Section 2 Materials
2.2 Typical applications of elemental and compound semiconductors

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School of Electrical and Computer Engineering

Section 2
Materials

One Video Segment

- 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

One Video Segment

- 2.2 Typical applications of elemental and compound semiconductors

One Video Segment

- 2.3 Atomic Positions and Bond Orientations
  - » Solid State vs. other crystals
  - » Typical Atomic Arrangements in MOSFETS

Applications of Elemental Semiconductors

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

Si: Transistors - $260billion industry

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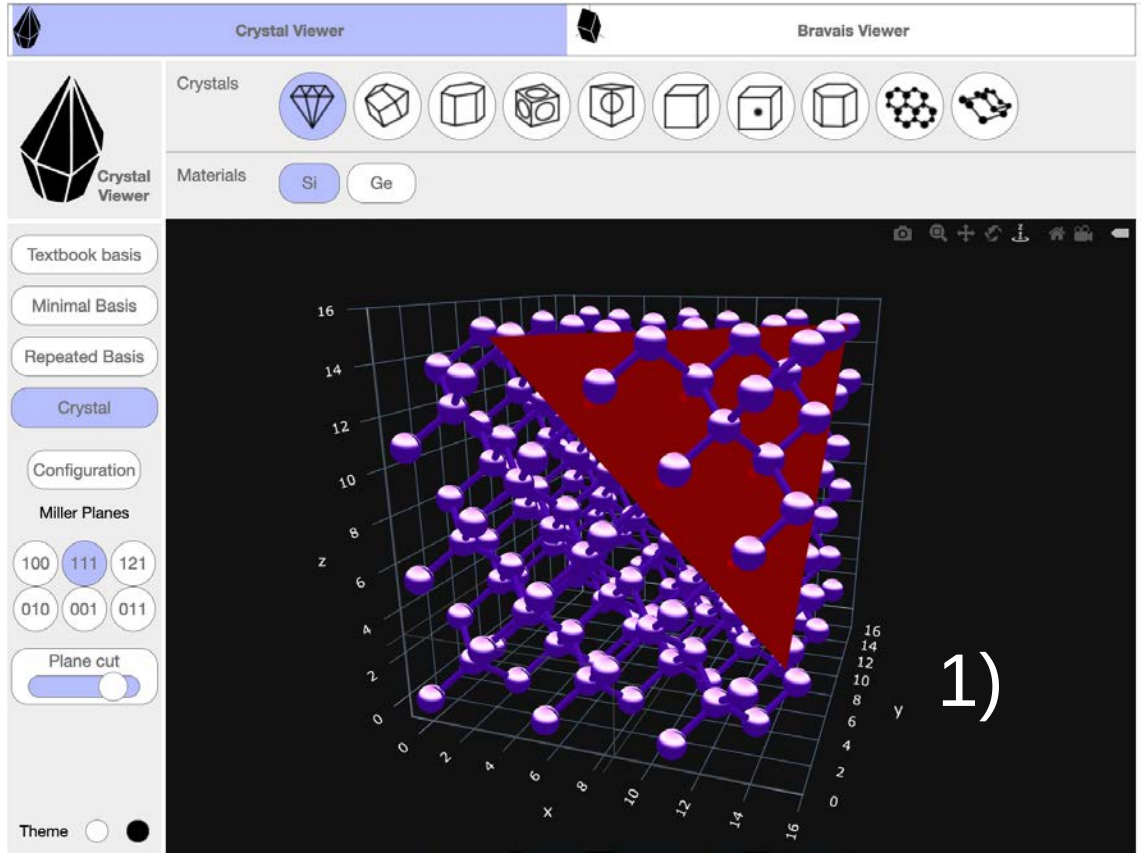

1)

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Applications of Elemental Semiconductors Compounds

