Special Topics on Basic EECS I Design Technology Co-Optimization

Lecture 13

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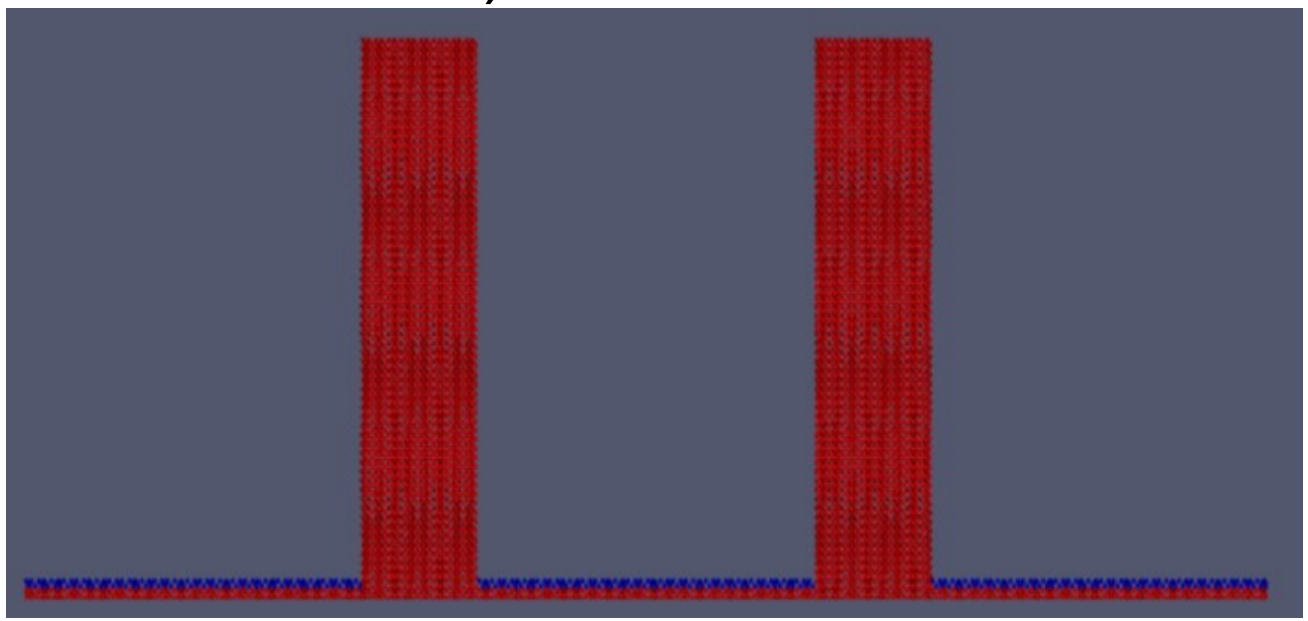
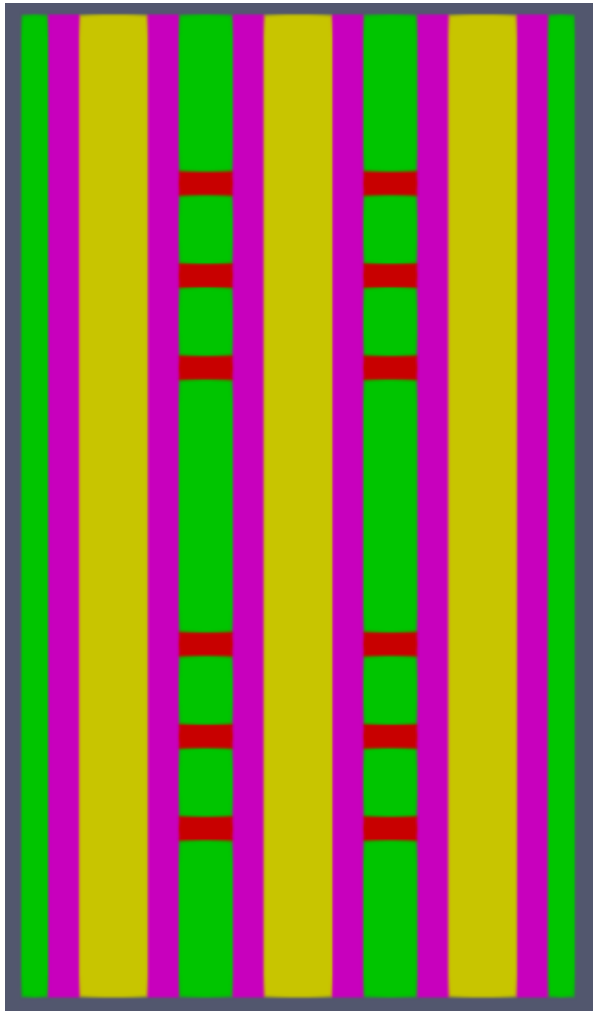
L13

