Crystal structures

Crystal Structure

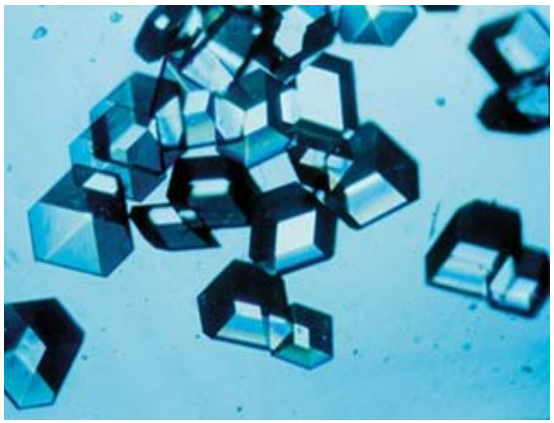
Atoms are arranged in a periodic pattern in a crystal.

The atomic arrangement affects the macroscopic properties of a material.

Many important materials (silicon, steel) are crystals

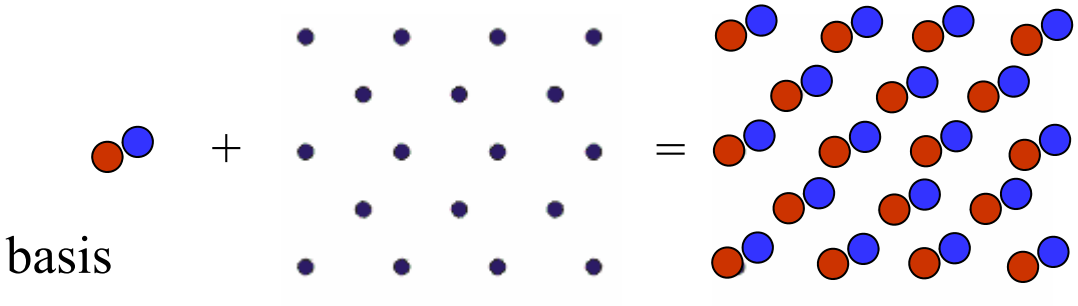
Gallium crystals

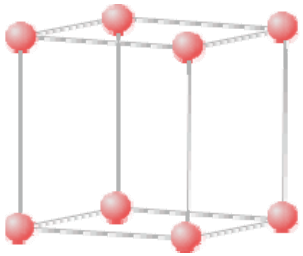
quartz



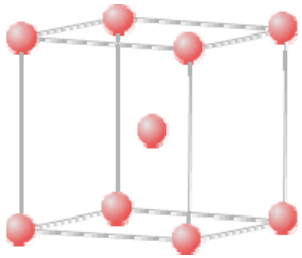
