Computational Microelectronics L20

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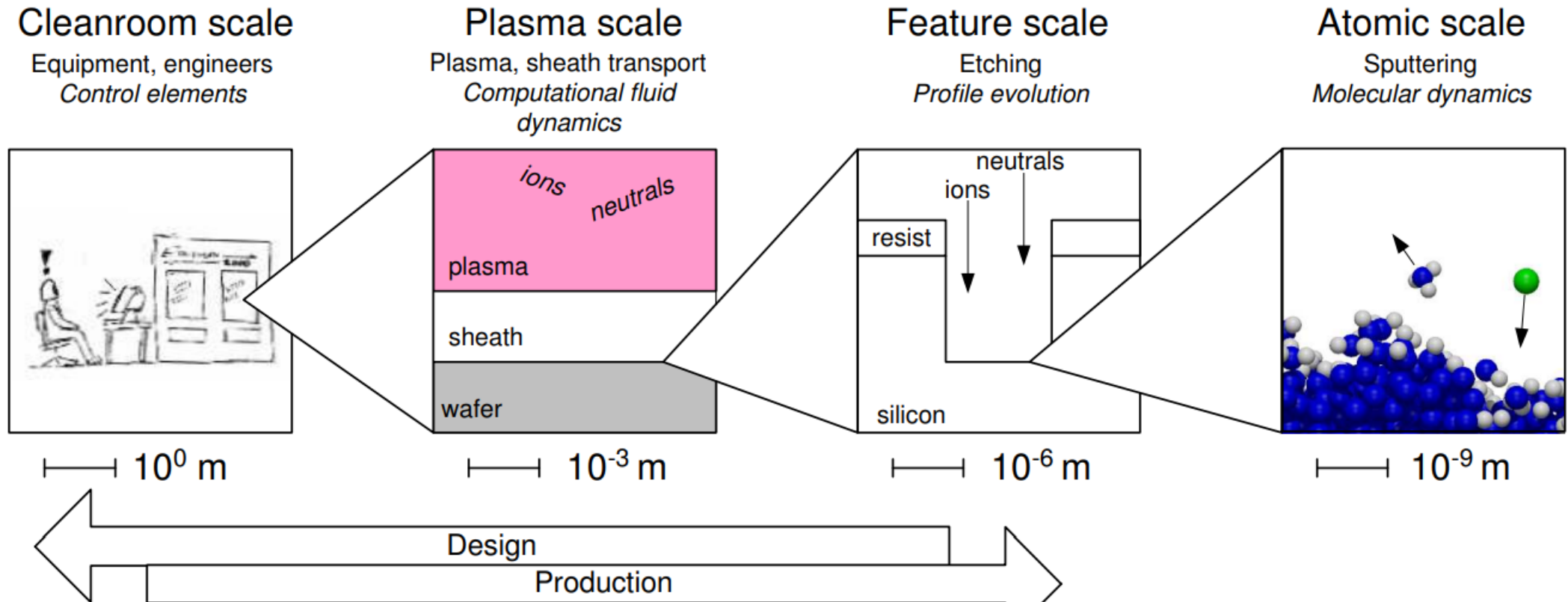
smhong@gist.ac.kr

