

Section 2 Materials

2.3 Atomic Positions and Bond Orientations

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Computer Engineering

Section 2 Materials

• 2.1 Typical Semiconducting Materials

- » Current flow in semiconductors (reminder)
- » Elemental semiconductors in the periodic table
- » Bonding for half-filled shells, column IV, III-V, and II-VI

II	III	IV	V	VI
Be	B	C	N	O
Mg	Al	Si	P	S
Zn	Ga	Ge	As	Se
Cd	In	Sn	Sb	Te
Hg	Tl	Pb	Bi	Po

• 2.2 Typical applications of elemental and compound semiconductors

Elemental (e.g., Si, Ge, C)

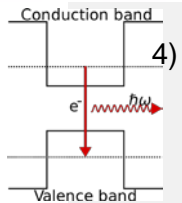
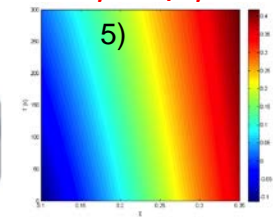
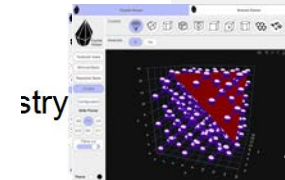
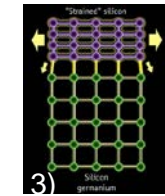
Compound

IV-IV: Si-Ge, Si-C

III-V: InP, GaAs, $(\text{In}_x\text{Ga}_{1-x})(\text{As}_y\text{P}_{1-y})$

II-VI: $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$

IV-VI: PbS



• 2.3 Atomic Positions and Bond Orientations

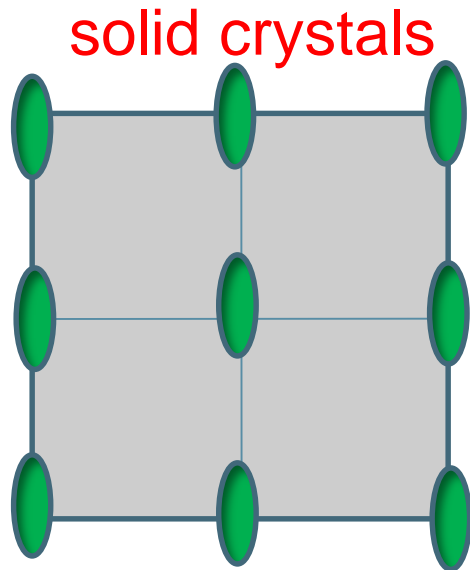
- » Solid State vs. other crystals
- » Typical Atomic Arrangements in MOSFETS

One Video Segment

One Video Segment

One Video Segment

Spatial Atomic Arrangements Position and Bond Orientation



specific position
specific orientation

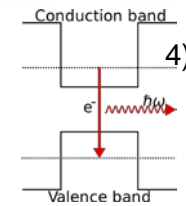
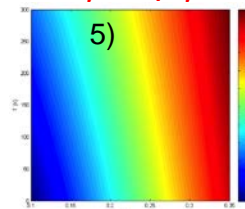
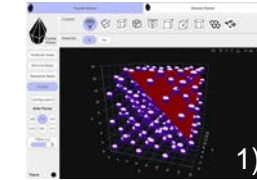
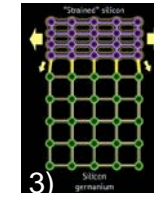
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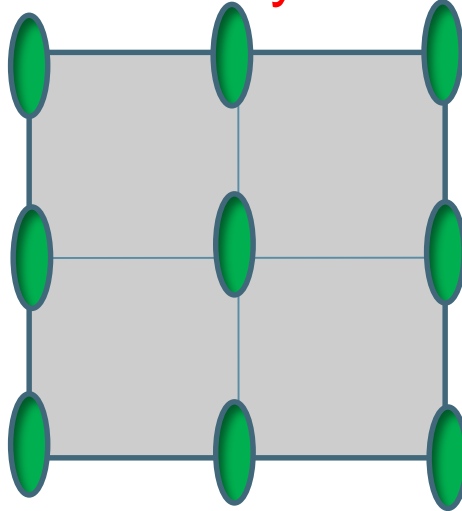