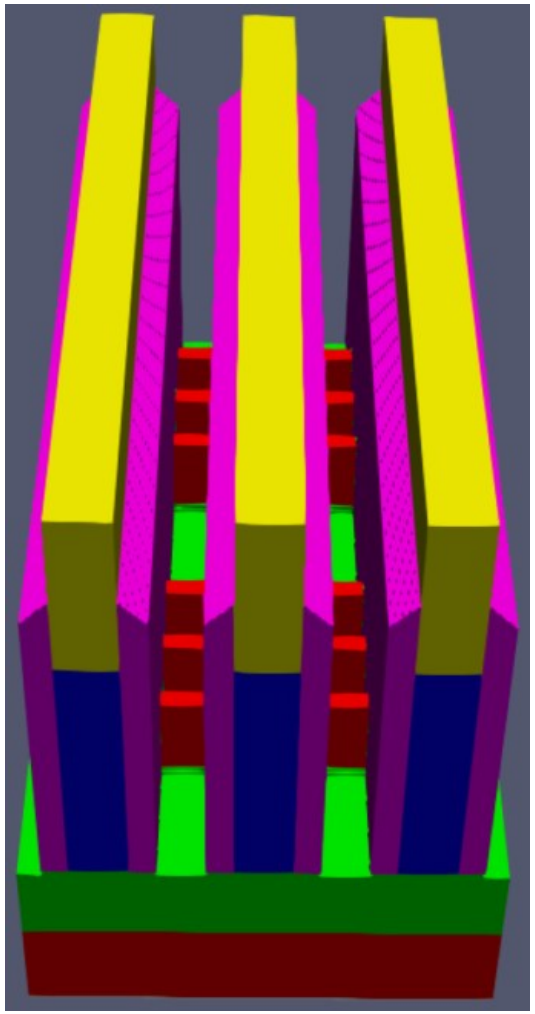
Coming back to the FinFET

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



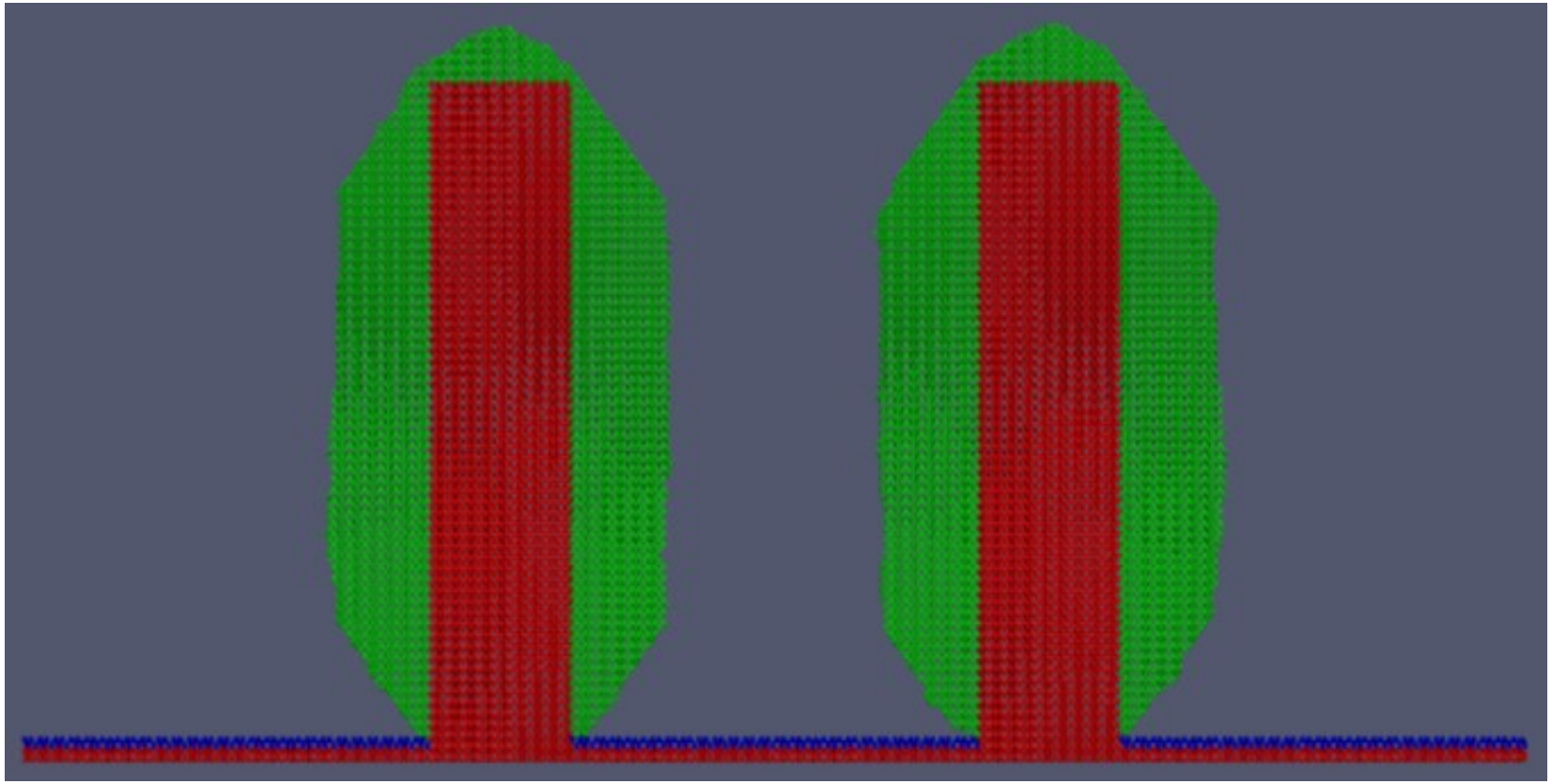
20 nm





