

# Special Topics on Basic EECS I Design Technology Co-Optimization

## Lecture 13

Sung-Min Hong ([smhong@gist.ac.kr](mailto:smhong@gist.ac.kr))

Semiconductor Device Simulation Laboratory

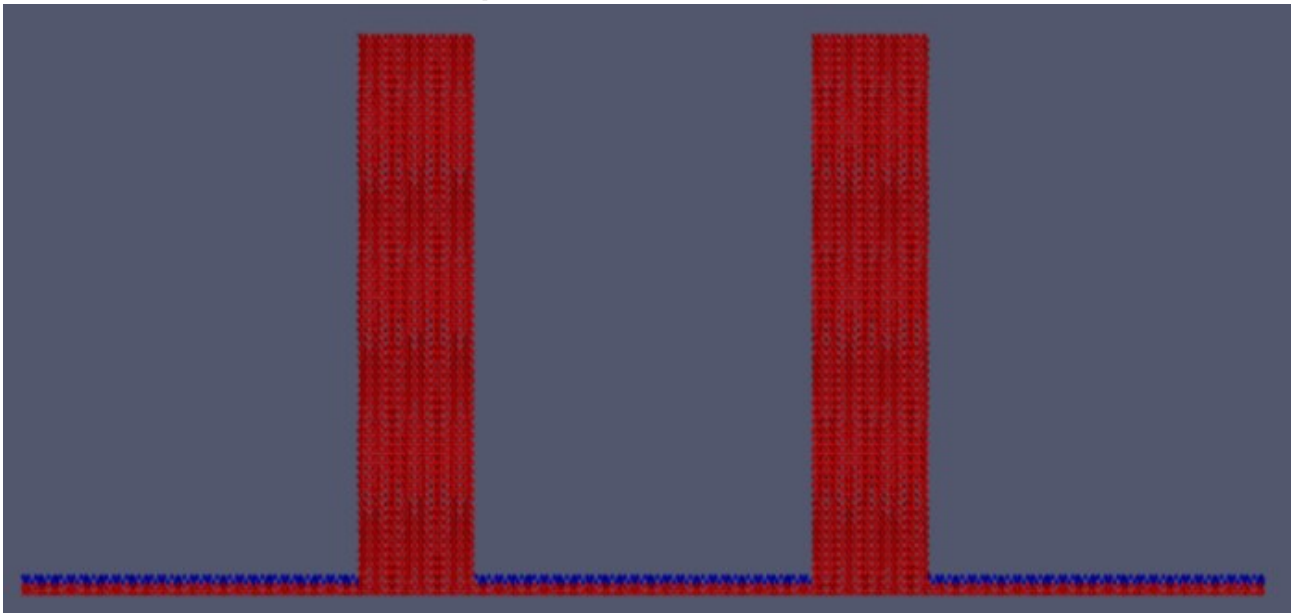
Department of Electrical Engineering and Computer Science

Gwangju Institute of Science and Technology (GIST)

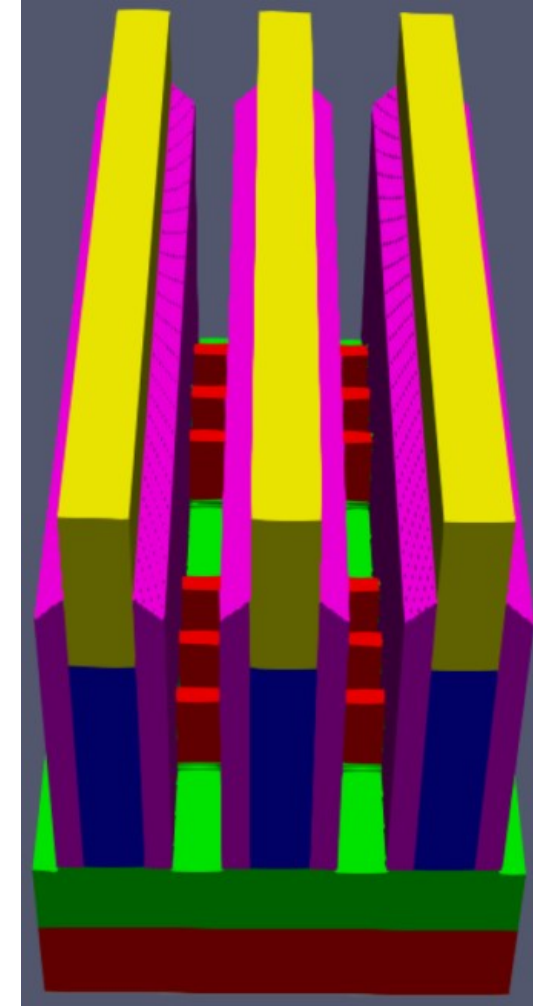
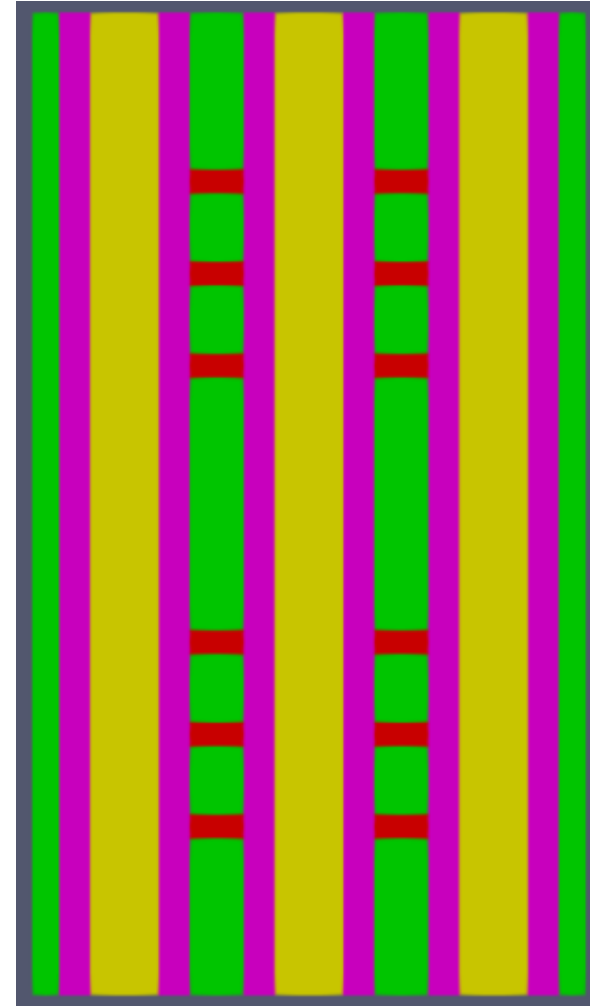
# L13