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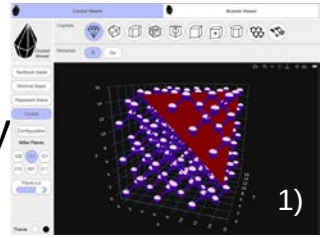
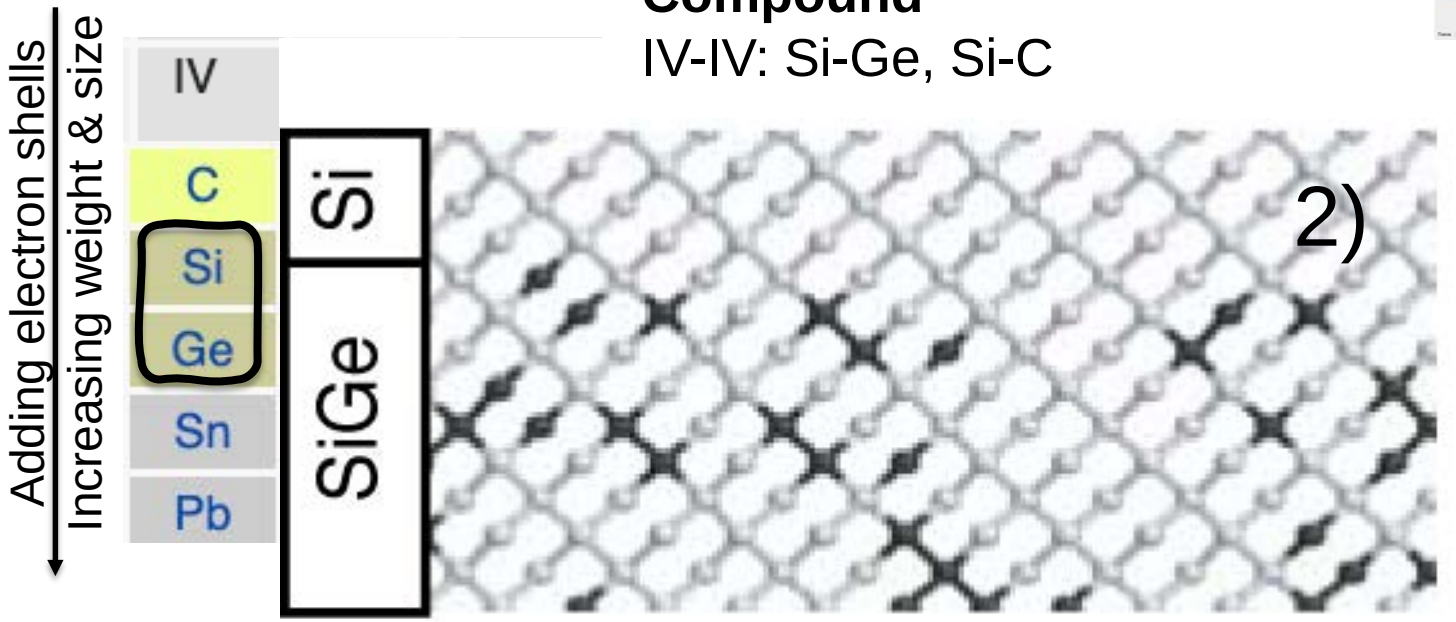


Compound

IV-IV: Si-Ge, Si-C



SiGe is a random alloy!

- No long-range order
- Interfaces are NOT atomically flat
- NOT a uniform bond length

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2) © Gerhard Klimeck

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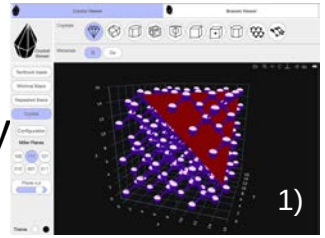