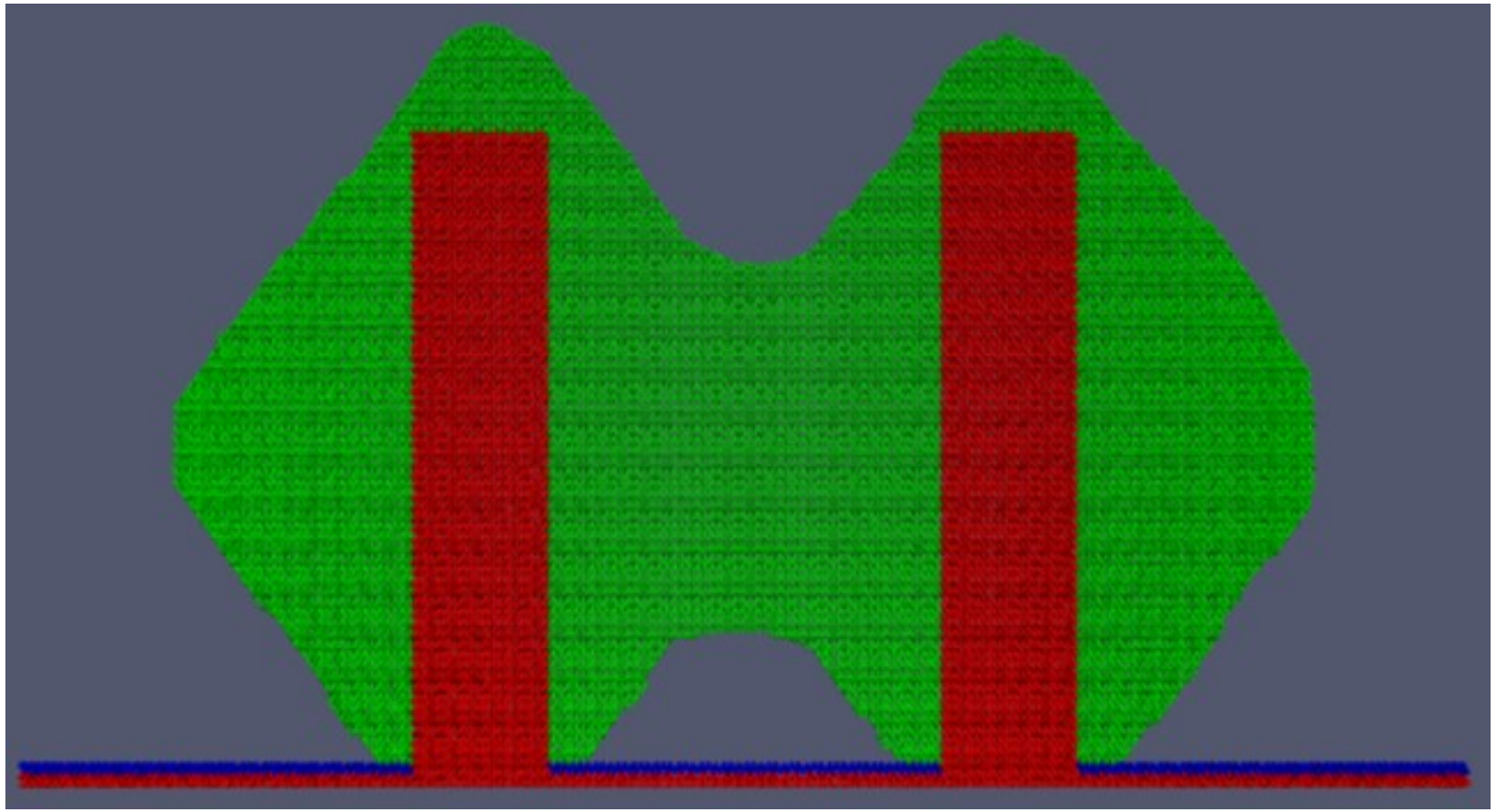
Thickness ~ 4.5 nm

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



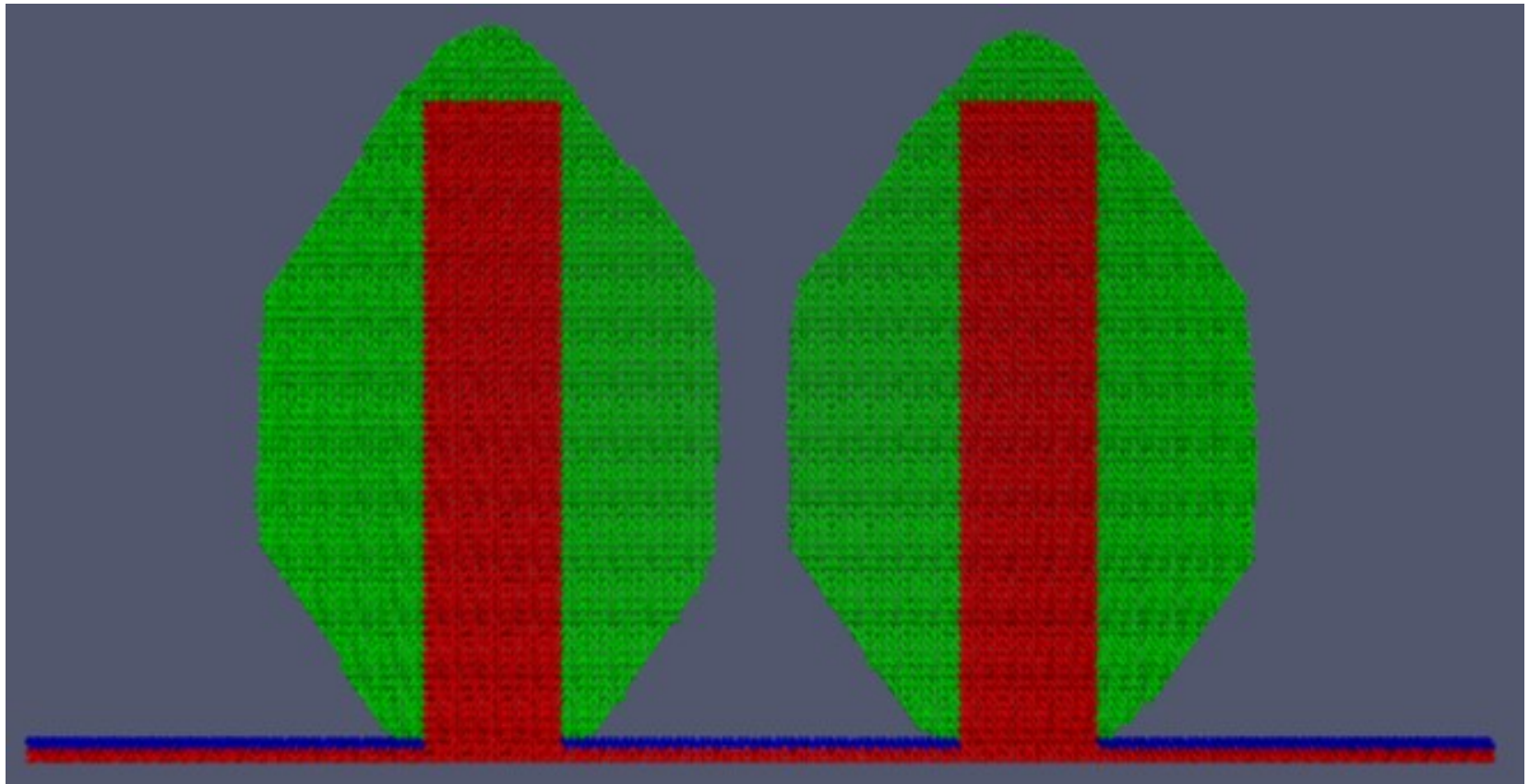
Double the number of atoms.