Insulin crystals

Crystal Structure

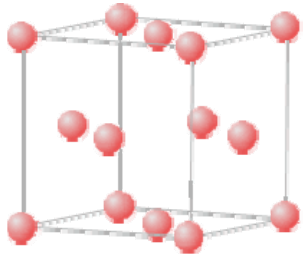




simple cubic

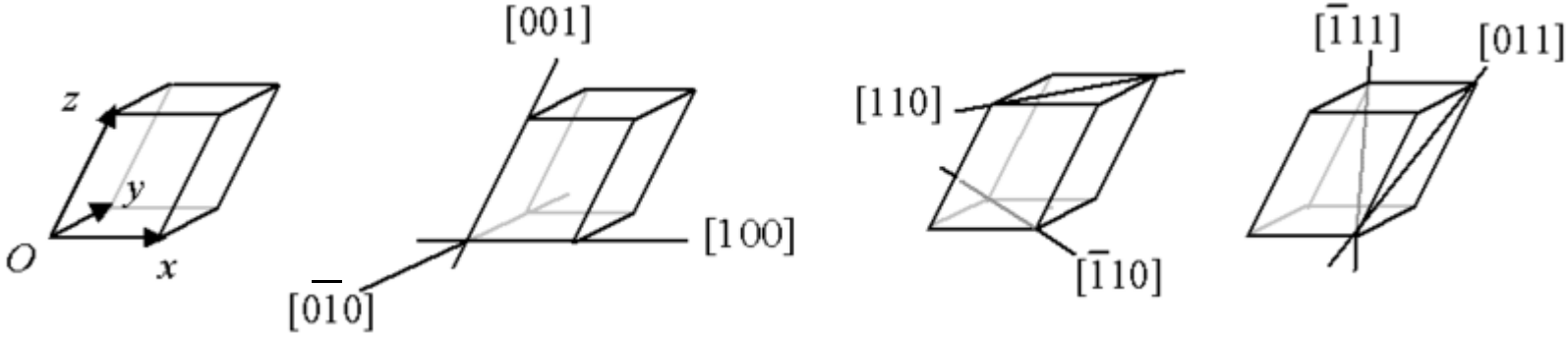


body centered cubic, bcc

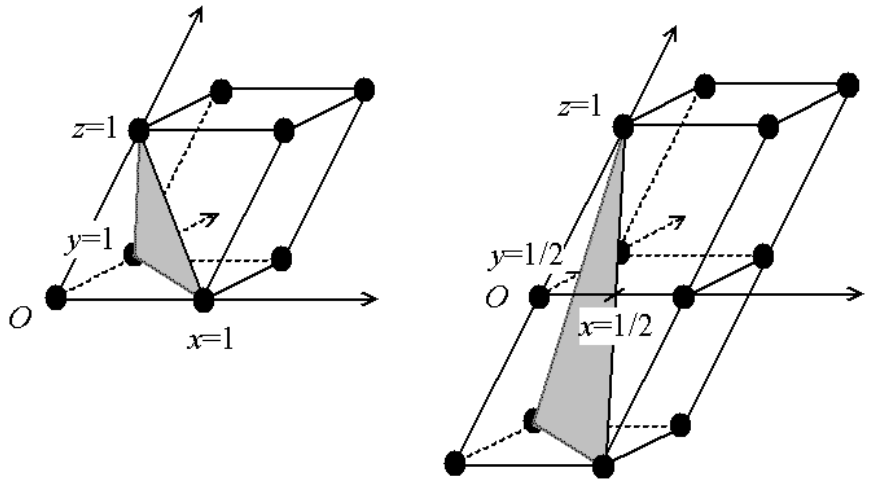


face centered cubic, fcc

Crystal planes and directions: Miller indices



plan (111) plan (221)

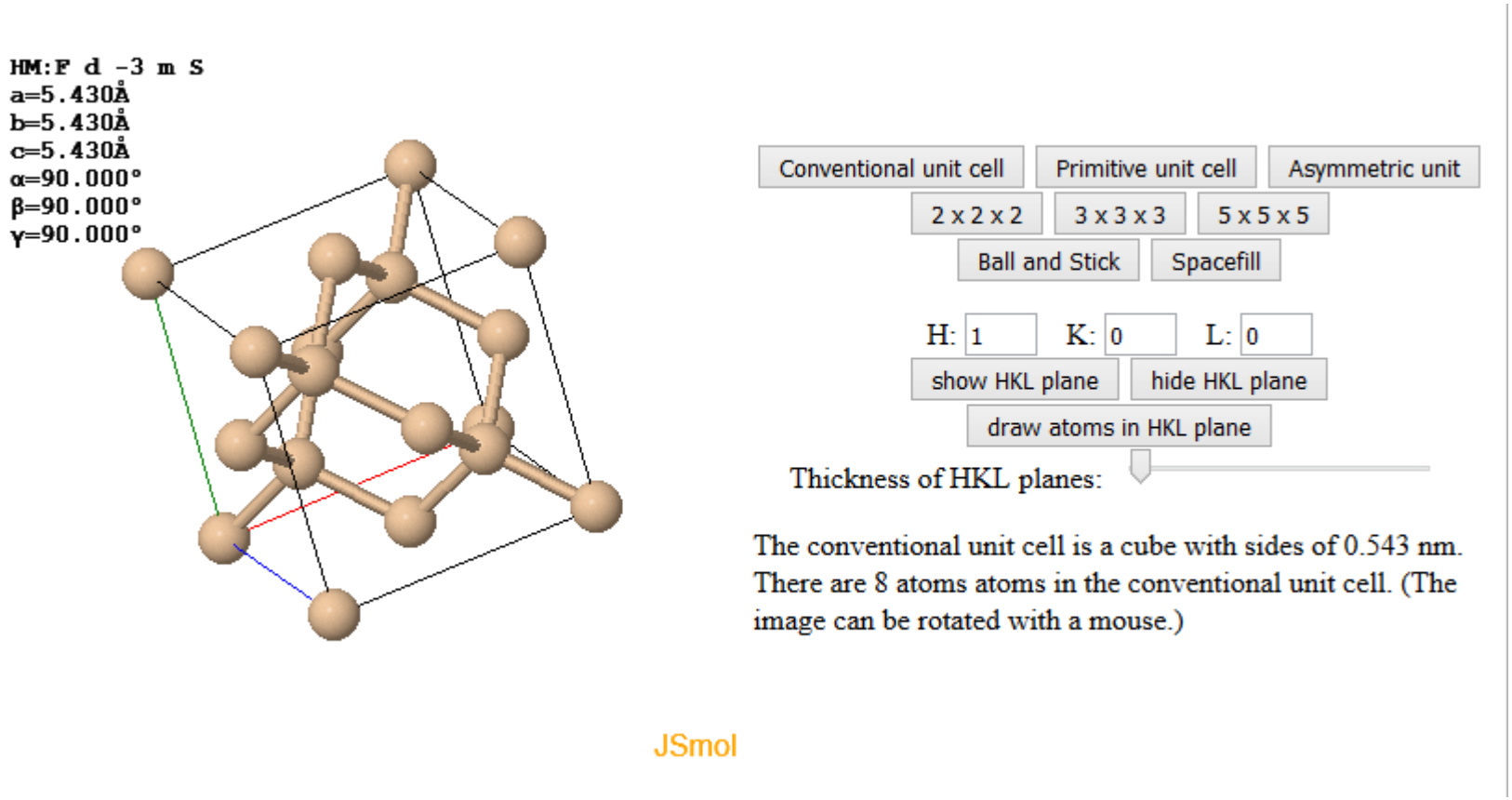


A plane with the intercepts $1/h$, $1/k$, $1/l$ is the (h,k,l) plane.