# Coming back to the FinFET

- There are fins.
  - Separated by 20 nm
  - Test a two-fin structure. (32-nm-tall)

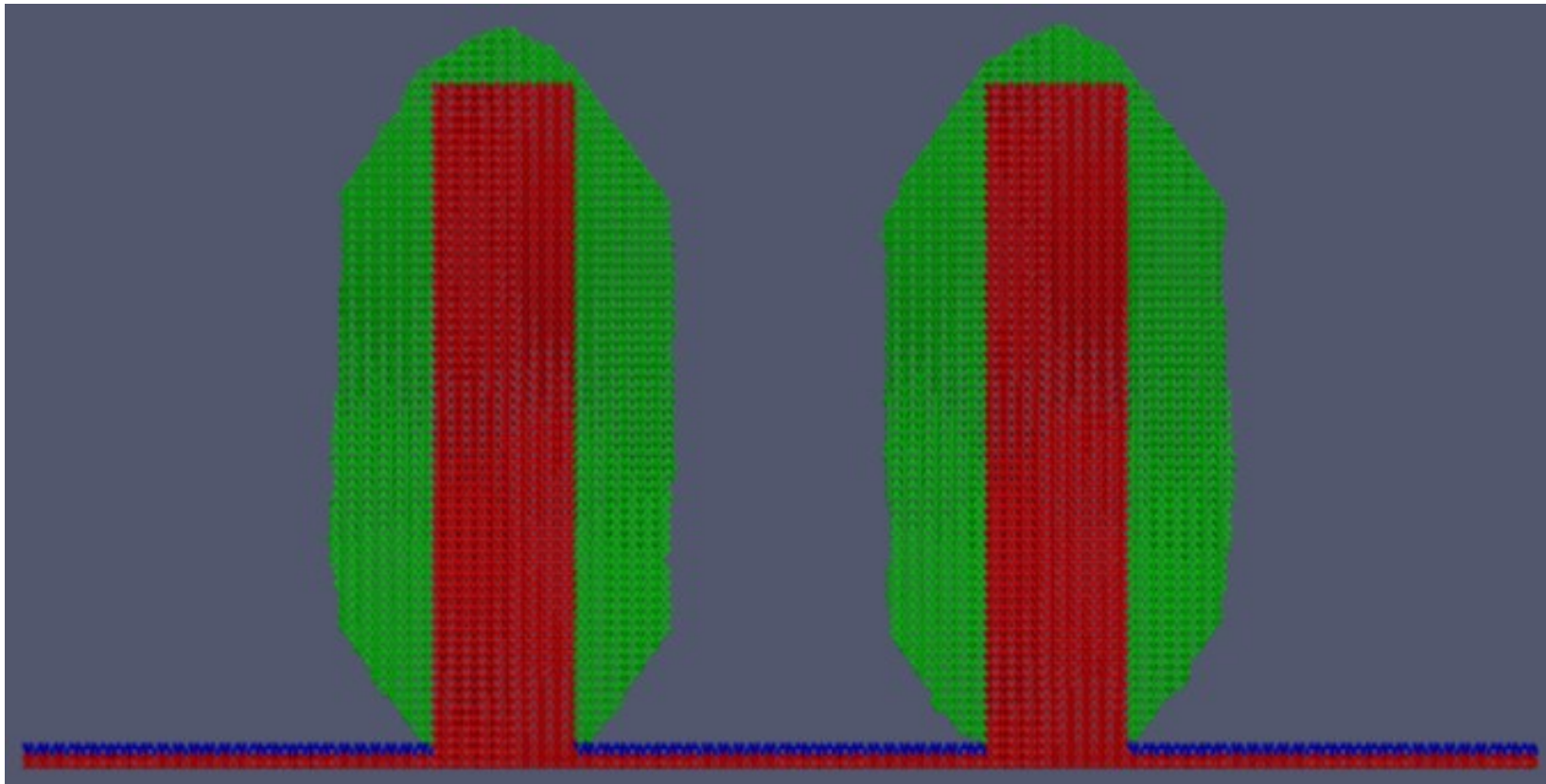


20 nm



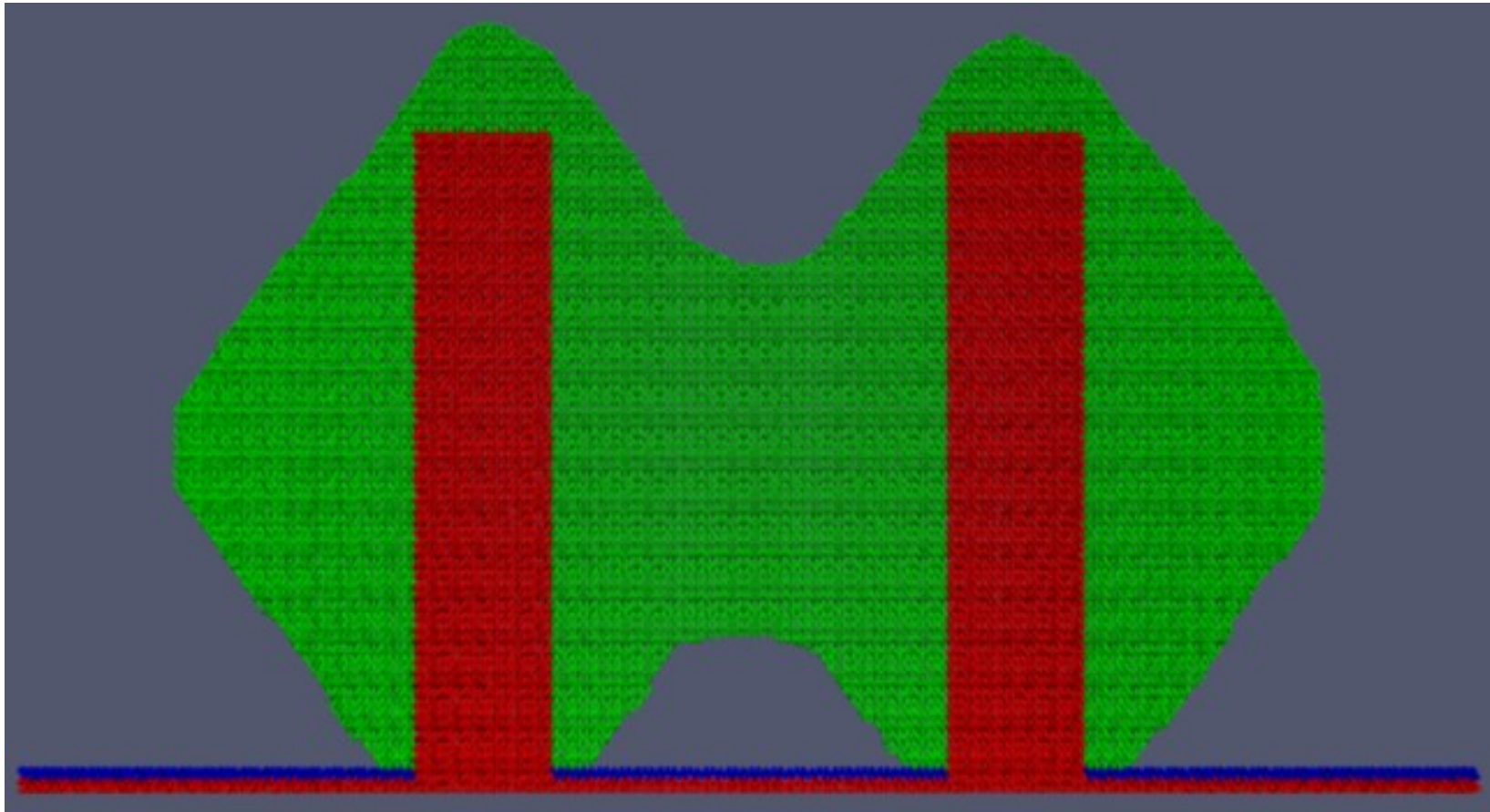
# Thickness $\sim 4.5$ nm

- They are separated.
  - $\{111\}$  surfaces are observed.
  - On the top surface,  $\{311\}$  surfaces are dominant.