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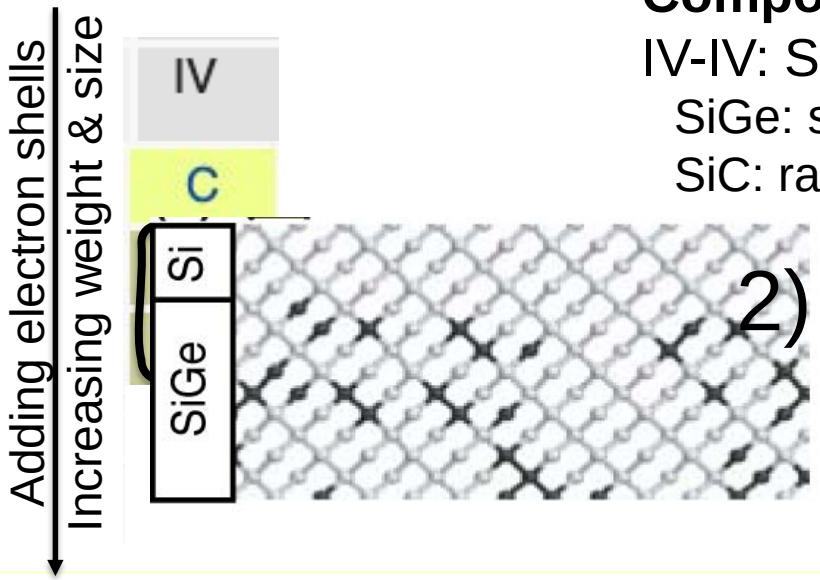
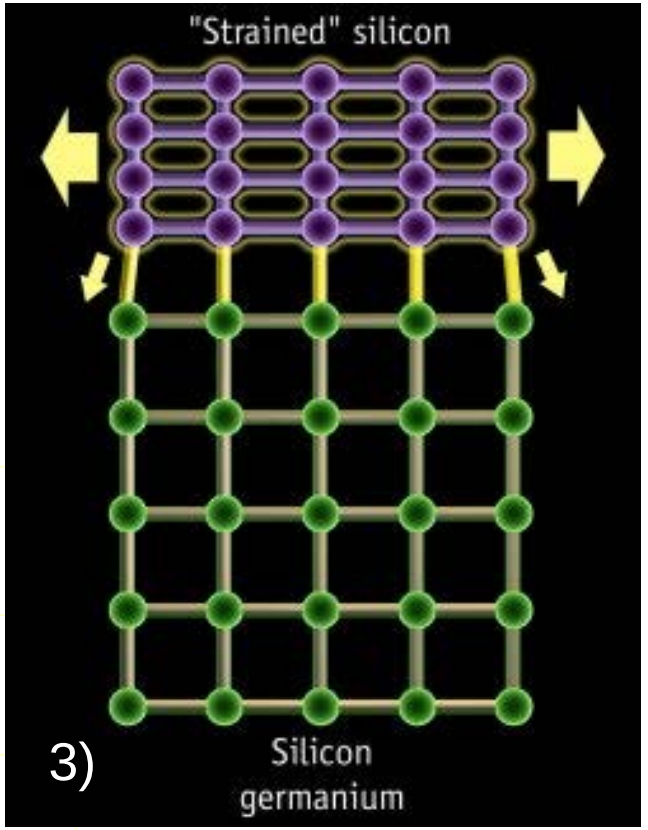
SiGe: stressors

SiC: radiation





Top layer has a different natural lattice constant
=> get strained to fit!

Strained bonds => modified "electron sharing"
=> modified electronic properties

=> Bandgaps, effective masses, mobility….

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2) © Gerhard Klimeck
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Applications of III-V Compound Semiconductors

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

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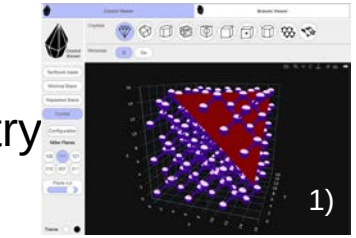

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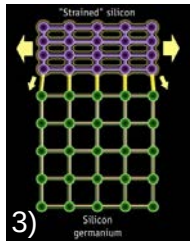
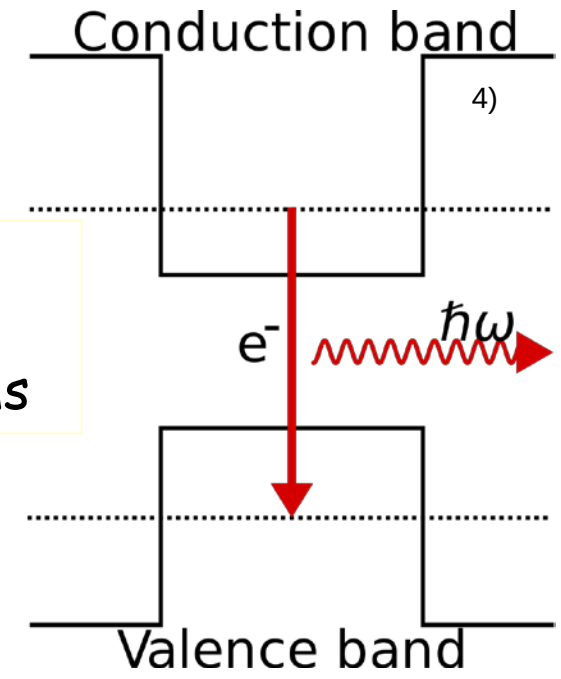