[ ] specific direction
< > family of equivalent directions
( ) specific plane
{ } family of equivalent planes

MOSFETs are made on <100> wafers

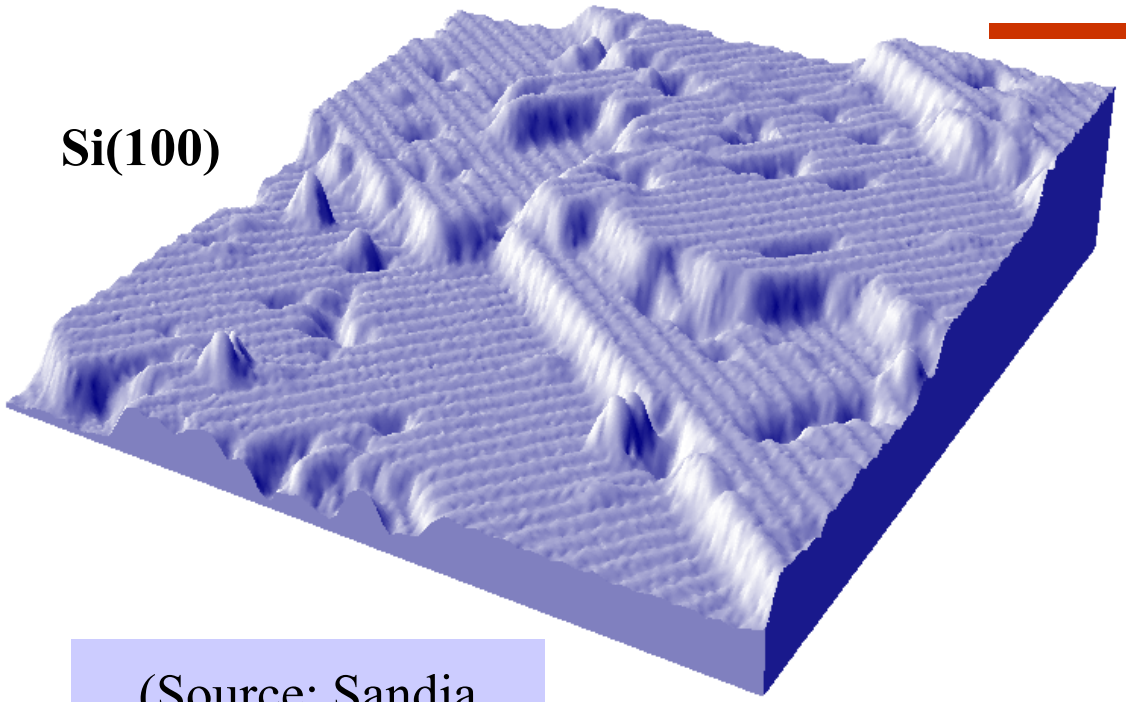
silicon



http://lampx.tugraz.at/~hadley/memm/materials/silicon/silicon.php

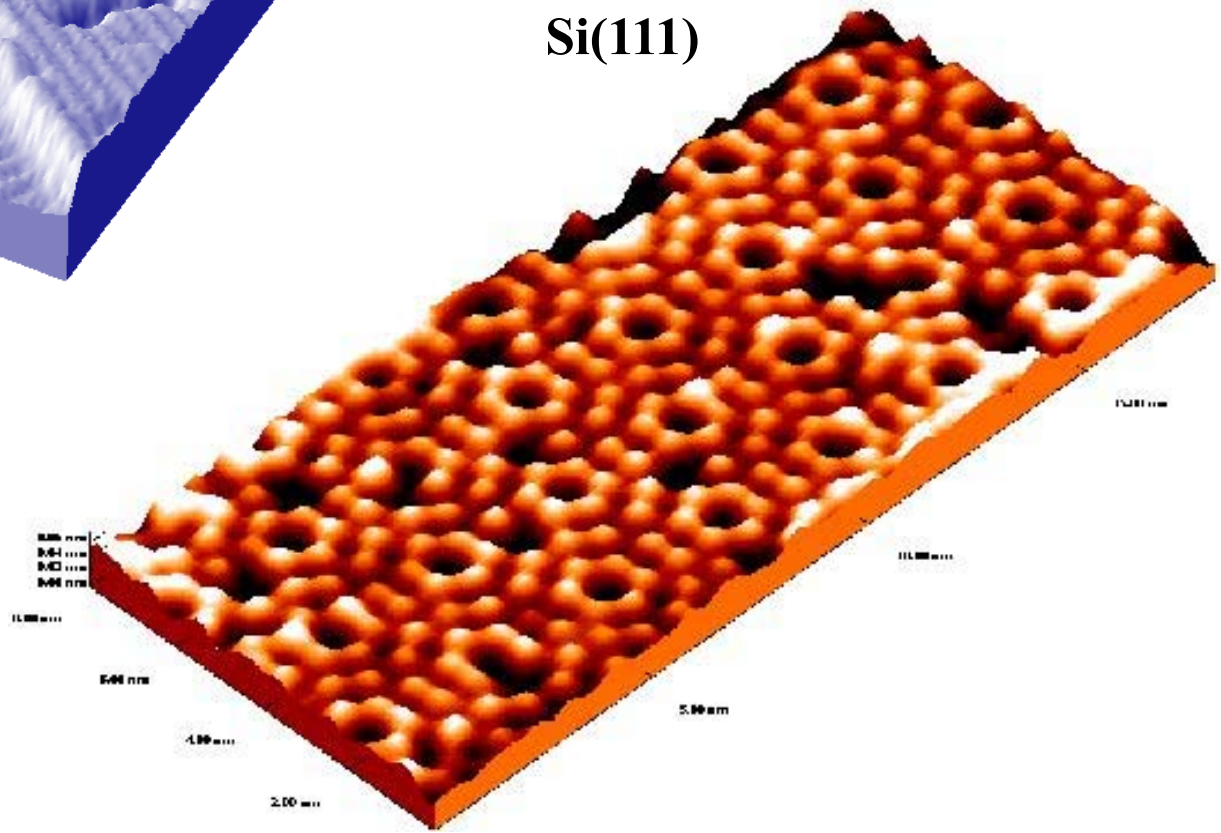
Silicon surfaces

Si(100)

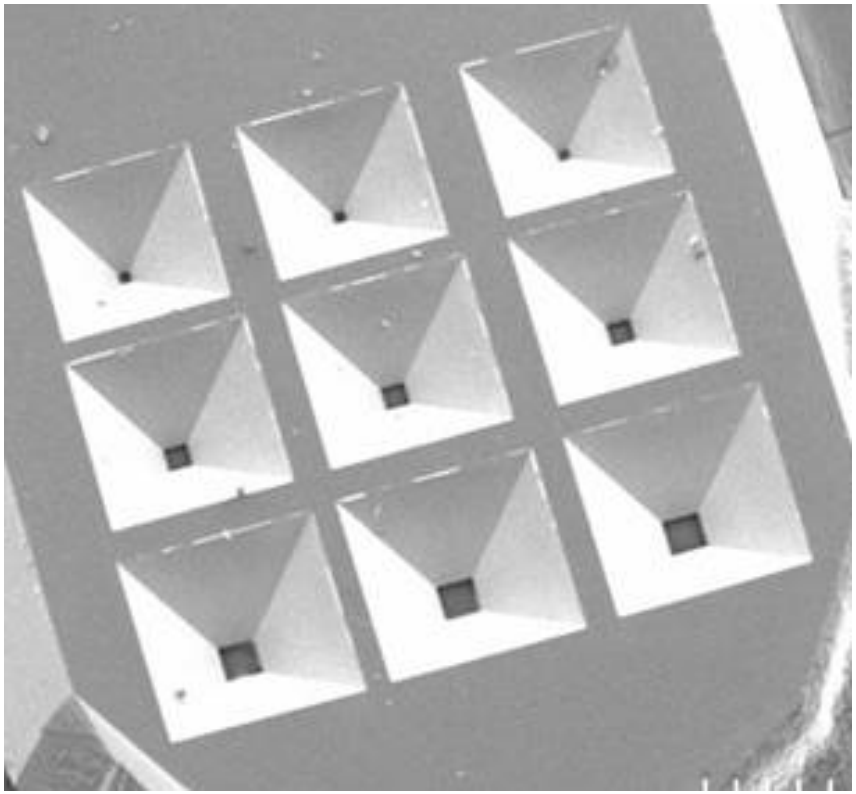


(Source: Sandia Nat.Labs.)

Si(111)