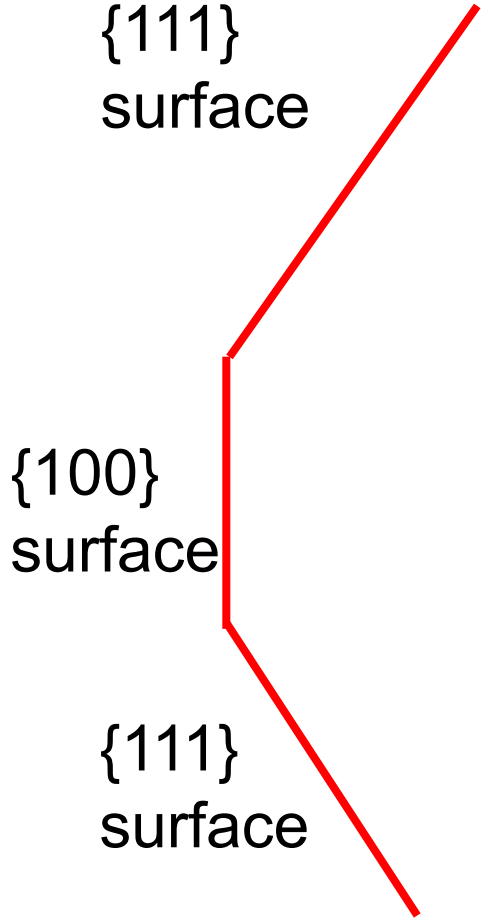
- They are bridged. It looks like mushrooms.
  - (Can we trust this result?)



In between,

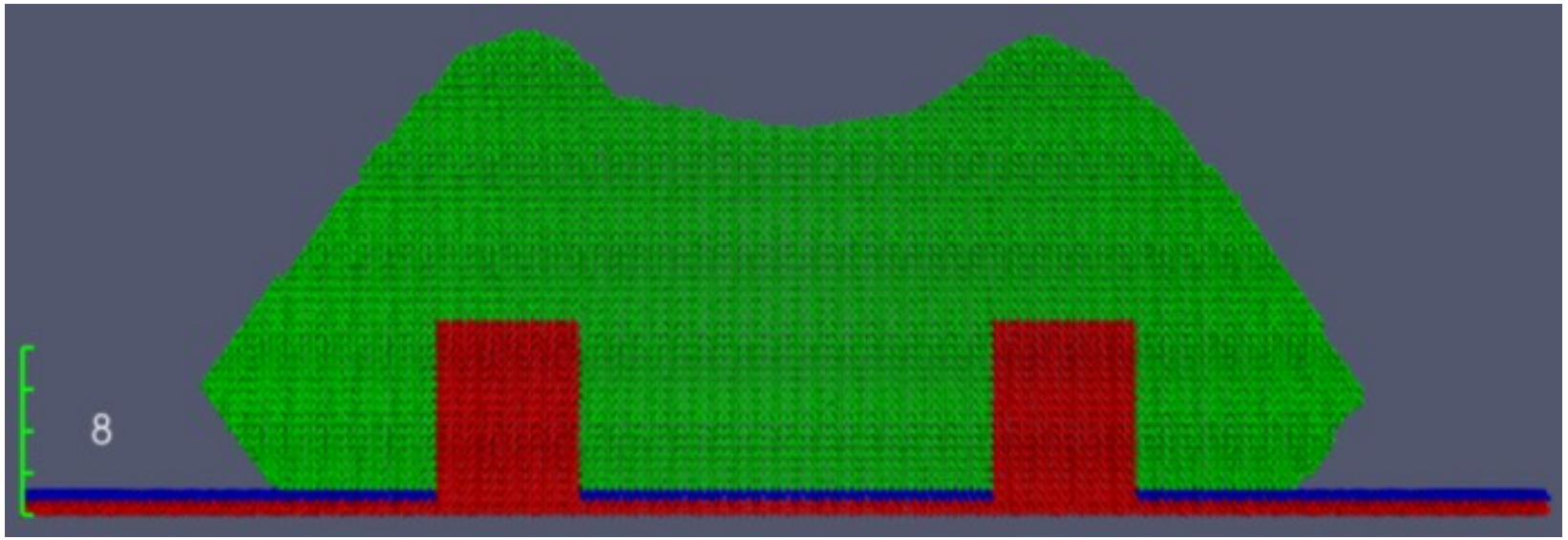
- We can find a condition of unmerged fins.
  - The fin shape can be well approximated.