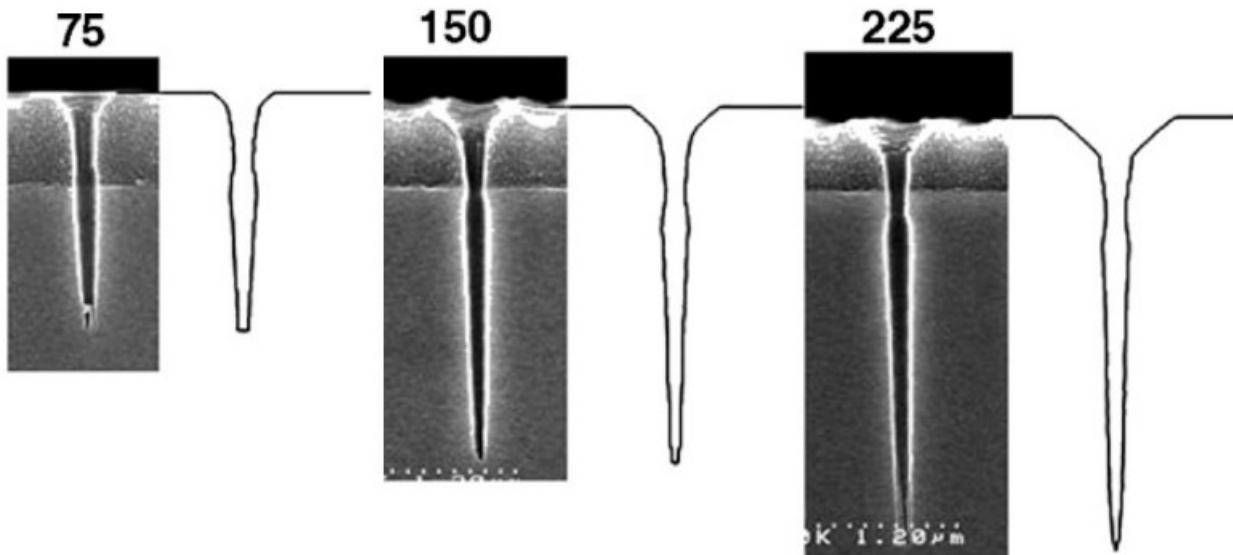Semiconductor Device Simulation Laboratory, GIST

Level-set

Etching

- Various scales are involved.

Flow of information in the semiconductor design and fabrication
(D. Humbird, Ph. D. dissertation, UC Berkeley, 2004)
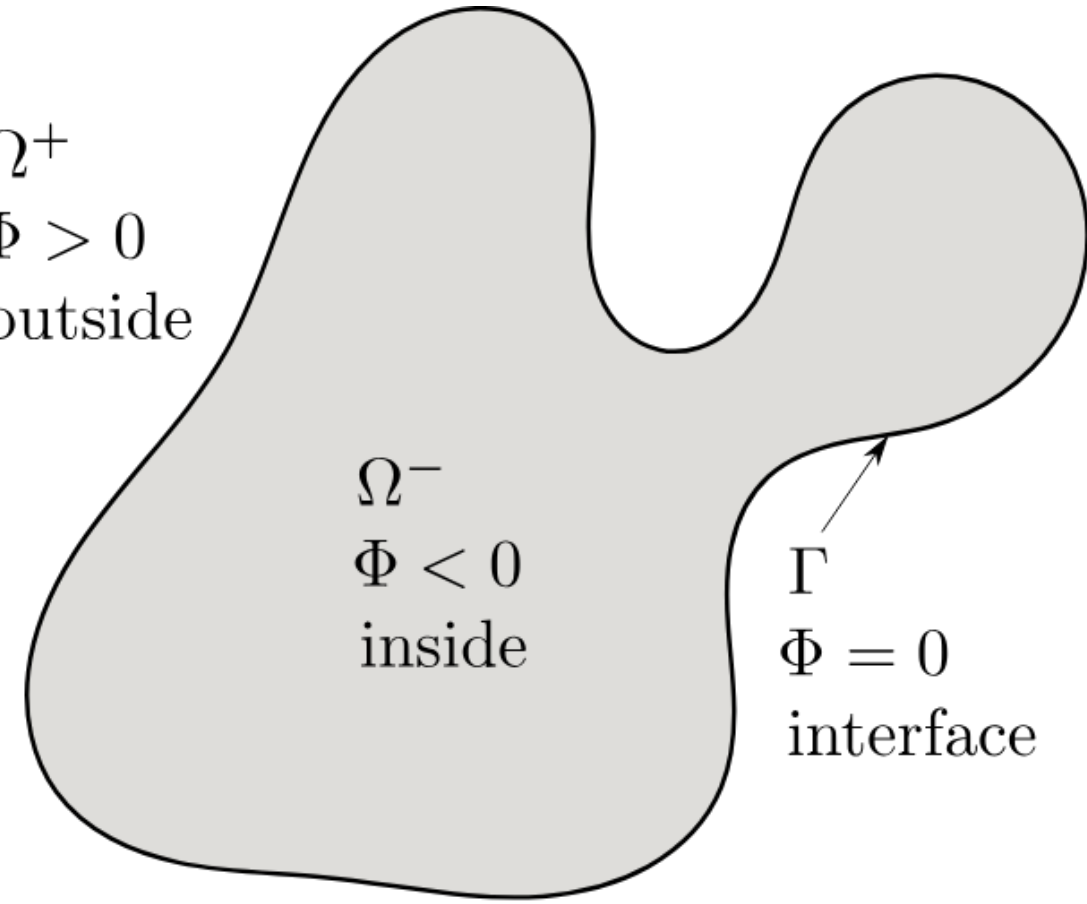
Feature scale

- Boundary evolution is important.
  - Moving boundary is troublesome.
  - Level-set method is most popular.