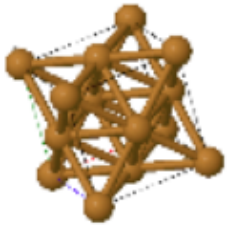
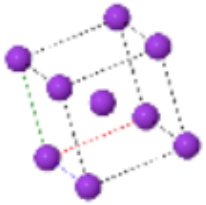
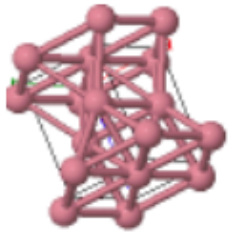
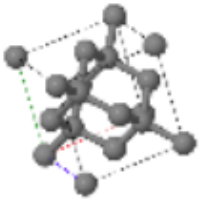
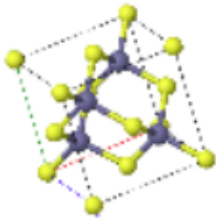
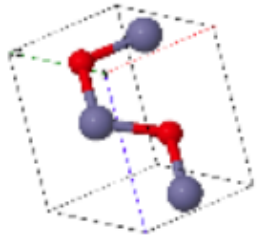
KOH etching of silicon



KOH etches Si {110} > {100} > {111}, producing a characteristic anisotropic V-etch, with sidewalls that form a 54.7° angle with the surface (35.3° from the normal).