Impact of fin height

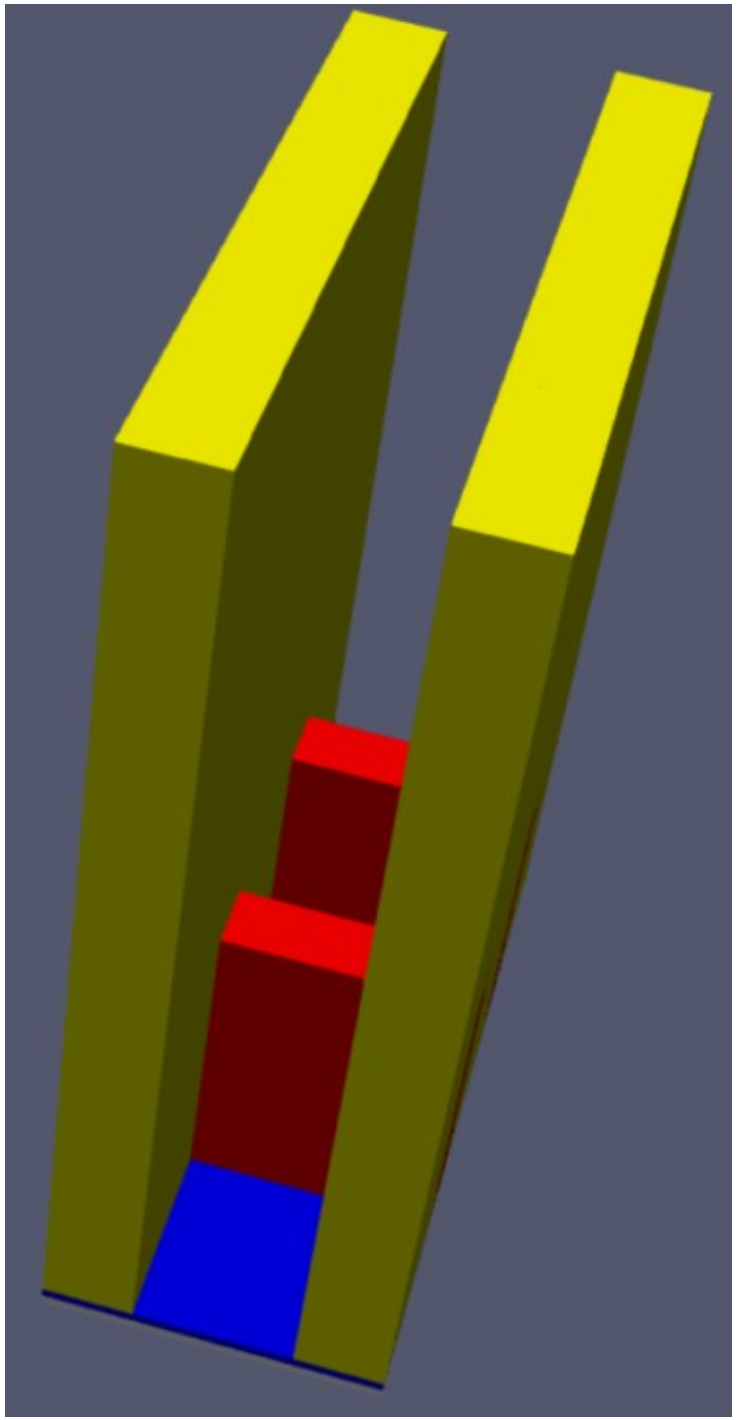
- Consider 8-nm-tall fins.
  - Repeat the previous test. (The same number of atoms in the last slide)



Try this.