High aspect ratio contact etch
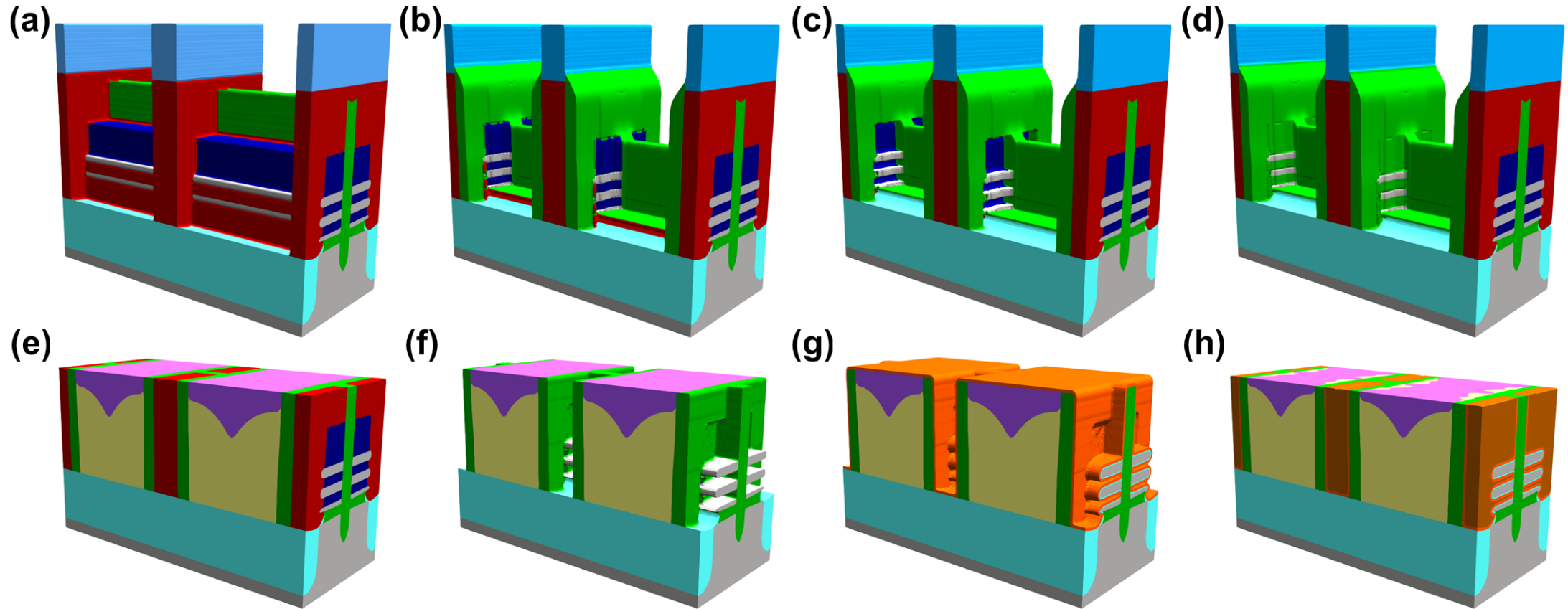(D. Kim, Thin Solid Films, 2006)

$$\Omega^+ \quad \Phi > 0 \quad \text{outside}$$

$$\Omega^- \quad \Phi < 0 \quad \text{inside}$$

$$\Gamma \quad \Phi = 0 \quad \text{interface}$$

Representation of a domain via the level-set function (M. Quell, Ph. D. dissertation, TU Wien, 2021)

Process "emulation"

