EPITAXY

- Epitaxy is a very special case of thin-film deposition.
  - The deposited film is single crystalline.
  - The deposited layer registers the crystalline information from the substrate.
  - The crystal lattices of the film and the substrate must be identical or closely matching.

HETEROEPITAXY/EPITAXIAL GROWTH

- Homoepitaxy:
  - Substrate crystal is the same material of the grown thin film.
  - The growing crystal layer maintain the crystal structure and orientation of the substrate.
- The methods: chemical vapor (vapor-phase) deposition (CVD), liquid-phase deposition (LPE), solid-phase deposition (MBE)
- Heteroepitaxy:
  - Epitaxial layers are different materials from substrate.
  - The growing crystal layer maintain the crystal structure and orientation of the substrate, if the lattice structure and constant a match for the two materials.
  - Buffer layer: a thin low temperature growth film between substrate and epitaxial thin film to reduce misfit dislocations and stress.

HETEROEPITAXY/LATTICE MATCHING IN EPITAXIAL GROWTH

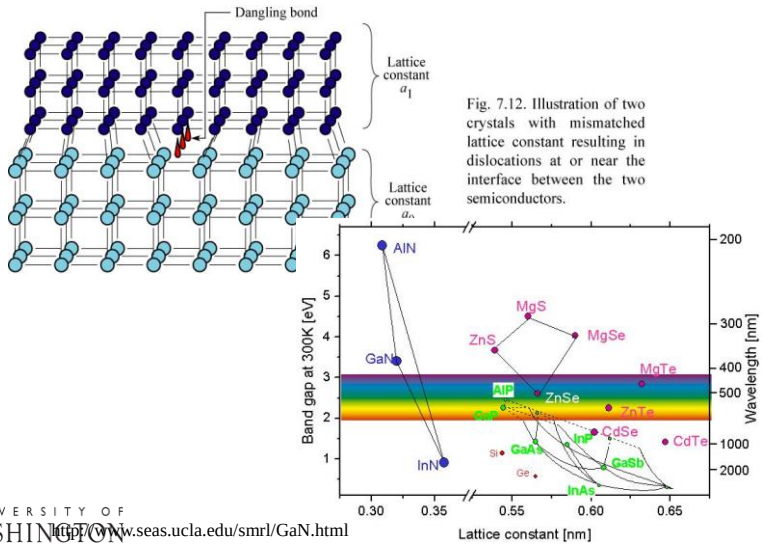

Fig. 7.12. Illustration of two crystals with mismatched lattice constant resulting in dislocations at or near the interface between the two semiconductors.

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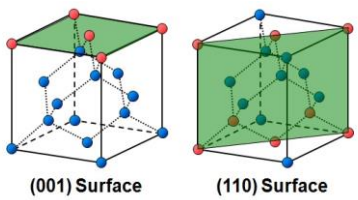
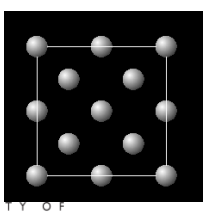
http://www.seas.ucla.edu/smrl/GaN.html

HETEROEPITAXY/LATTICE MATCHING IN EPITAXIAL GROWTH

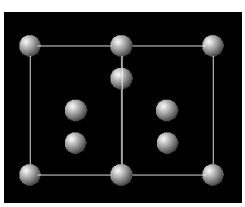


ero02.eps.png

View in <100> direction



View in <110> direction



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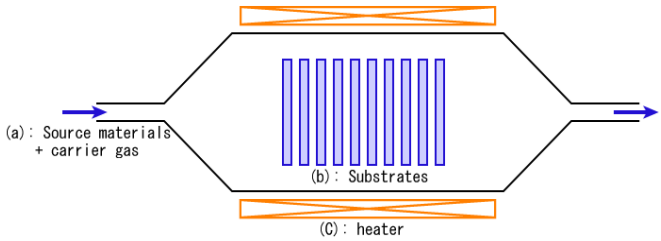
EPITAXY/VAPOR-PHASE EPITAXY (CVD)

- VPE is a particular important source of semiconductor material.
- Advantages:
  - Low temperature and high purity growth.



Reaction chamber: Reactor
Heating: rf heating or W halogen lamps
http://en.wikipedia.org/wiki/

EPITAXY/VAPOR-PHASE EPITAXY (CVD)

Use Si VPE as an example:

- Dichlorosilane at 1150 °C

$$SiH_2Cl_2\ (g) \Rightarrow Si\ (s) + 2\ HCl\ (g)$$

- A gas phase of silicon tetrachloride ($SiCl_4$) reacts with H_2, at 1250 °C

$$SiCl_4\ (g) + 2H_2\ (g) \Leftrightarrow Si\ (s) + 4\ HCl\ (g)$$

- This reaction is reversible, and cleaning is possible with HCl when the reaction proceeds from right to left.
- Above process temperatures are very high and undesirable for certain fabrication processes.
- Use silane as the Si source at 500 – 1000 °C

$$SiH_4\ (g) \leftrightarrow Si\ (s) + 2H_2\ (g)$$

CVD/CVD POLYSILICON

CVD Poly-silicon

- Pyrolysis of silane: $SiH_4 \rightarrow Si + 2H_2$
  - LPCVD Process 1: 100% SiH_4, 0.2 - 1.0 torr
  - LPCVD Process 2: 30% SiH_4 in nitrogen, 0.2 - 1.0 torr
  - deposition rates: 10 - 20 nm/min
  - APCVD: 3% SiH_4 in nitrogen
- Amorphous (< 600°C) or polycrystalline (> 600°C)