II	III	IV	V	VI
Be	B	C	N	O
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- Columns II-VI build a "Lego-like" tool box for semiconductor Devices
- Chemical differences lead to different bandgaps
- Physical lattice mismatch leads to strain
 - Can be design feature or a physical instability
- Not all combinations possible:
 - lattice mismatch, room temperature instability

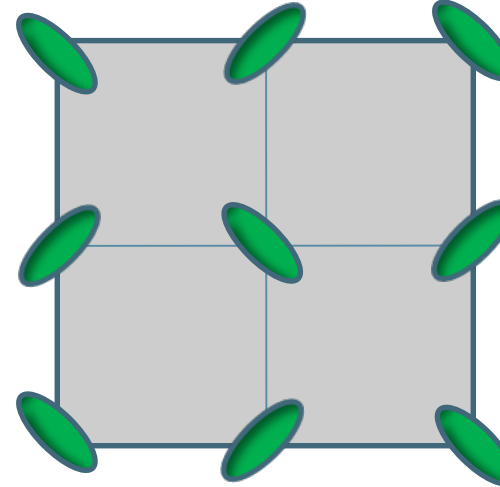
Spatial Atomic Arrangements Position and Bond Orientation

solid crystals



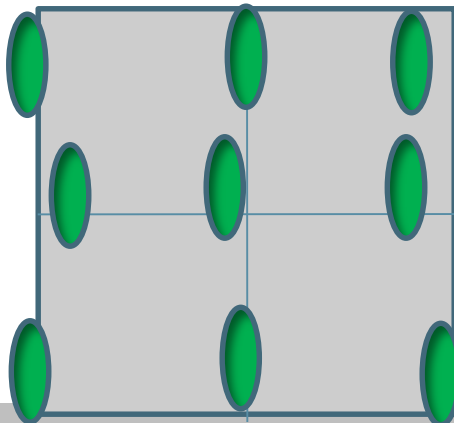
specific position
specific orientation

plastic crystals



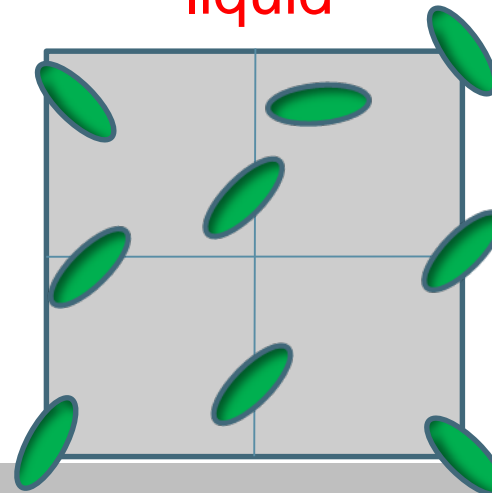
specific position
random orientation

liquid crystals



random position
specific orientation

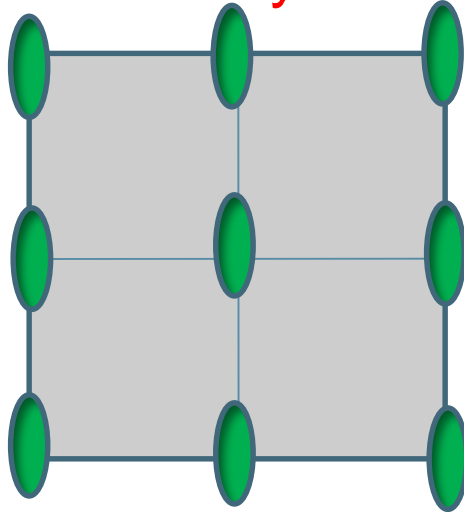
liquid



random position
random orientation

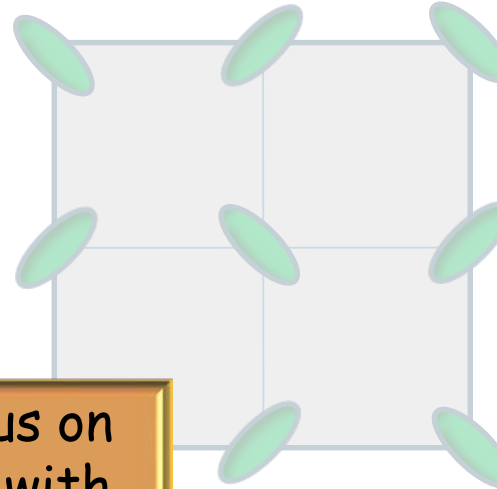
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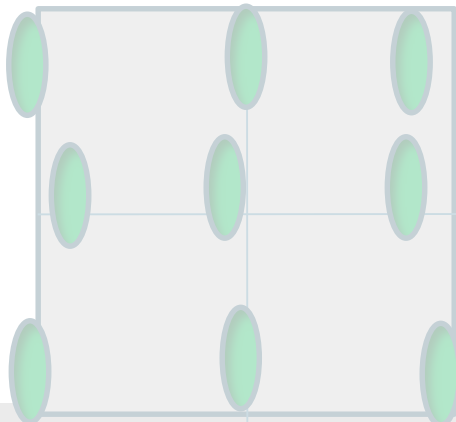
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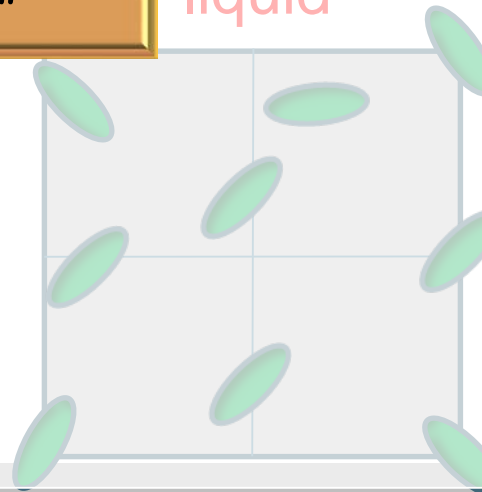
specific position
random orientation