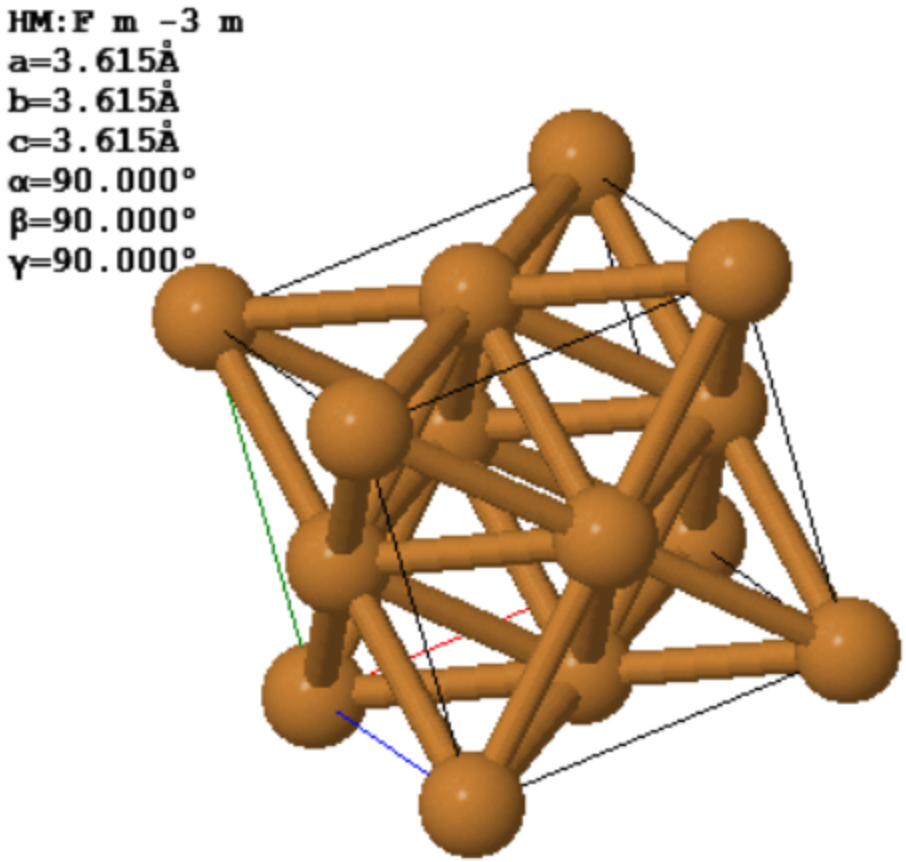
http://www.ece.uncc.edu/research/clean_room/fabprocesses/KOH-EtchingAndDecon.pdf

Crystal structures

 Face Centered Cubic Al, Cu, Ni, Ag, Pt, Au, Pb	 Body Centered Cubic W, Cr, Fe, Mo, Ta	 Hexagonal Close Packed Ti, Co, Zn, Zr
 Diamond C, Si, Ge, α-Sn	 Zincblende GaAs, InP, GaP, InAs, AlAs	 Wurzite ZnO, GaN, AlN, CdSe

face centered cubic (fcc)

Al, Cu,
Ni, Ag,
Pt, Au,
Pb

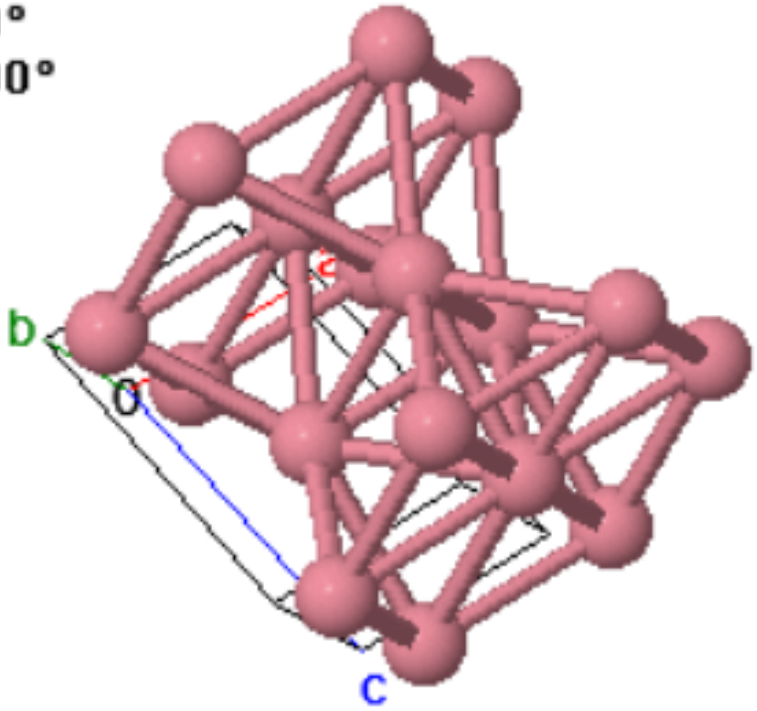


http://lampx.tugraz.at/~hadley/ss1/crystalstructure/structures/fcc/fcc_jsmol.php

hexangonal close pack (hcp)