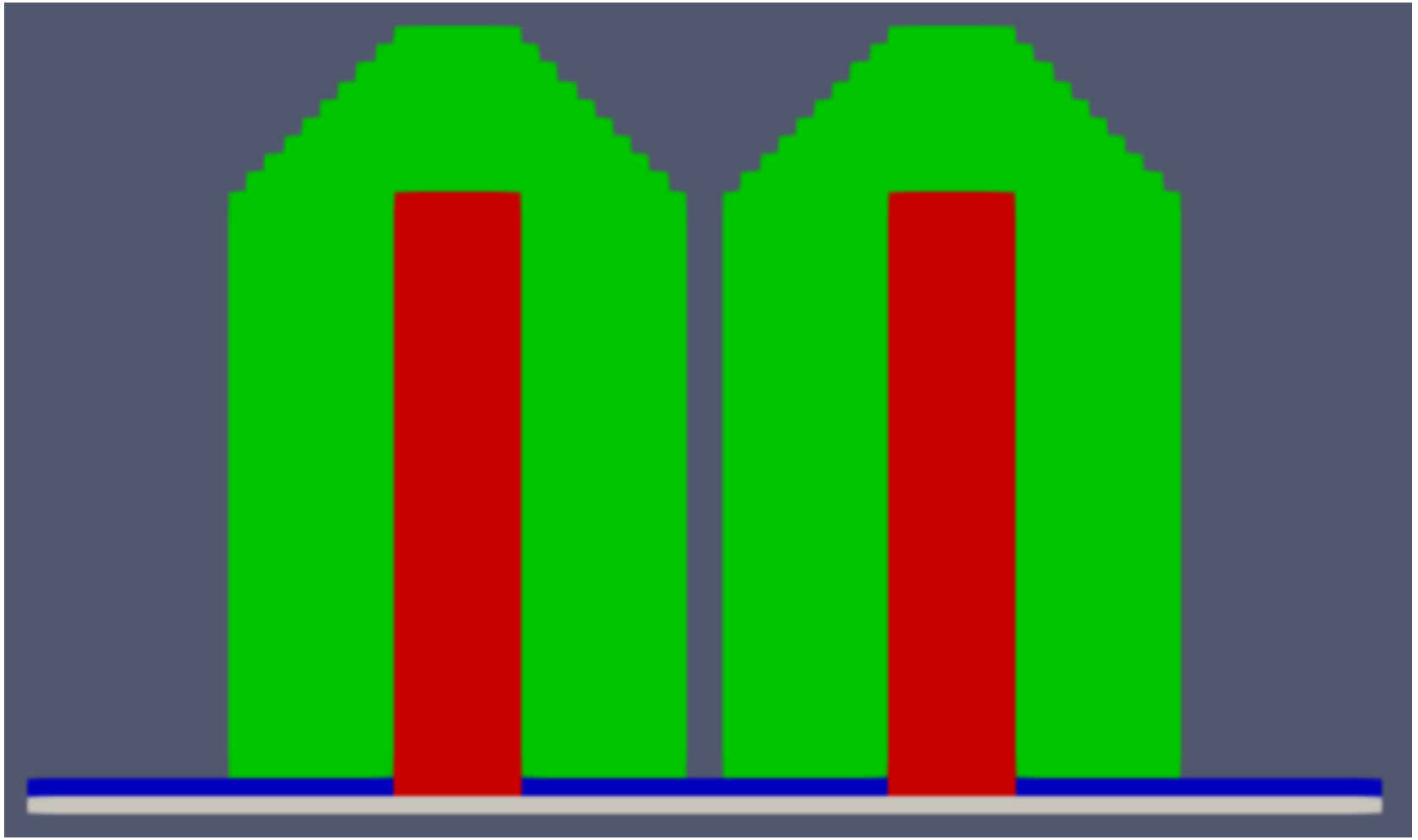
- Construct a test structure.
  - 34 nm (= 9 +16 + 9) by 74 nm (= 20 + 7 + 20 + 7 + 20)
  - (The colors of the regions do not matter.)
  - Now, we are ready to test the selective epitaxial growth.

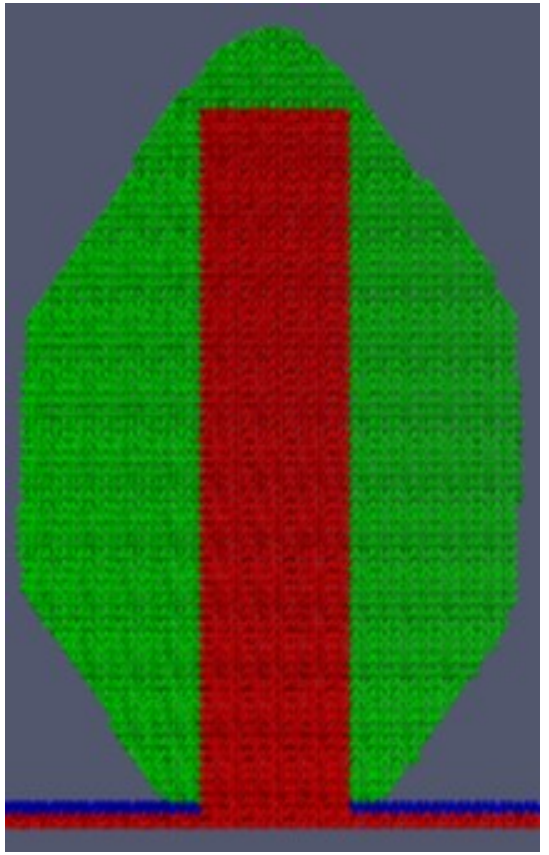
```
model (name="model_sd") {
    select (region="Fin")
    select (region="SD")
}
```



Isotropic depo with a thickness of 9 nm

- No boundary condition. 45 degree.