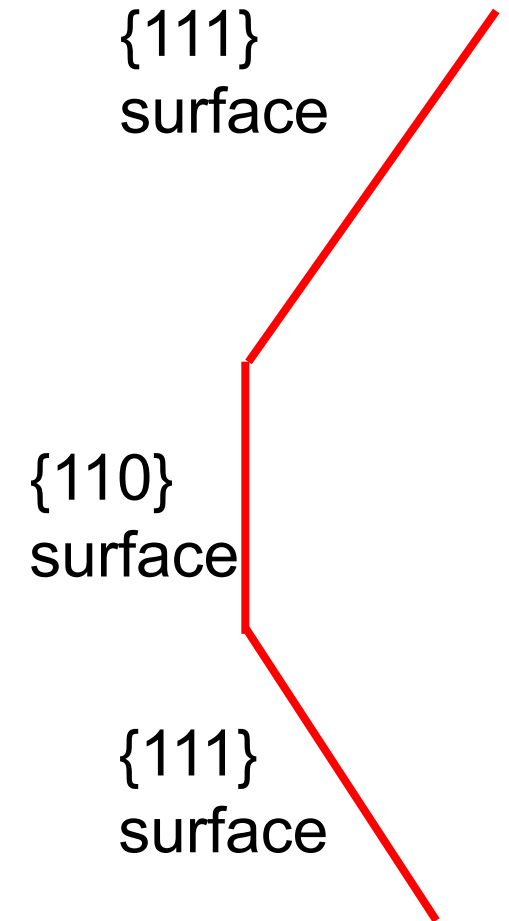
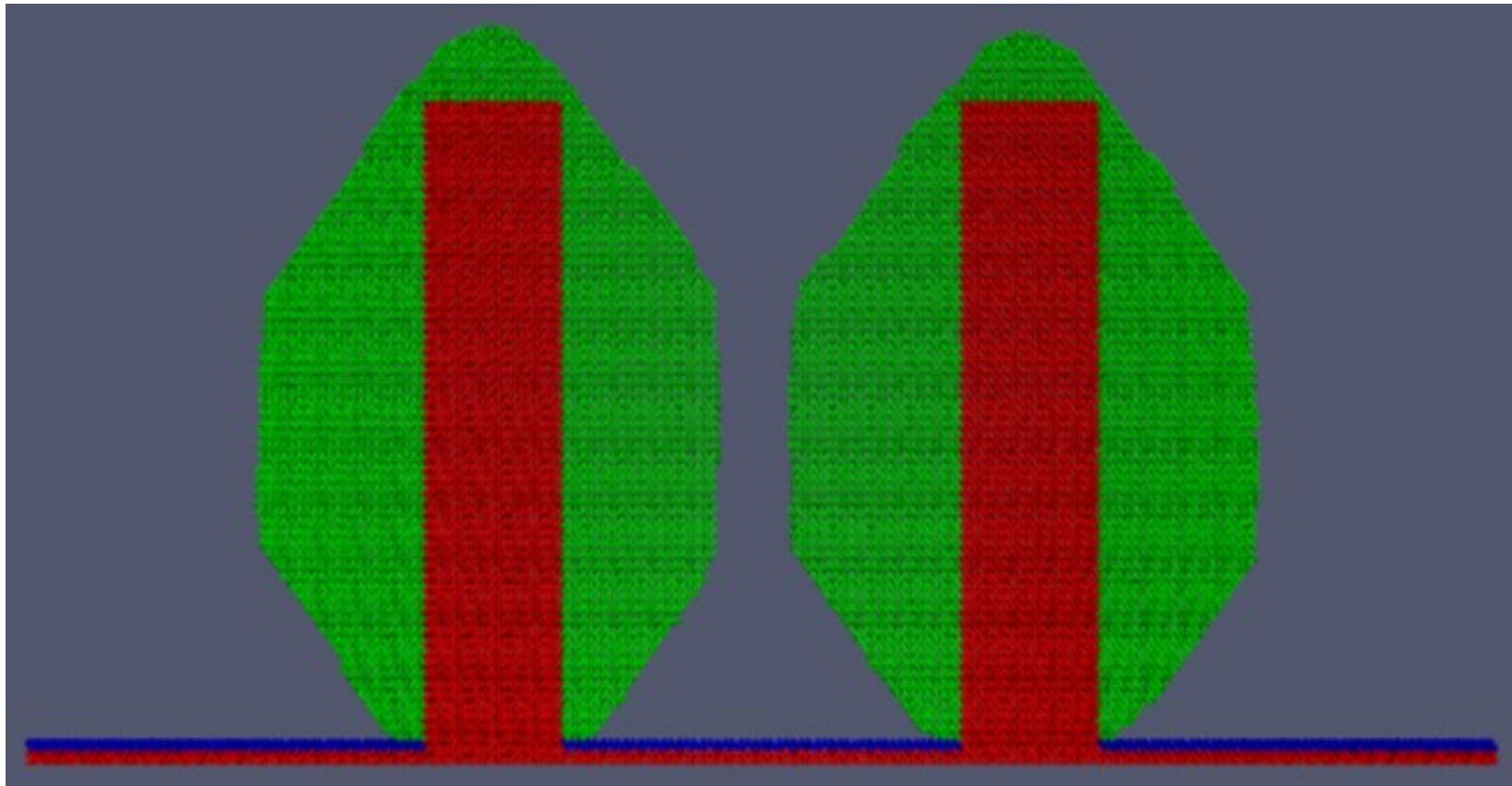
# Double the number of atoms.

- They are bridged. It looks like mushrooms.