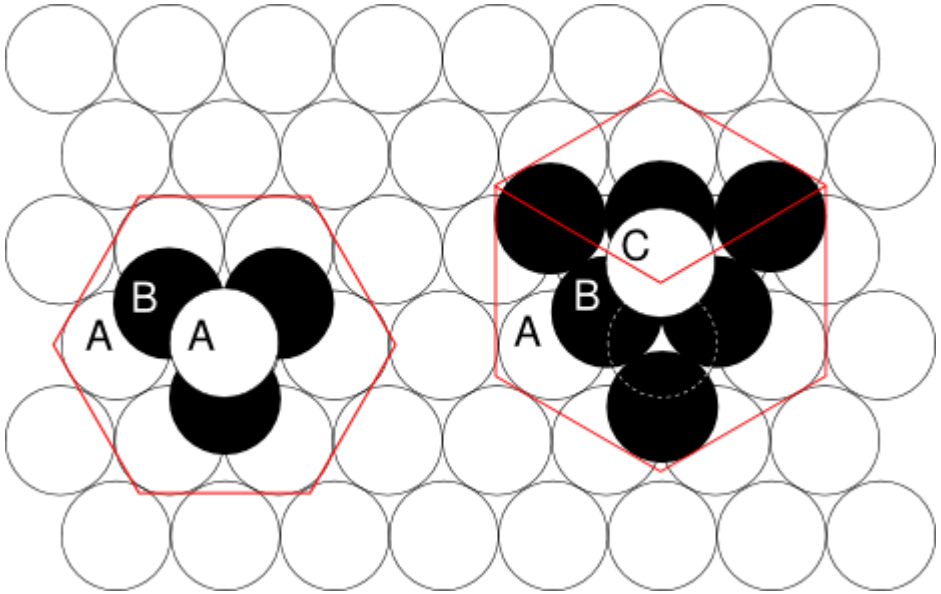
Ti, Co,
Zn, Zr,

HM:P 63/m m c
a=2.507Å
b=2.507Å
c=4.069Å
α=90.000°
β=90.000°
γ=120.000°

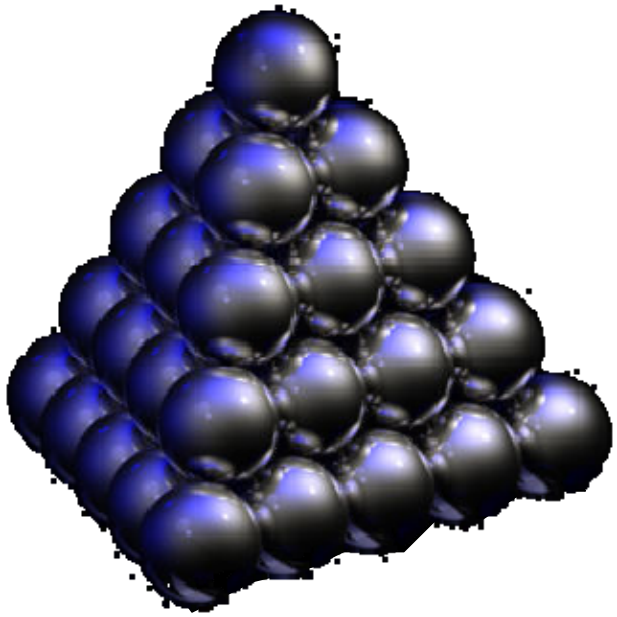


http://lampx.tugraz.at/~hadley/ss1/crystalstructure/structures/hcp/hcp_jsmol.php

Close packing



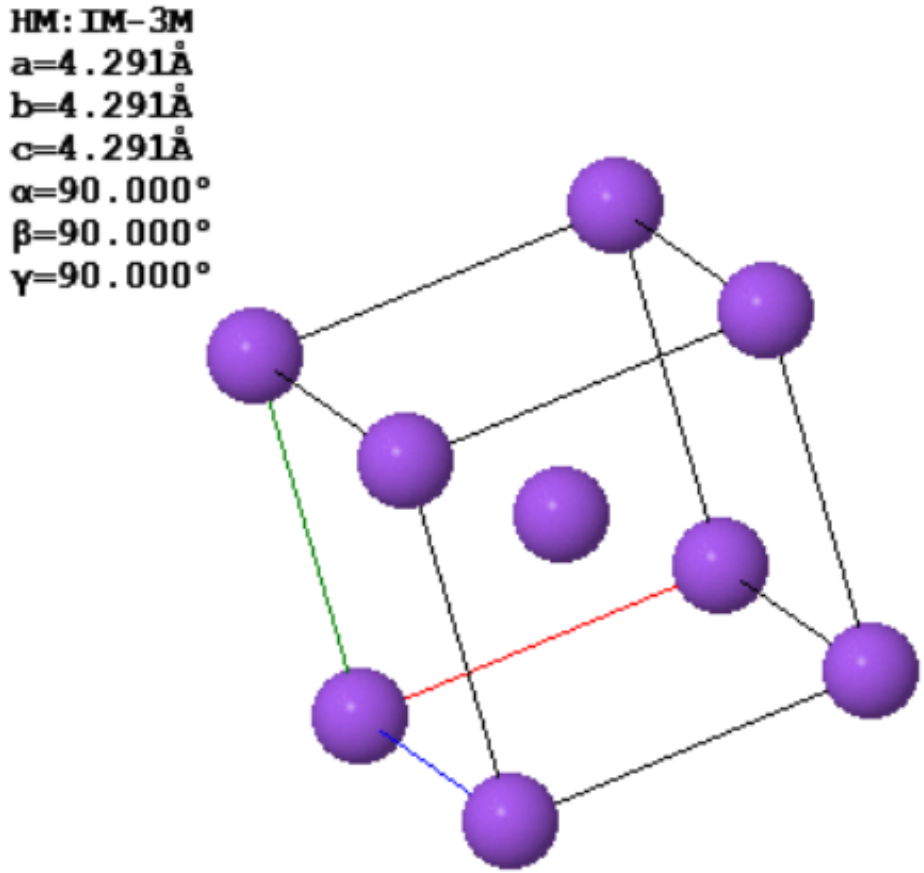
HCP FCC



FCC = Face Centered Cubic ABCABC...
HCP = Hexagonal close pack ABAB...
Hexagonal Bravais lattice with two atoms in the basis.

