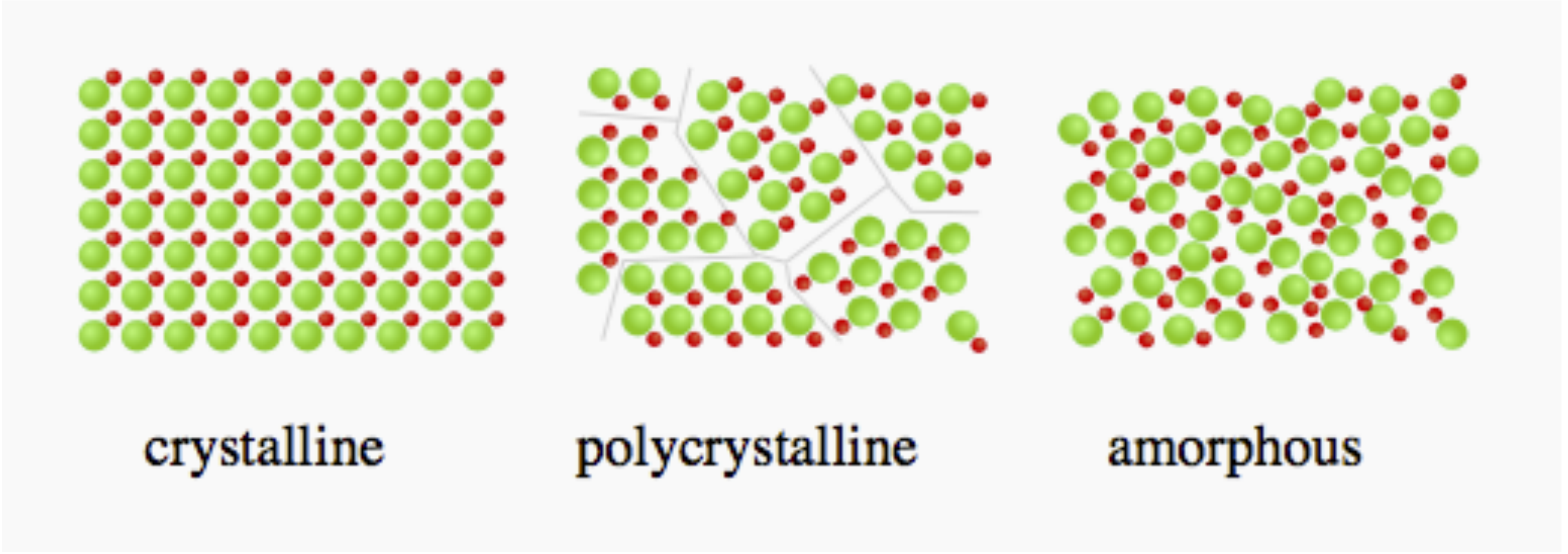
ChE 430
Nanomaterials for Chemical Engineering Applications

Appendix: Bravais lattices and Miller Indeces

Classification of solids



Unit cells

In a crystal we can identify repetitive units. This repetitive units are called “unit cells”

For a given crystal there are always quite a few possible unit cells:

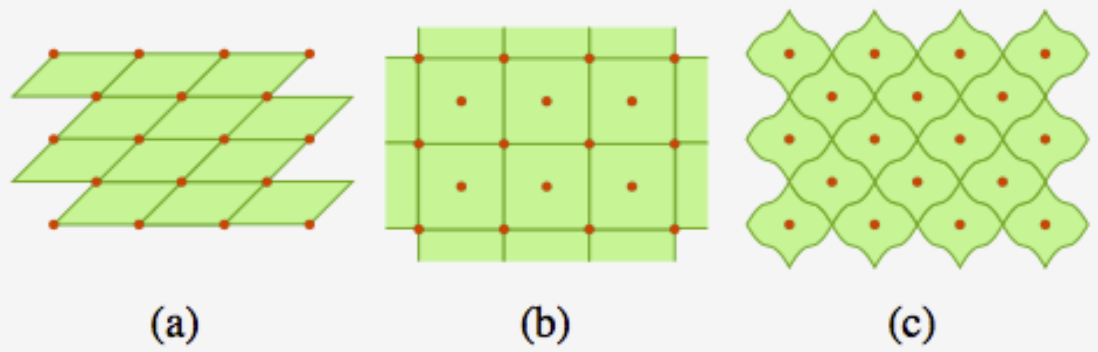


Fig. 1 - For a certain lattice there are many different possible unit cells. Here are some examples for a two-dimensional lattice.