  - (Can we trust this result?)



# In between,

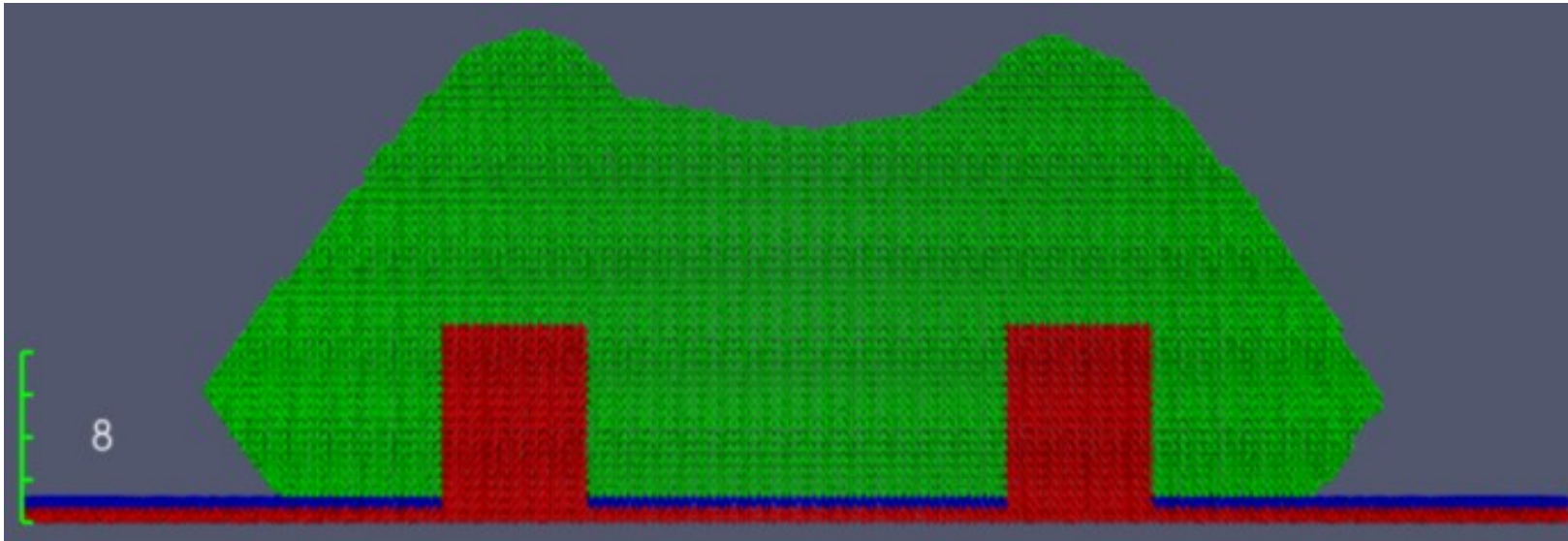
- We can find a condition of unmerged fins.
  - The fin shape can be well approximated.