body centered cubic bcc

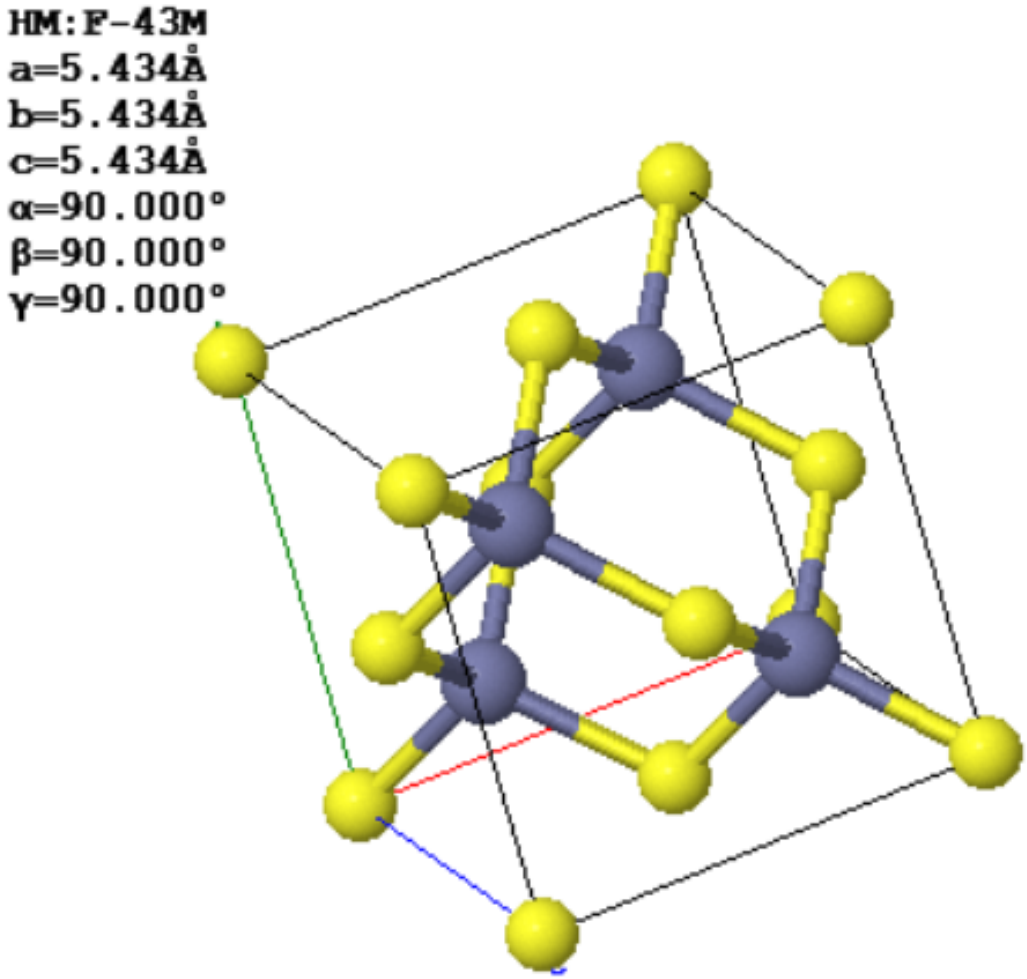
W
Cr
Fe
Mo
Ta



http://lampx.tugraz.at/~hadley/ss1/crystalstructure/structures/bcc/bcc_jsmol.php

zincblende

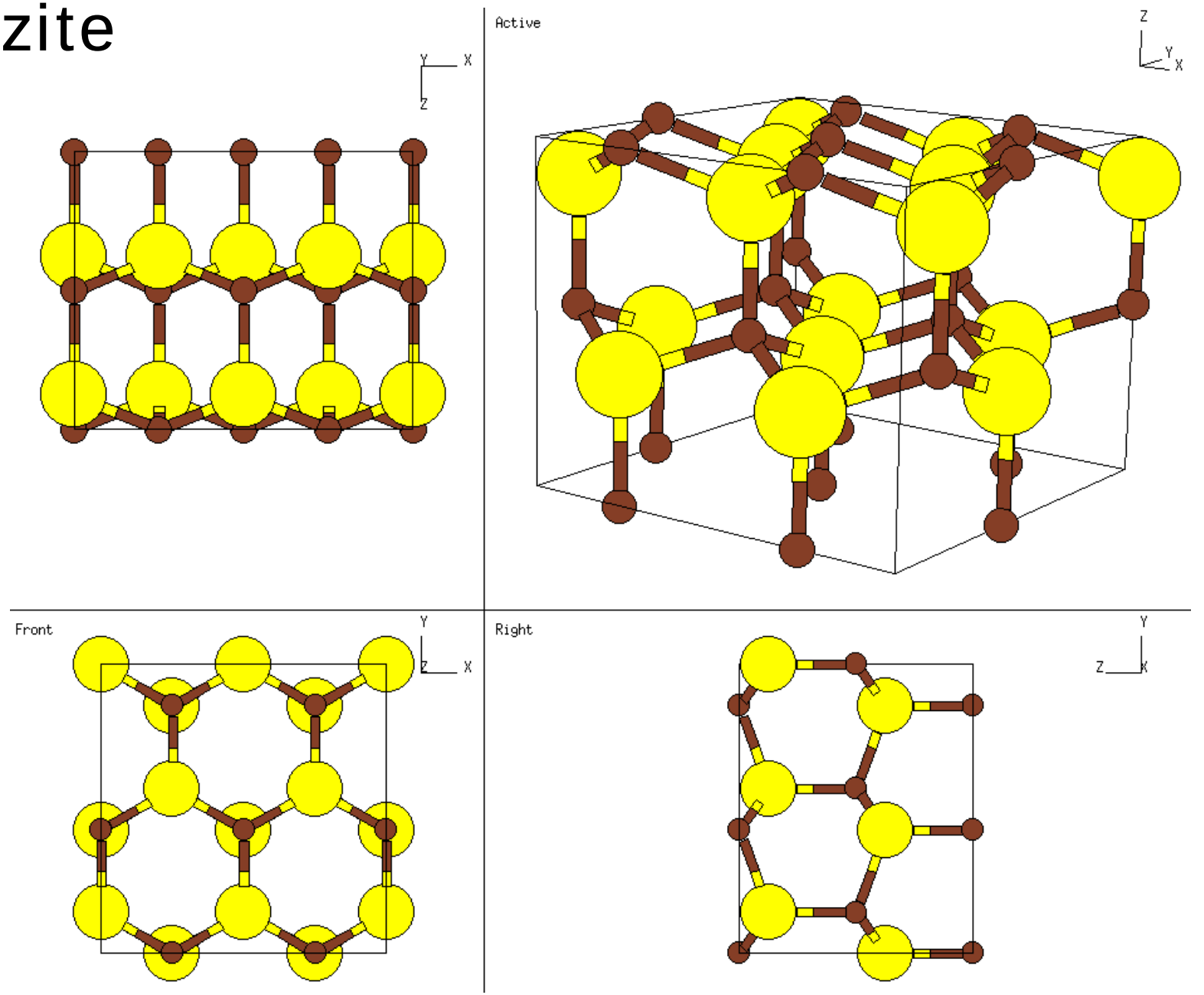
ZnS
GaAs
InP
GaP
InAs
AlAs



http://lampx.tugraz.at/~hadley/ss1/crystalstructure/structures/zincblende/zincblende_jsmol.php