- Check the feasibility of a given fabrication process
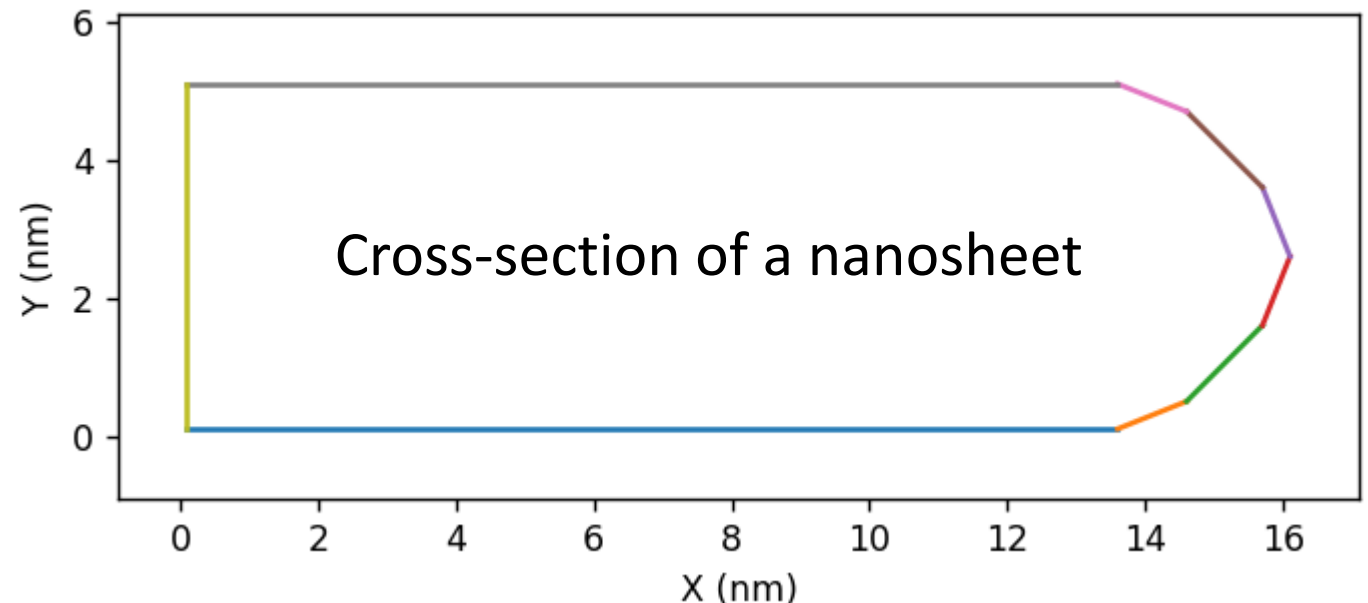

Process flow of a forksheet FET (I. Kim, SISPAD, 2023)

Loading an initial structure

- Two-dimensional space
  - We have a set of points. (Counter-clockwise) Draw edges connecting two neighboring points. (The last one is connected to the first one.)
  - For example,

0.1 0.1
13.6 0.1
14.6 0.5
15.7 1.6
16.1 2.6
15.7 3.6
14.6 4.7
13.6 5.1
0.1 5.1

Cross-section of a nanosheet

Alternative way

- Calculate the shortest distance from the boundary edges.
  - For the boundary point, it becomes 0.
  - We can calculate the distance on a rectangular grid.