Often it is convenient to choose the one with the highest level of inner symmetry.

Bravais lattices

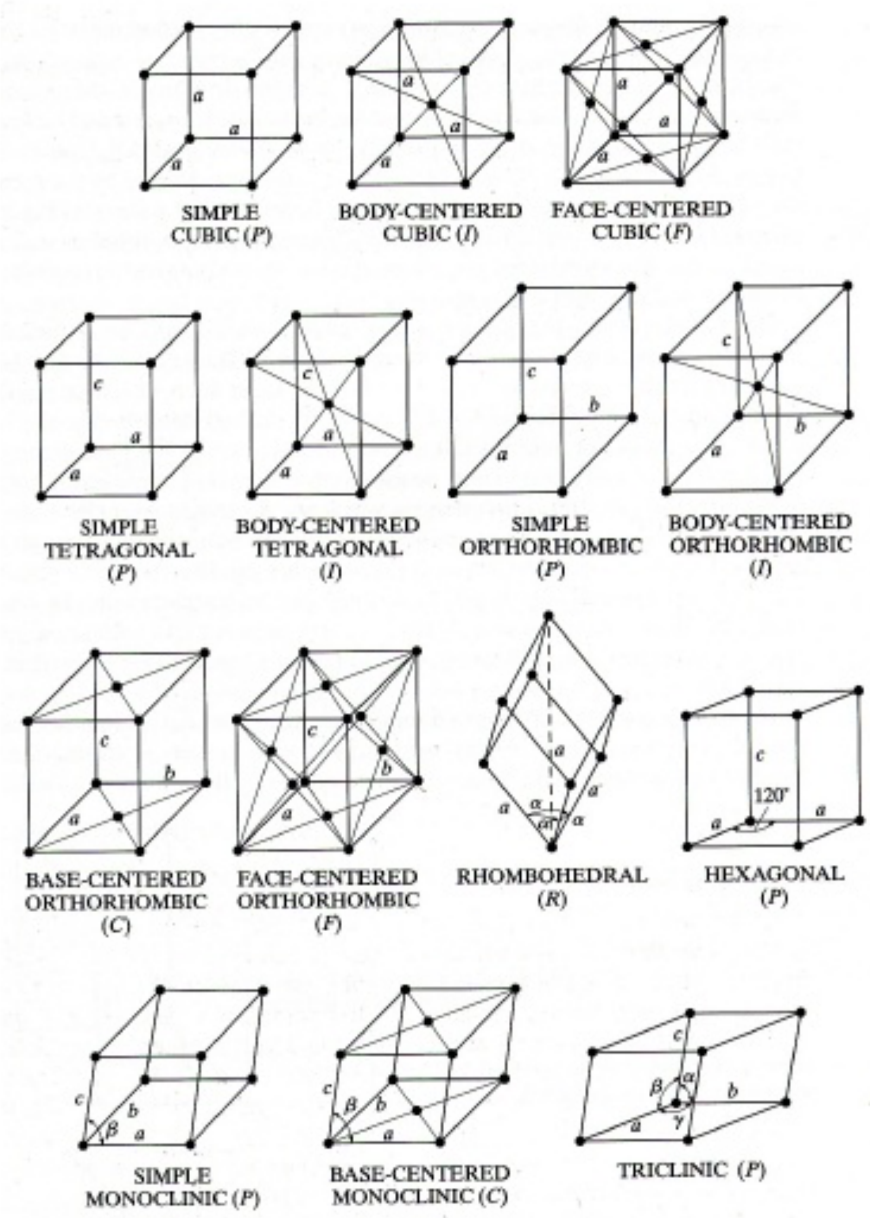
FIRST STEP: 7 CYSTAL SYSTEMS BASED ON THE SIMMETRY OF THE UNIT CELL

In a first step one divides the Bravais lattices into 7 **crystal systems** which are defined by the lengths a, b, c and angles α, β, γ between the primitive translation vectors. The resulting crystal systems are listed and visualised below.[2] [3] [4]

Crystal System	Lengths	Angles
cubic	$a = b = c$	$\alpha = \beta = \gamma = 90^\circ$
trigonal	$a = b = c$	$\alpha = \beta = \gamma < 120^\circ, \neq 90^\circ$
hexagonal	$a = b \neq c$	$\alpha = \beta = 90^\circ, \gamma = 120^\circ$
tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90^\circ$
orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90^\circ$
monoclinic	$a \neq b \neq c$	$\alpha = \beta = 90^\circ \neq \gamma$
triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma$

Fig. 1 - Overview over the 7 crystal systems: They are defined by the lengths and angles of the primitive translation vectors and exhibit different levels of symmetry.

