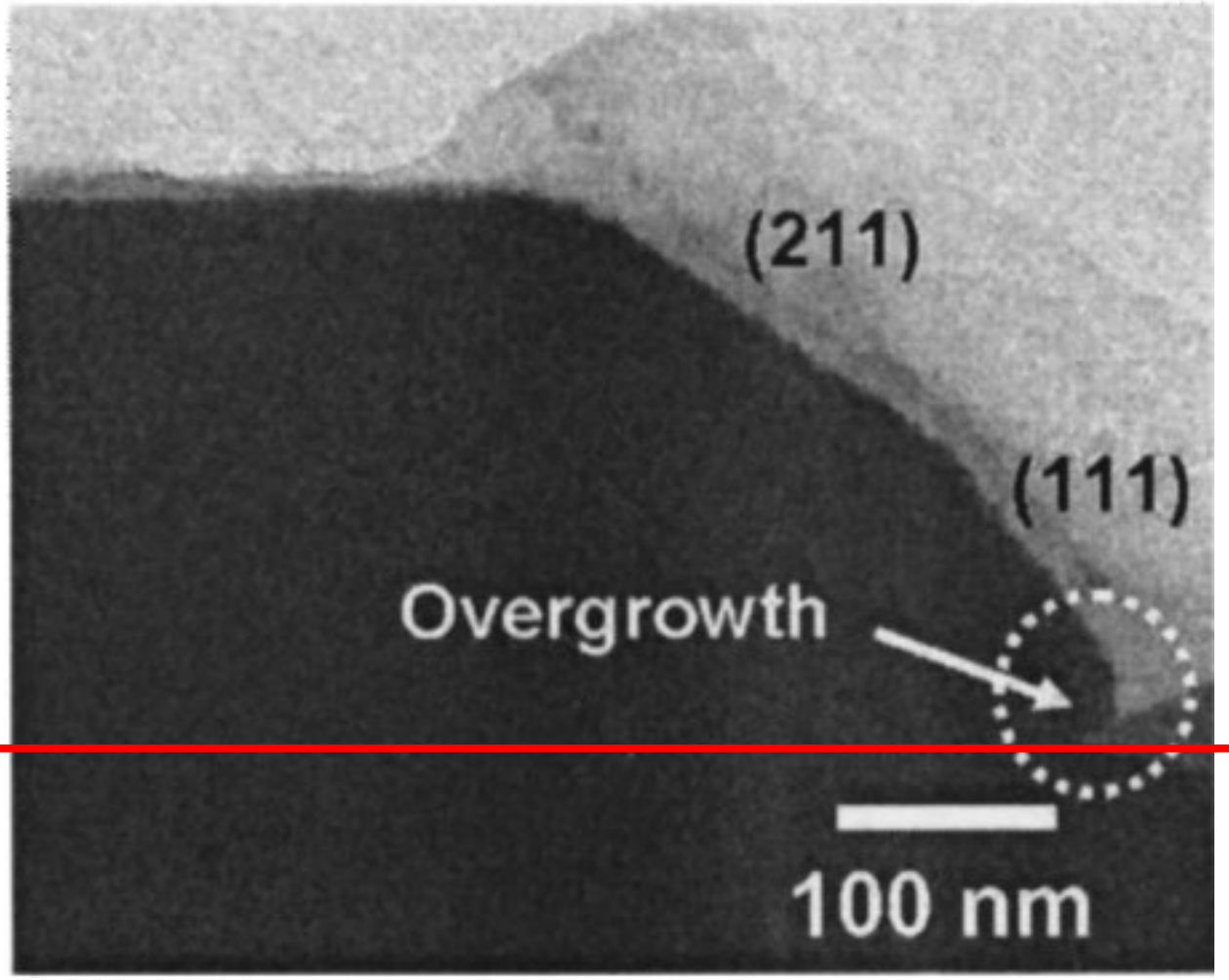


SEG result peformed on SiN patterned wafer (K. Miyano et al., Toshiba)

Facet evolution is SEG

- Initially, {311} facet
  - Later, {211} and {111} facets





XTEM micrographs of Si epitaxial layers whose thicknesses are 60 nm and 240 nm (S.-H. Lim et al., SNU)

Homework#10

- Due: 08:00 on Oct. 15
- Submit a report through the GIST LMS system.
  - By using the AngstromCraft code, follow L10 lecture material.
  - Your report must show structures and the input file.

Thank you!