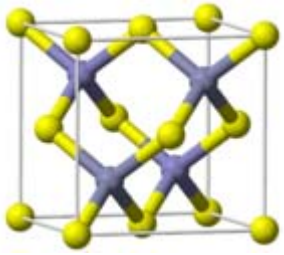
wurtzite

ZnO
CdS
CdSe
GaN
AlN



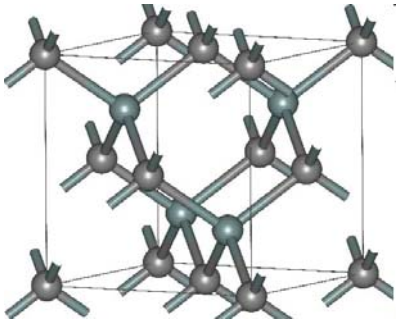
http://cst-www.nrl.navy.mil/lattice/

Structural phase transitions

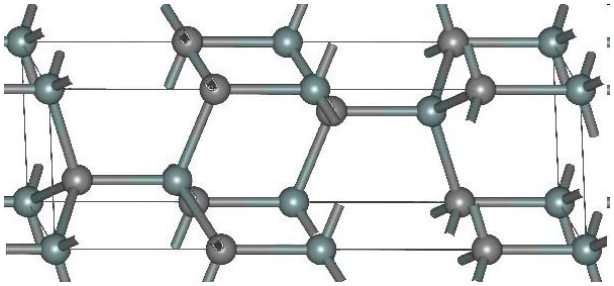


GaAs, Zincblende

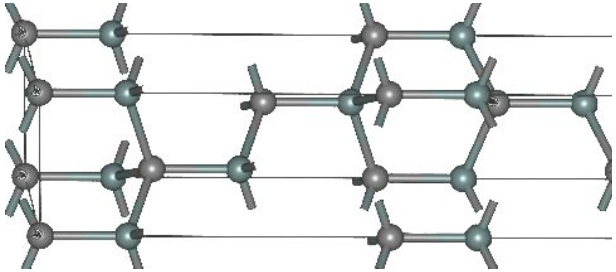
GaAs, Wurtzite



3C - SiC



4H - SiC



6H - SiC

SiC has about 100 polytypes