Bravais lattices

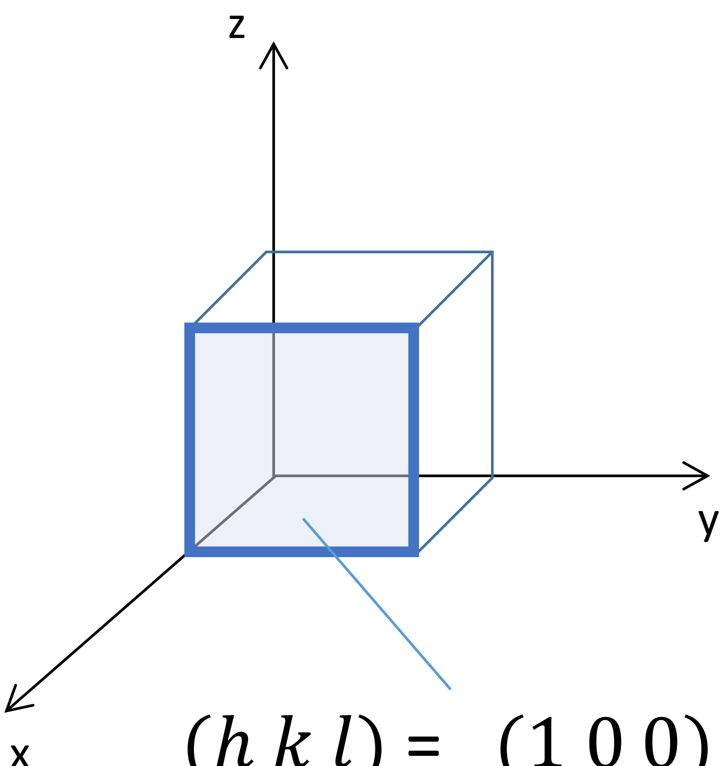


SECOND STEP:

The 14 Bravais lattices

The Miller Indeces

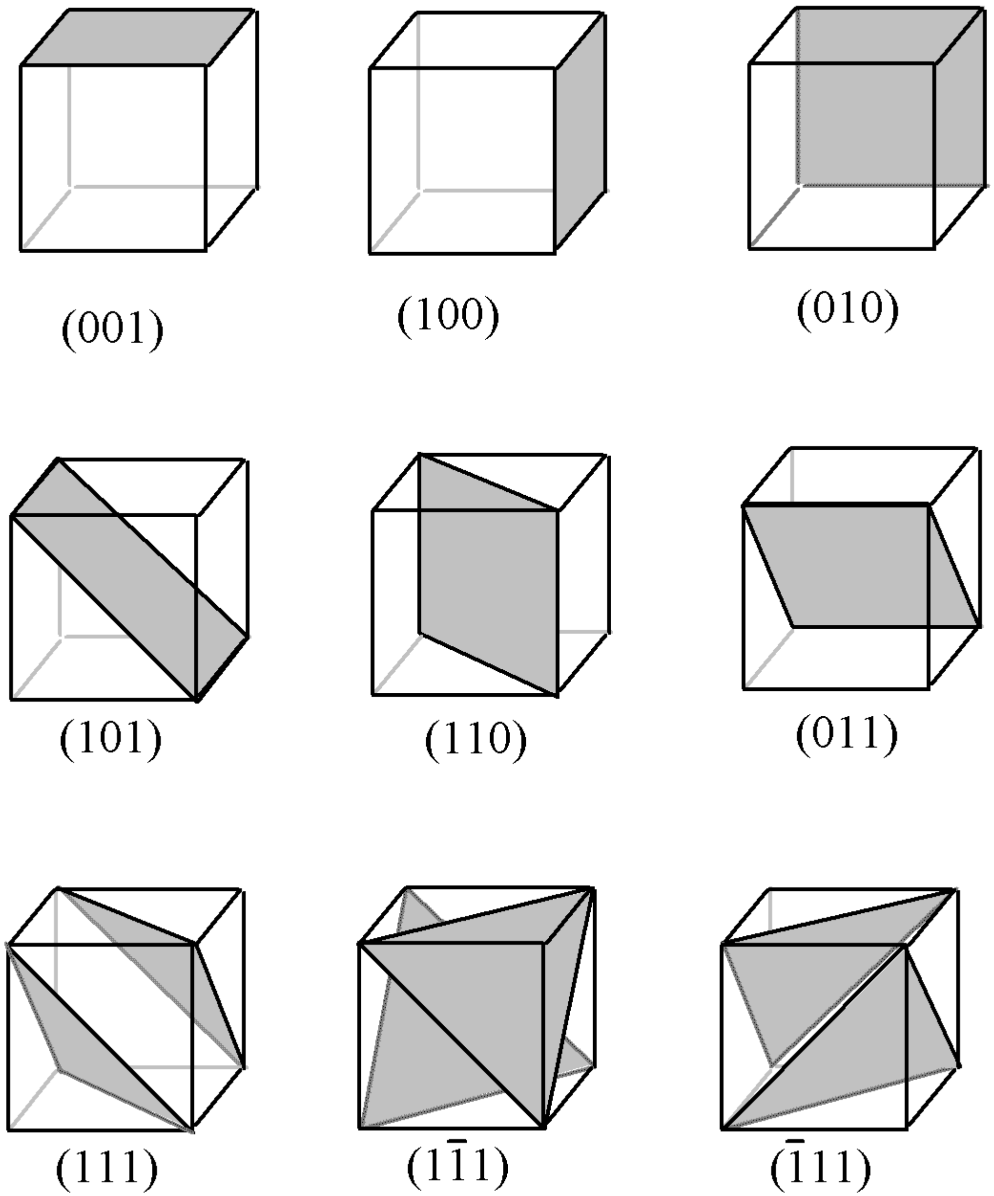
Miller indeces are used to refer to specific lattice planes