III-V: InP, $GaAs$, $(In_xGa_{1-x})(As_yP_{1-y})$

Light Emitting Diodes, Lasers, Detectors

expensive

Different bandgaps
=> Heterostructure engineering
=> Artificial atoms with custom designed wavelengths



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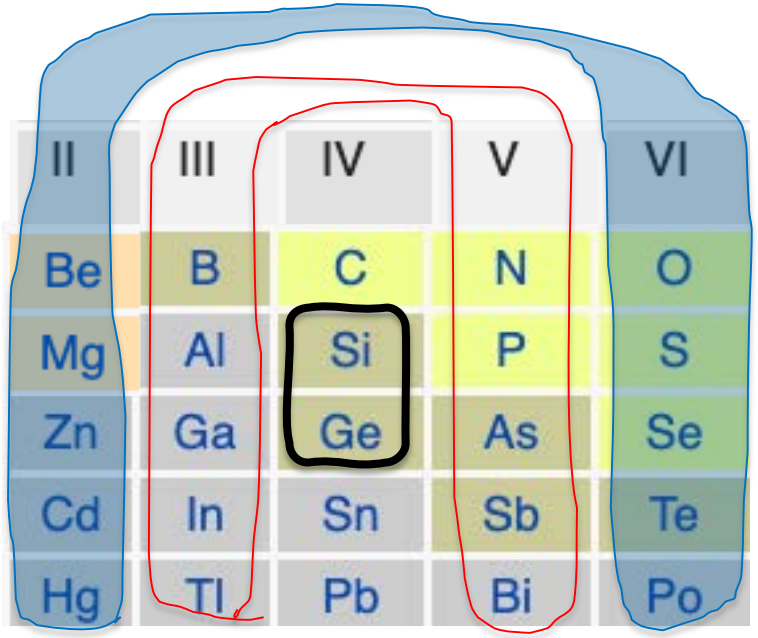
Applications of II-VI Compound Semiconductors



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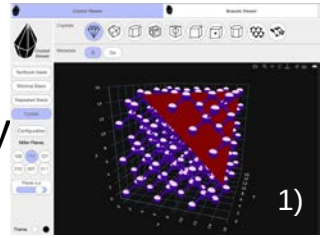

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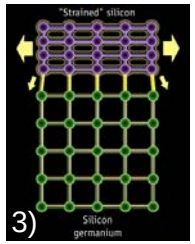

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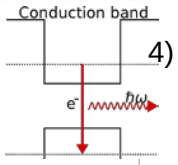
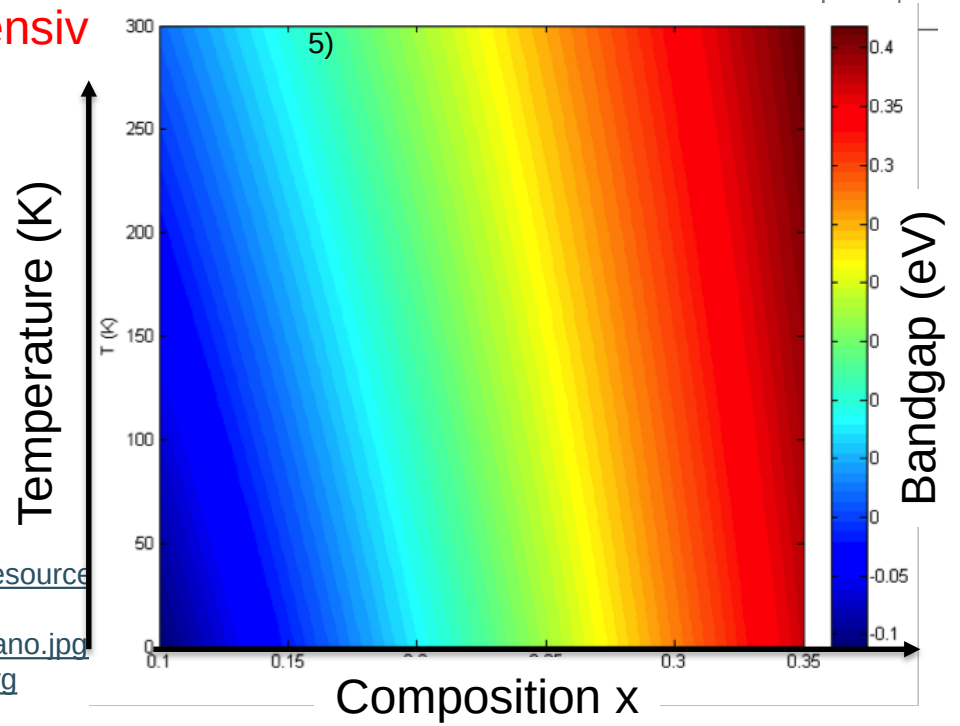
expensiv