# Impact of fin height

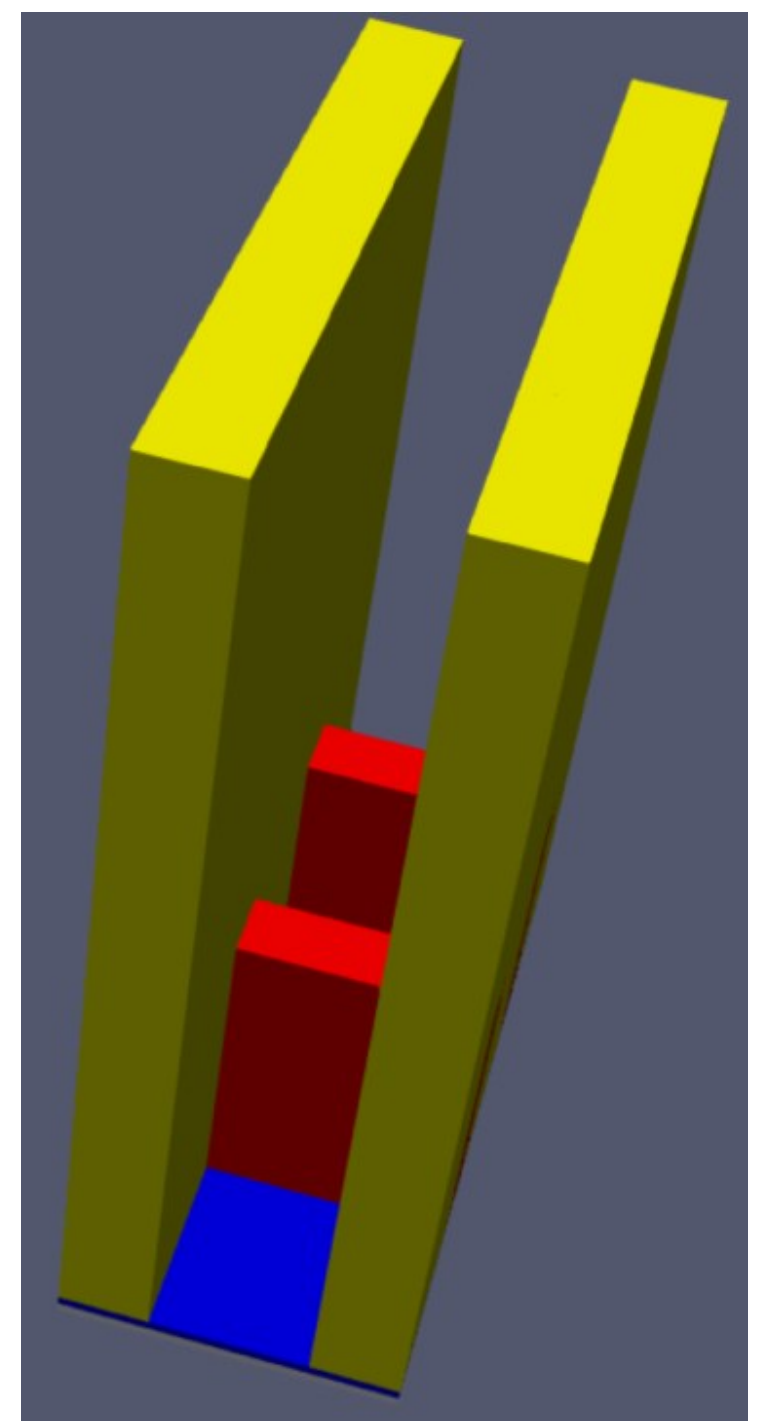
- Consider 8-nm-tall fins.
  - Repeat the previous test. (The same number of atoms in the last slide)



# Try this.

- Construct a test structure.
  - 34 nm (= 9 + 16 + 9) by 74 nm (= 20 + 7 + 20 + 7 + 20)
  - (The colors of the regions do not matter.)
  - Now, we are ready to test the selective epitaxial growth.