liquid crystals



random position
specific orientation

liquid

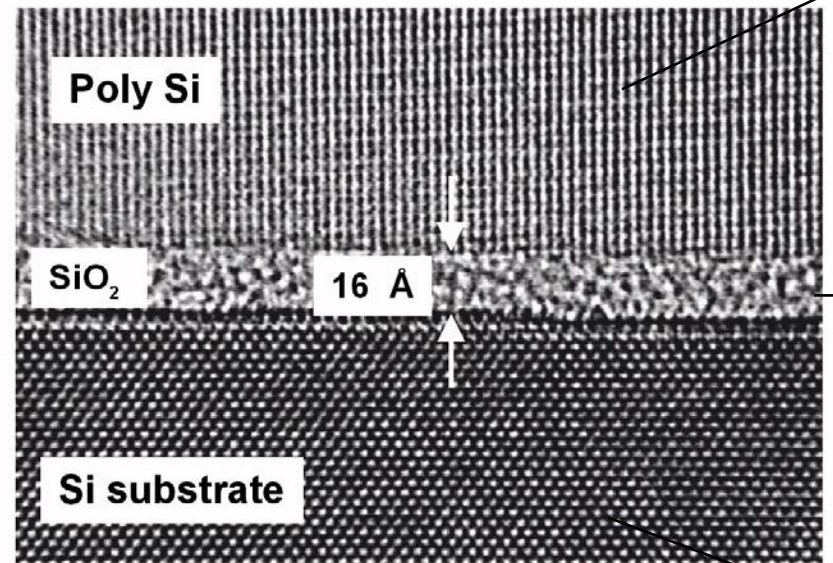


random position
random orientation

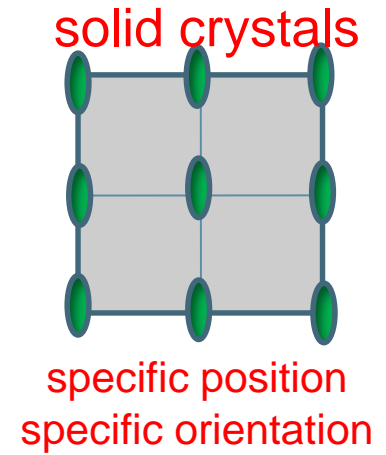
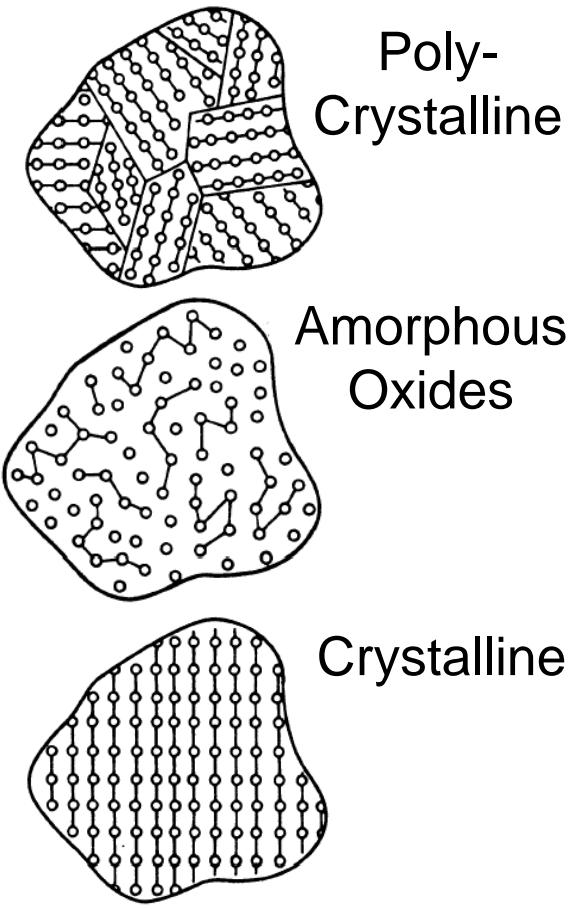
Course will focus on
solid materials with
stable bonds:
"Solid State"

Solid State Atomic Arrangements in MOSFETS

Cross section of a MOSFET