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

Far IR detectors

Soft and difficult



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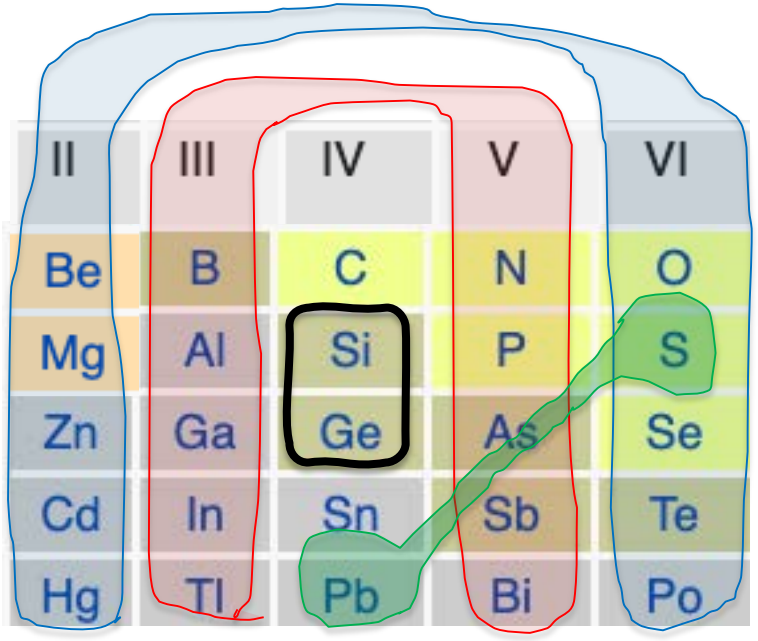
5) https://commons.wikimedia.org/wiki/File:Hgcdte_bandgap_x_t.png

Lead Sulfide – PbS – is different!



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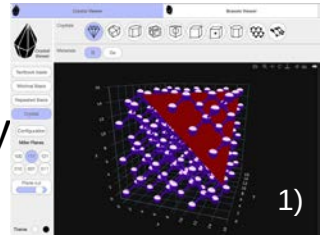

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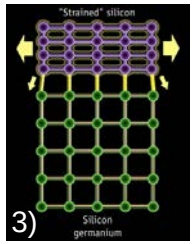

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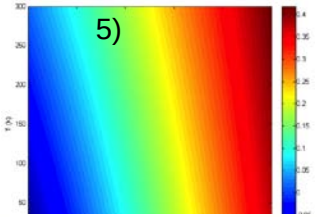