2 nm is the shortest.
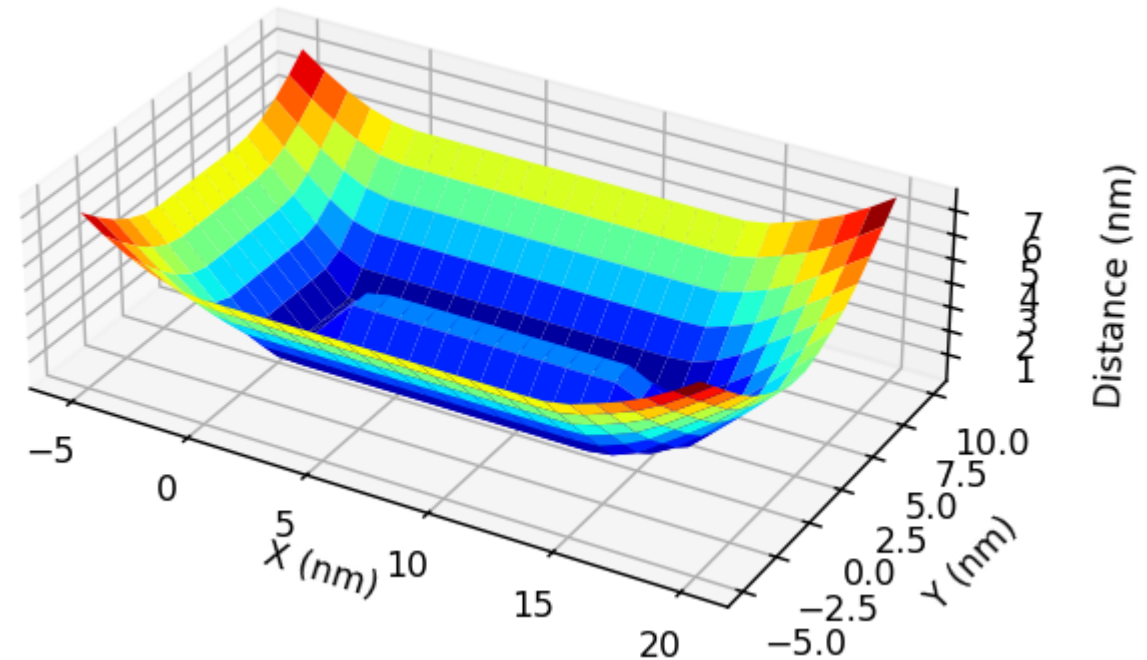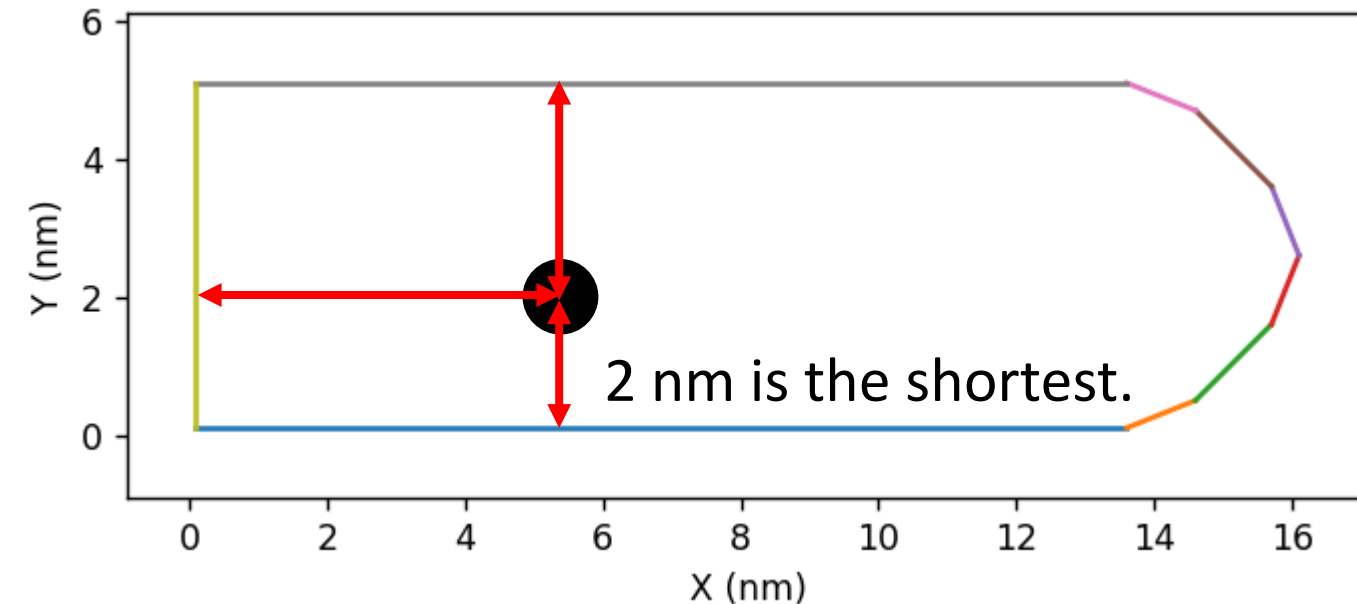
Interior? Exterior?