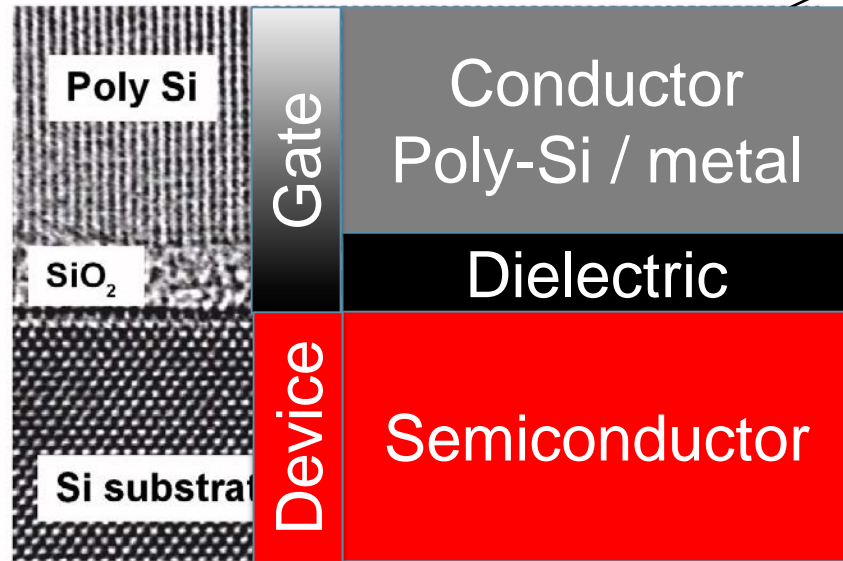


Substrate is a perfectly arranged Si crystal



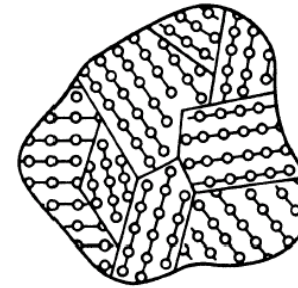
Functional Layers in MOSFETS

Cross section of a MOSFET

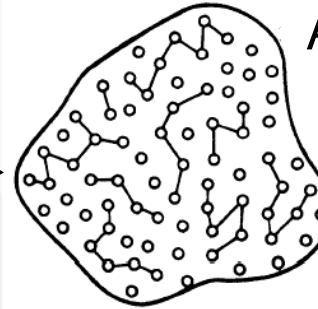


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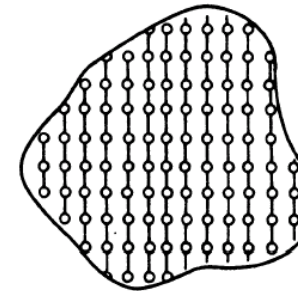
Device is a perfectly arranged crystal