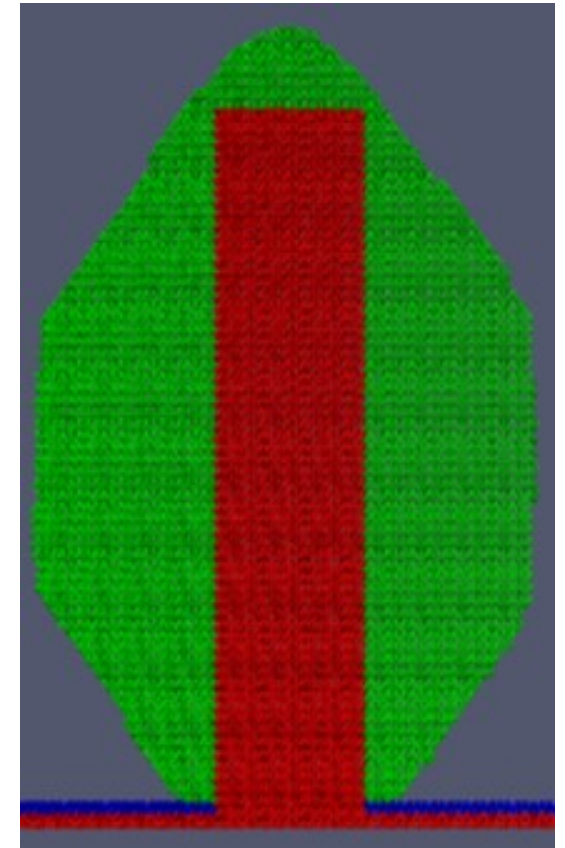
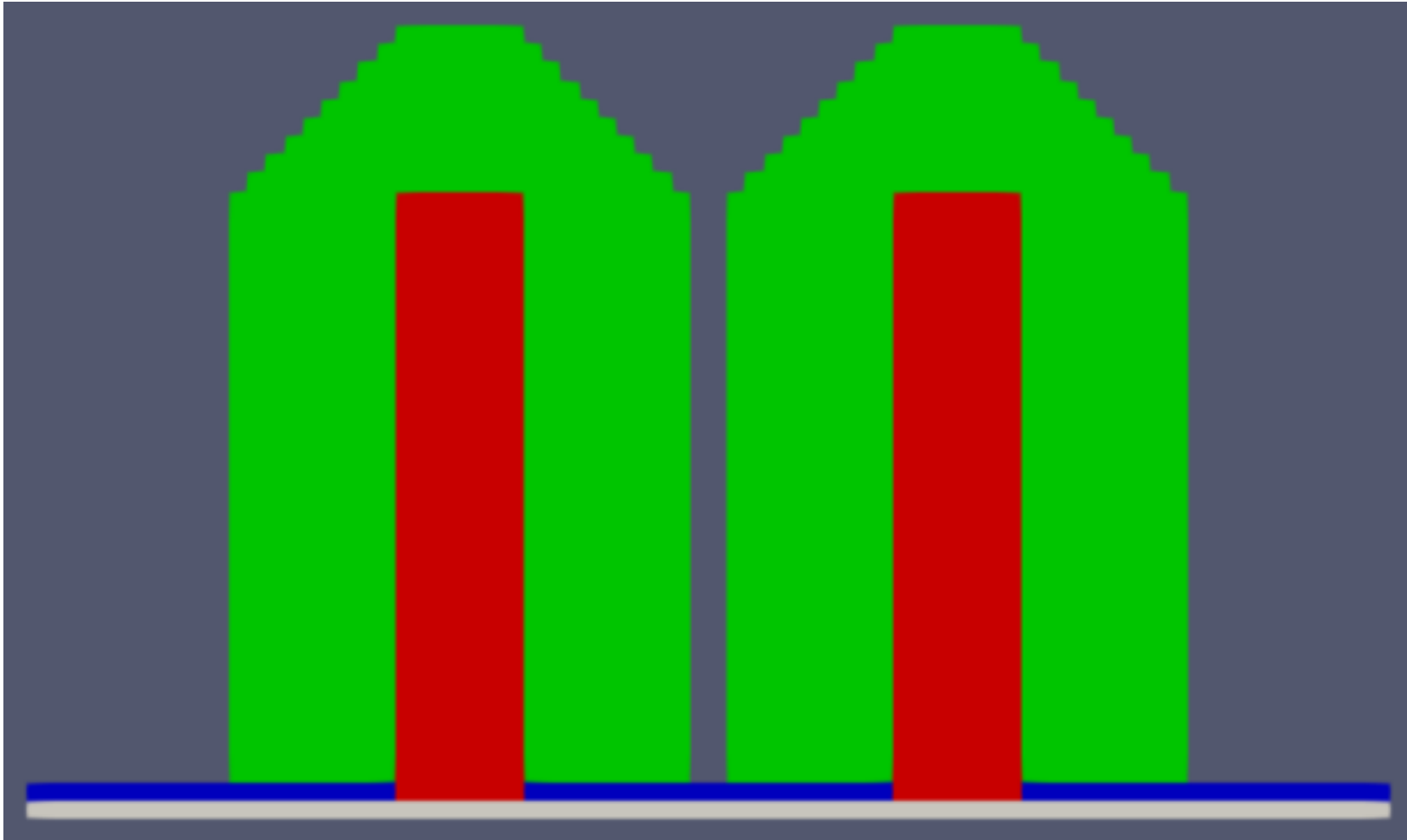
```
model (name="model_sd") {  
    select (region="Fin")  
    select (region="SD")  
}
```





# Isotropic depo with a thickness of 9 nm

- No boundary condition. 45 degree.