New `growth` statement

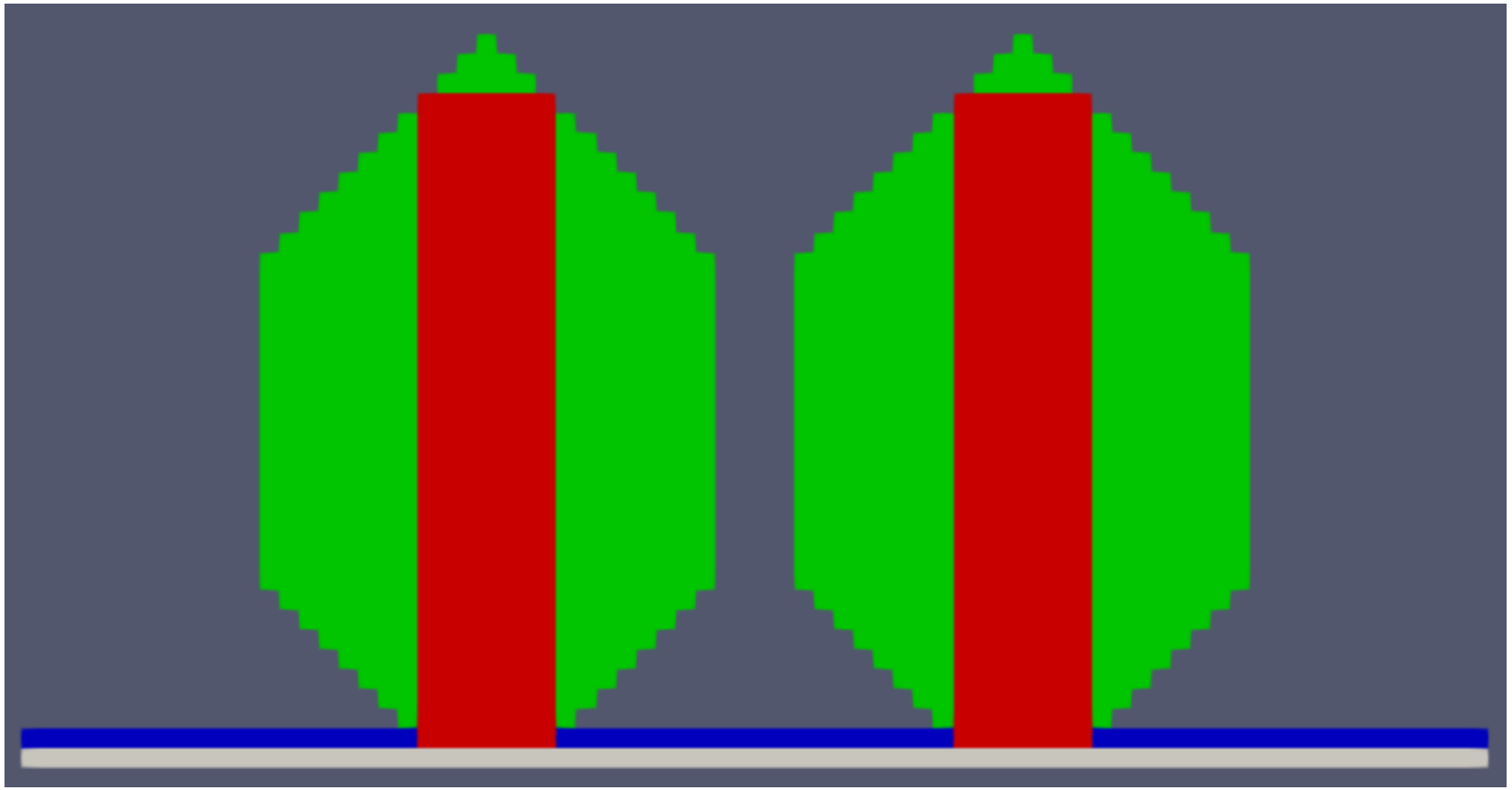
- This new statement takes three spec arguments.
  - Name of the added region: `region`
  - Name of the material selectivity: `model`
  - (Minimum) number of voxels to be added: `number`

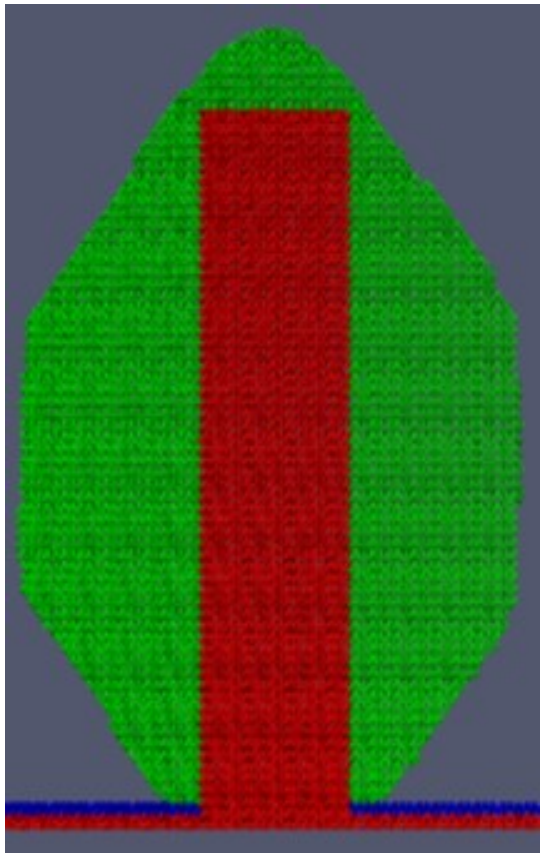
```
growth (region="SD",model="model_sd",number=12000)
```