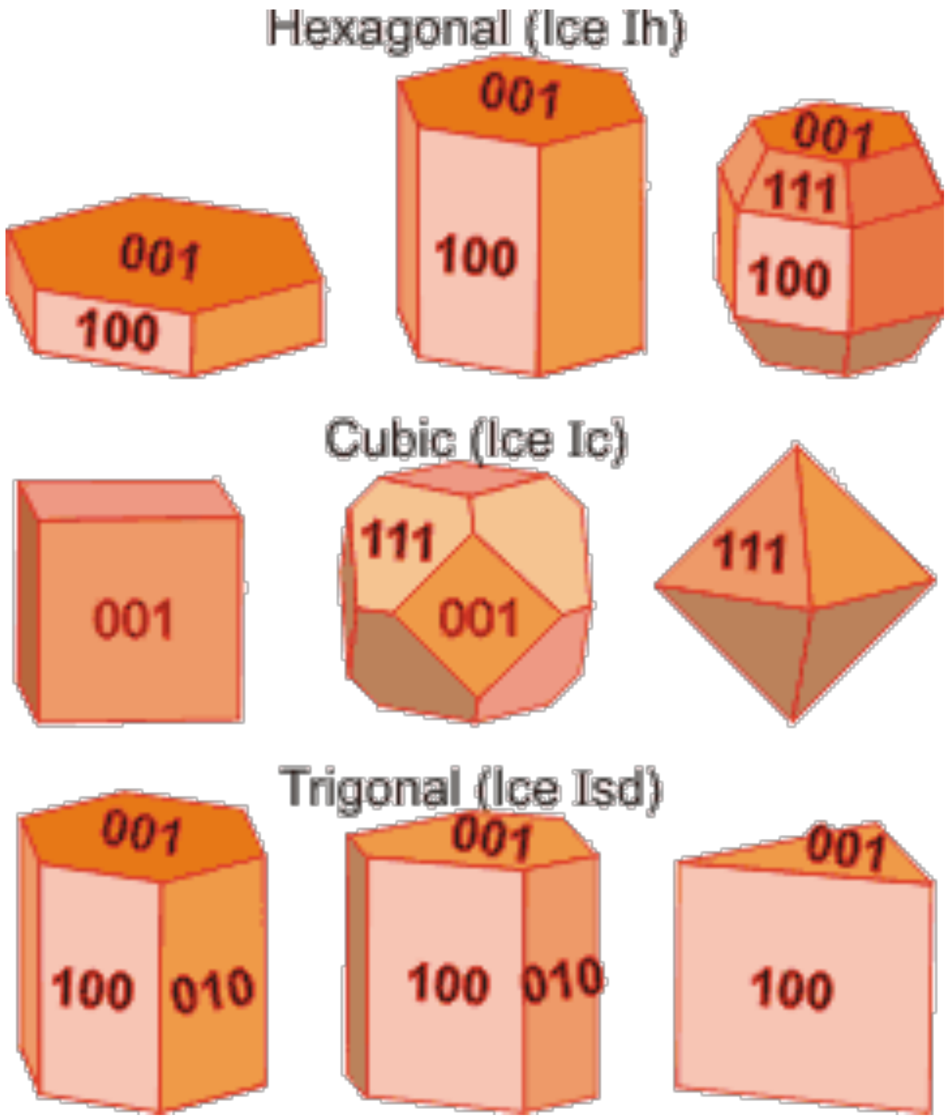
$$(h\,k\,l) = (1\;0\;0)$$

Intercepts	Reciprocal	
x = 1	$\frac{1}{1} = 1$	h
y → ∞	$\frac{1}{\infty} = 0$	k
z → ∞	$\frac{1}{\infty} = 0$	l

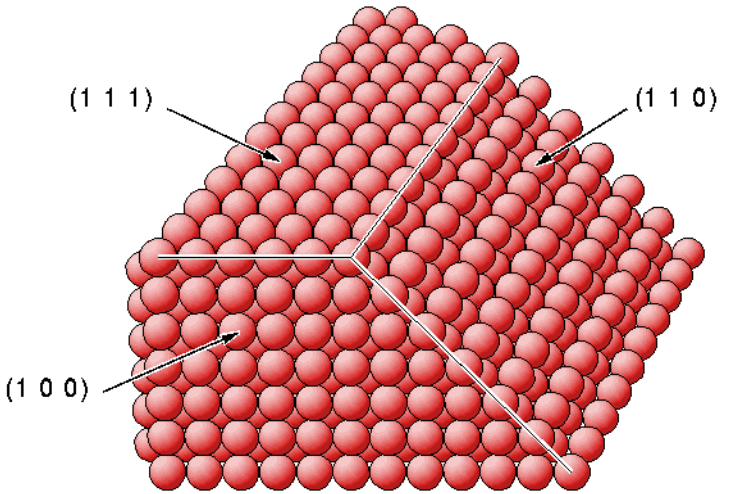