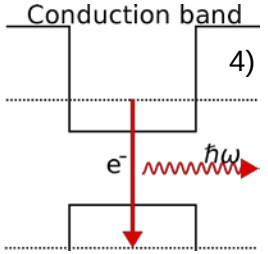

II-VI: $Hg_{1-x}Cd_xTe$

Far IR detectors

Soft and difficult

IV-VI: PbS

Outlier from the column IV balance

First semiconductor diodes

Very soft and difficult

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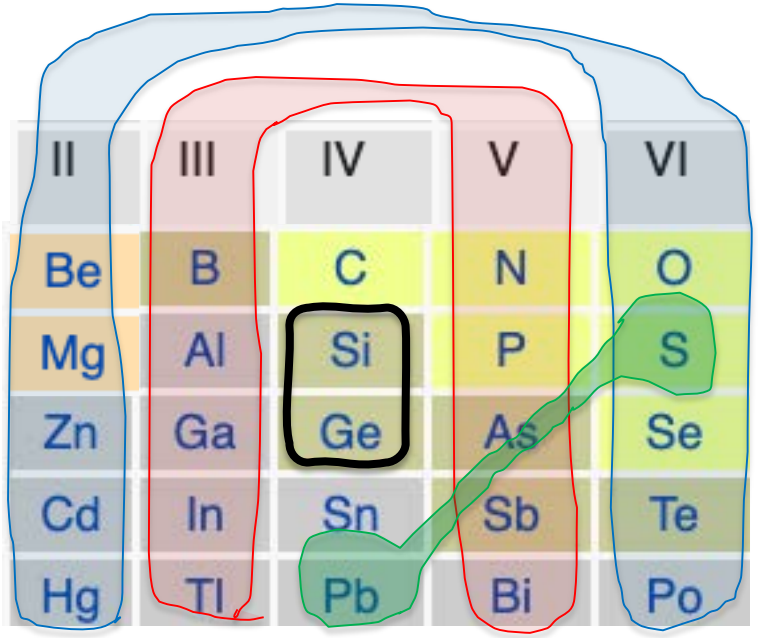
Applications of Semiconductors



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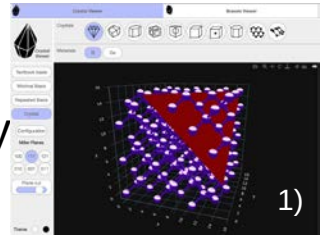

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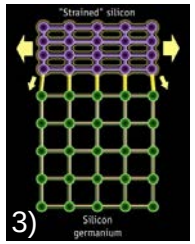

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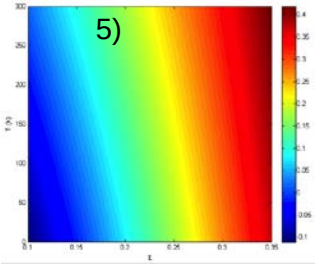

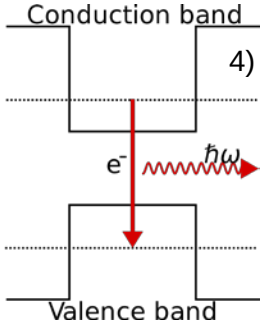

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Materials are the Toolbox for Devices

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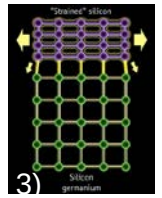

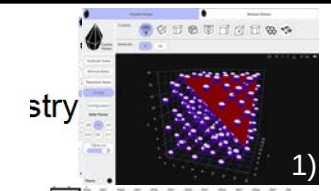

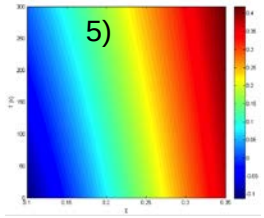

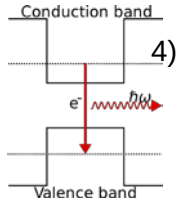

- Columns II-VI build a "Lego-like" tool box for semiconductor Devices
- Chemical differences lead to different bandgaps
- Physical lattice mismatch leads to strain
  - Can be design feature or a physical instability
- Not all combinations possible:
  - lattice mismatch, room temperature instability

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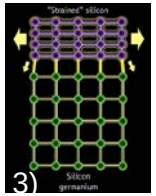

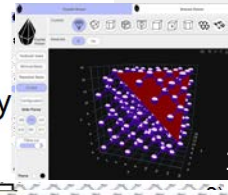

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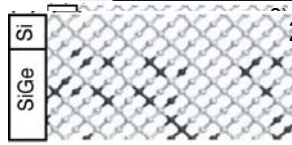

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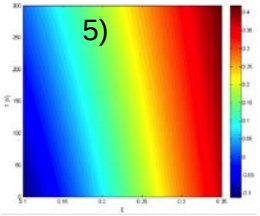

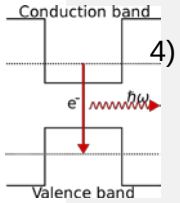

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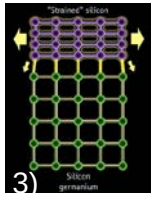

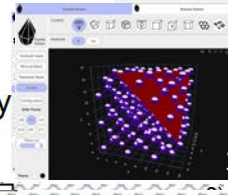

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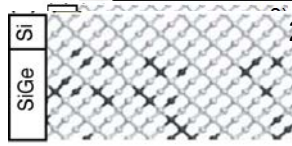

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