  - 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,

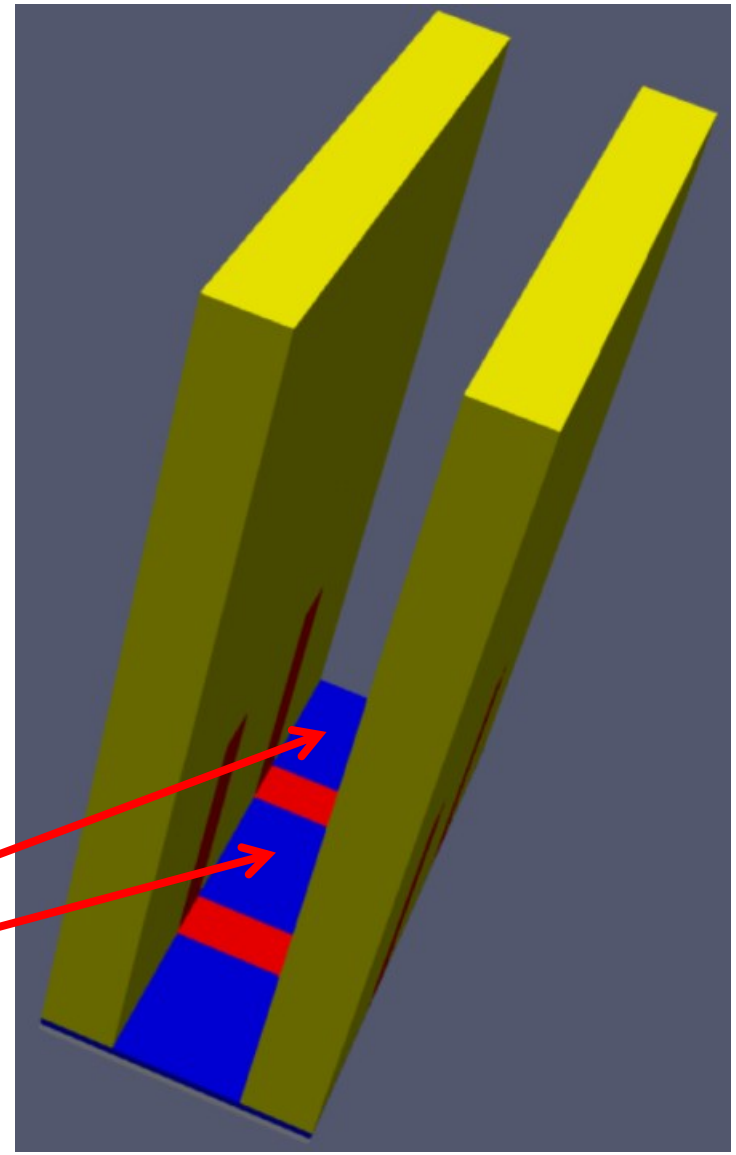
- We have a similar profile.
  - Of course, details cannot be reproduced.





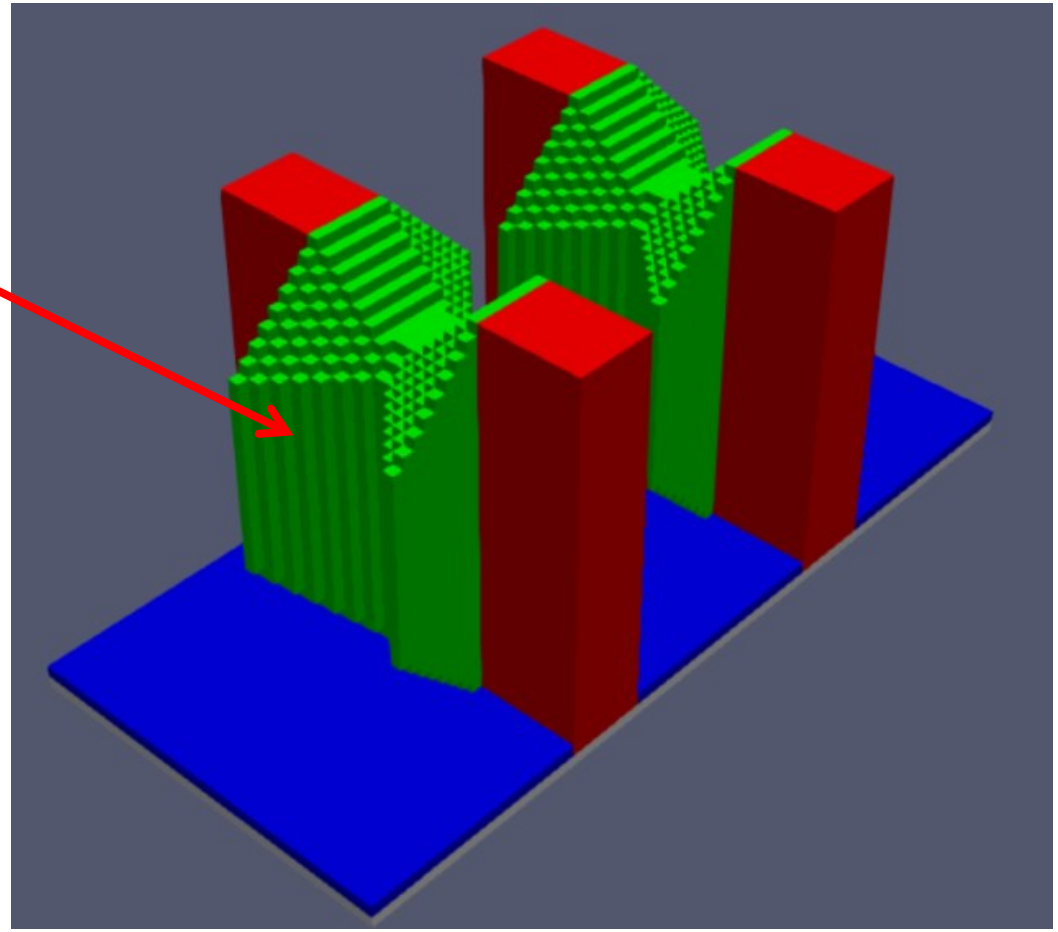
Three-dimensional shape

- 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.



Growth after cavity etching

- Contribution from two channels is dominant.
  - In this result, growth rates along (100) and (010) surfaces are underestimated.



```
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` statemtent, grow the epitaxial layer.

Thank you!