# New growth statement

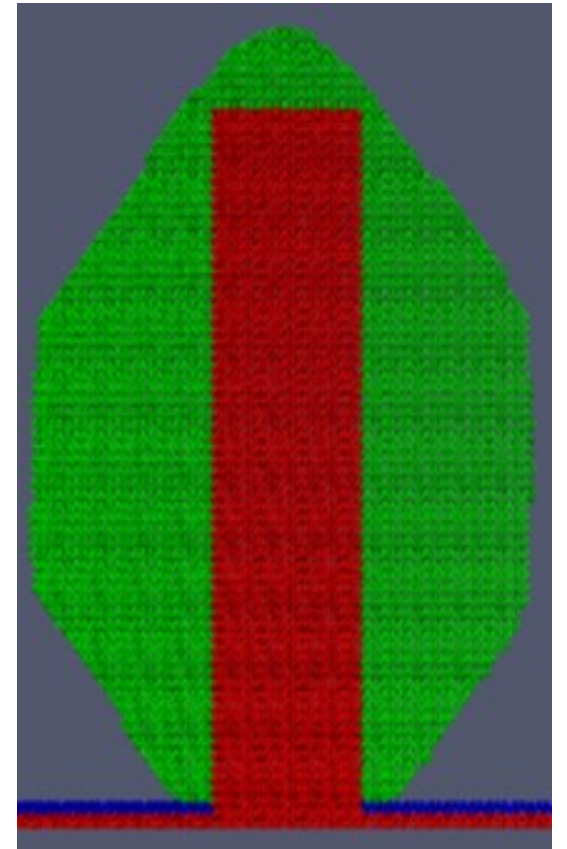
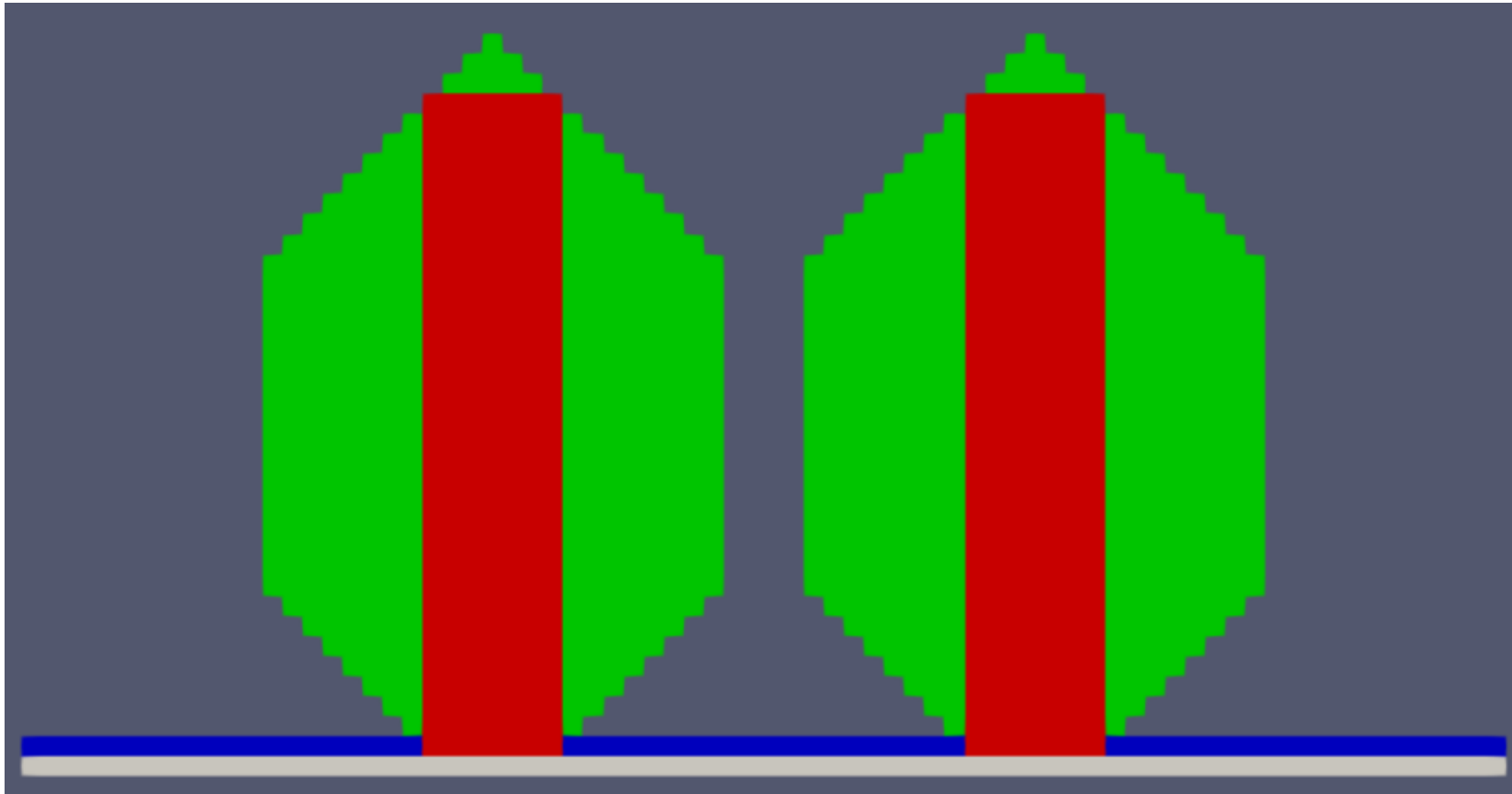
- This new statement takes three spec arguments.
  - Name of the added region: `region`
  - Name of the material selectivity: `model`
  - (Minimum) number of voxels to be added: `number`

`growth (region="SD",model="model_sd",number=12000)`

- DO NOT increase `number` too aggressively.
- Main idea
  - Check the existing surfaces.
  - {111} surfaces are approximated as diagonal surfaces. (45°)