Poly-Crystalline
Conductive
Electron transport
Hold charge



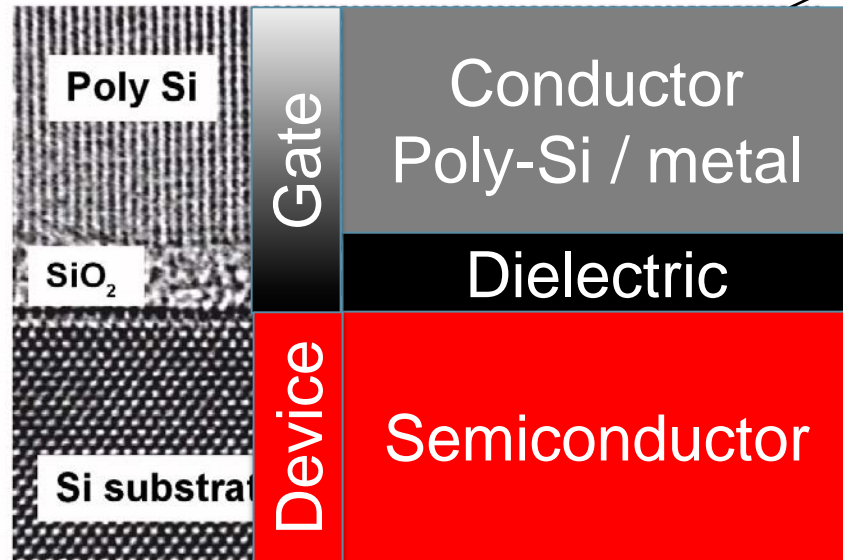
Amorphous Oxides
Non-Conductive
"NO" transport



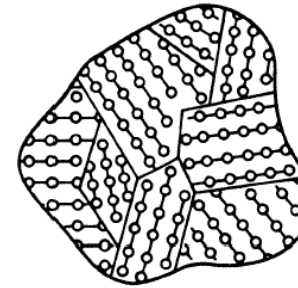
Crystalline
Highly conductive
Electron transport

Functional Layers in MOSFETS

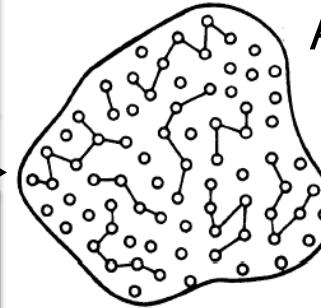
Cross section of a MOSFET



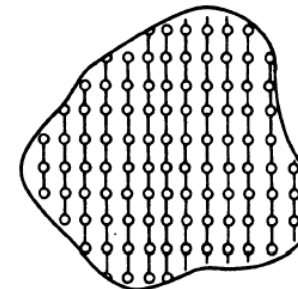
Device is a perfectly arranged crystal



Poly-Crystalline
Conductive
Electron transport
Hold charge



Amorphous Oxides
Non-Conductive
"NO" transport



Crystalline
Highly conductive
Electron transport

- Modern solid state devices use all forms these forms of materials
- Focus on Crystals first - start with 1D => 2D => 3D
- Transfer concepts of electronic behavior in crystals to other materials

Section 2 Materials

One Video Segment

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 - » Bonding for half-filled shells, column IV, III-V, and II-VI

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One Video Segment

- 2.2 Typical applications of elemental and compound semiconductors

Elemental (e.g., Si, Ge, C)

Si: Transistors - \$260billion industry

Compound

IV-IV: Si-Ge, Si-C

SiGe: stressors

SiC: radiation

III-V: InP, GaAs, $(In_xGa_{1-x})(As_yP_{1-y})$

Light Emitting Diodes, Lasers, Detectors

expensive

II-VI: $Hg_{1-x}Cd_xTe$

Far IR detectors

Soft and difficult

One Video Segment

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 - » Typical Atomic Arrangements in MOSFETS

Functional Layers in MOSFETS

Cross section of a MOSFET

Device is a perfectly arranged crystal

- Modern solid state devices use all forms these forms of materials
- Focus on Crystals first - start with 1D \Rightarrow 2D \Rightarrow 3D
- Transfer concepts of electronic behavior in crystals to other materials

PbS semiconductor diodes

soft and difficult