- It is better to assign a sign to represent interior/exterior points.
  - The convention is positive for an exterior point.
  - Then, negative for an interior point.
  - Since the surface is described in the counter-clockwise manner, by using the cross product, we can simply solve the point inclusion problem.
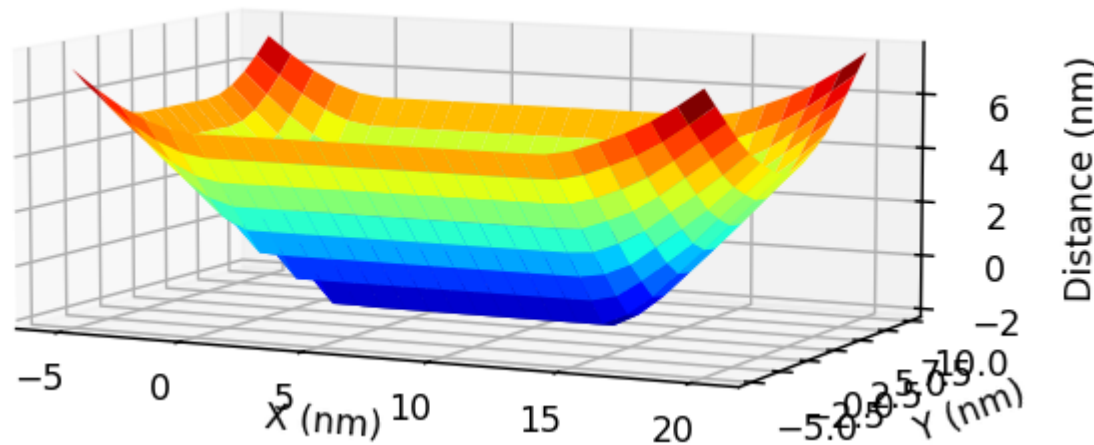
Re-constructing the boundary

- For each edge of the rectangular grid, we can find the point where the "level" vanishes.
  - For our example,
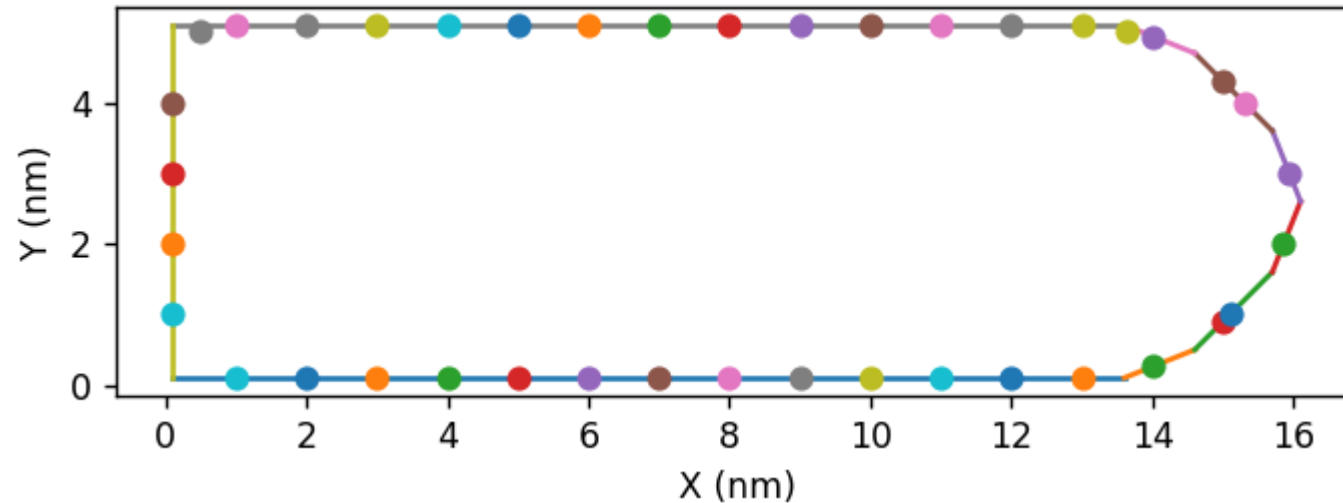
(Of course, the original boundary cannot be exactly re-constructed.)

Homework#20

- Due: AM08:00, November 28
- Problem#1
  - In this program, the user can provides a set of points. From this set of points, calculate the level-set.
  - Draw a three-dimensional graph for (x,y,level).
  - Test your program with your own cross-section.

Thank you for your attention!