# When the number of voxels is 12000,

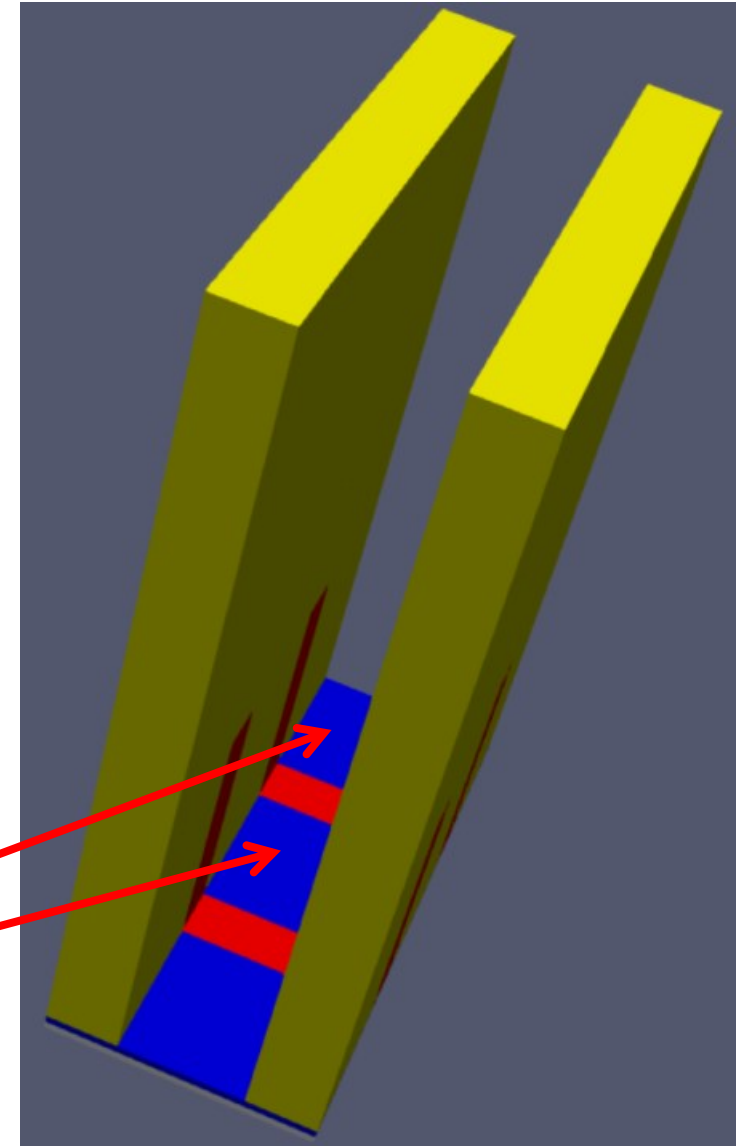
- We have a similar profile.
  - Of course, details cannot be reproduced.



# Three-dimensional shape

- Cavity etching
  - The 32-nm-tall fin is etched anisotropically.
  - The fin underneath the spacer is not etched. → In reality, these parts are also etched.
  - Etch depth is equal to the fin height. → In reality, it is not.

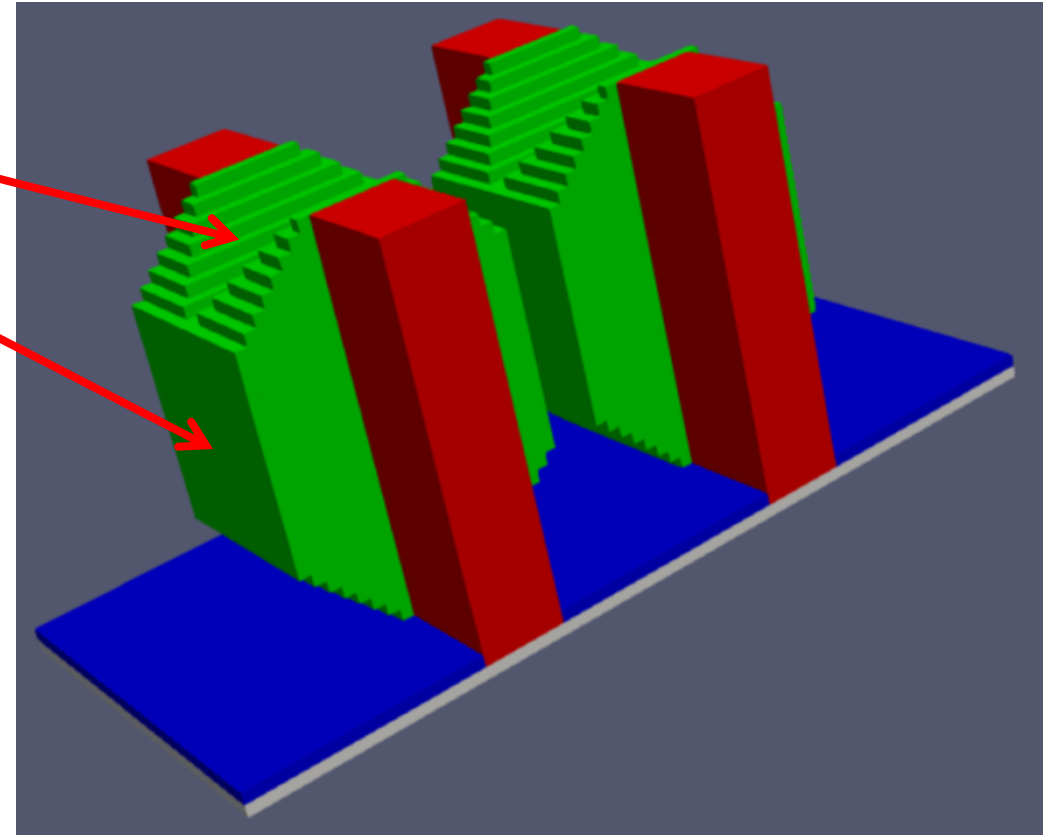
There is no fin.



# Growth after cavity etching

- Contribution from two channels is dominant.
  - In this example, increased `number` introduces more voxels to make a diamond-like shape.

```
model (name="model_sd") {  
  select (region="Fin")  
  select (region="SD")  
  neighbor (region="Spacer")  
}
```



# Homework#13

- Due: 08:00 on Nov. 3
- Submit a report through the GIST LMS system.
  - Construct the simple structure used in the L13 lecture material.  
Then, by using a `growth` statement, grow the epitaxial layer.



# Thank you!