The Miller Indeces for the cubic cell



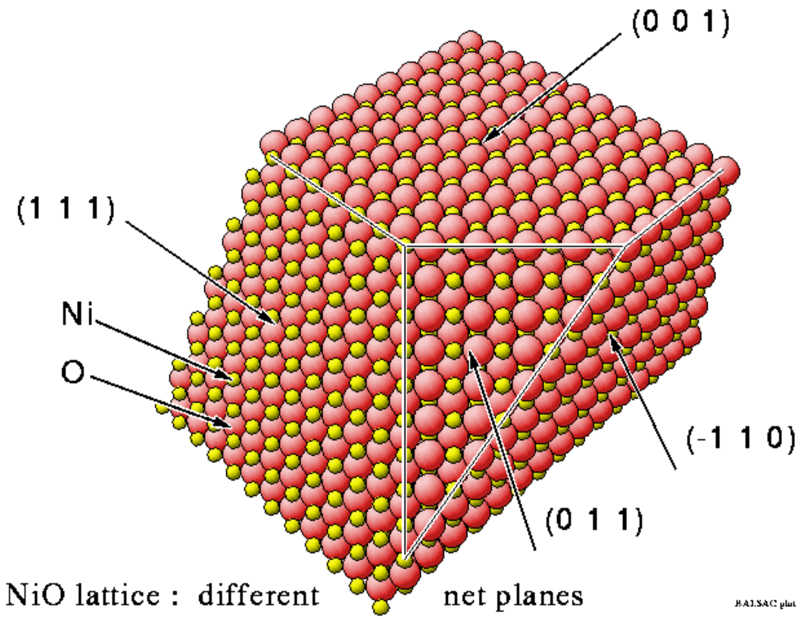
Naming crystal facets



Different arrangement of atoms on different facets



fcc lattice : different net planes



NiO lattice : different net planes