3.40 Lecture Summary

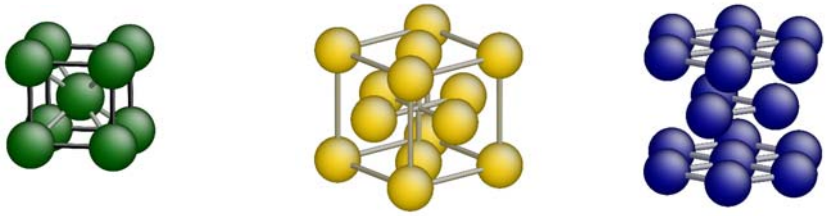
September 16, 2009

Department of Materials Science and Engineering

Basic Crystallography

BCC, FCC, and HCP Crystals

① BCC ② FCC ③ HCP



BCC Metals	FCC Metals	HCP Metals
Fe, W, V, Mo	Cu, Ag, Au, Pt, Al, Ni, Pb	Ti,Zr, Mg, Zn, Be, Cd
At high temps: Ti, Zr	At high temps: Fe	--

[1] Li, J. Modeling Simul. Mater. Sci. Eng. 11 (2003) 173. (AtomEye Visualization Software)
[2] NRL. Lattice Crystal Structures (2008)<http://cst-www.nrl.navy.mil/lattice/>.
[3] Abbaschian, R. et al. Physical Metallurgy Principles 4th ed. (2009).

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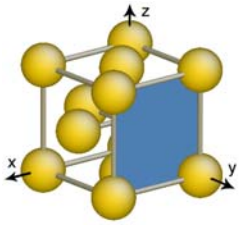
Basic Crystallography

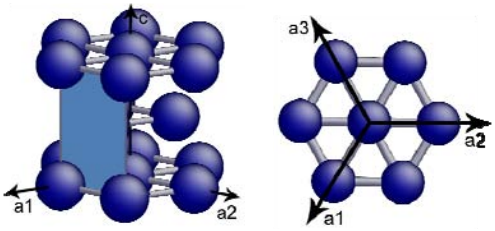
Miller Indices

1 Cubic Lattices



(010)	a	b	c
Intercept Length	∞	1	∞
Reciprocal	0	1	0

2 Hexagonal Lattices



(1010)	a1	a2	a3	c
Intercept Length	1	∞	-1	∞
Reciprocal	1	0	-1	0

[1] Li, J. Modeling Simul. Mater. Sci. Eng. 11 (2003) 173. (AtomEye Visualization Software)

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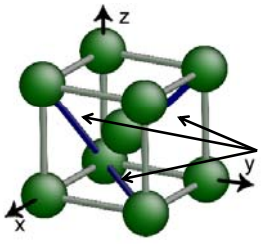
Basic Crystallography

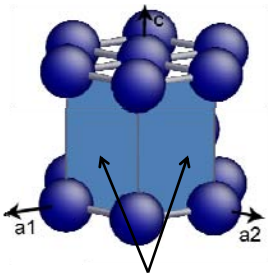
Crystal Symmetry

1 Cubic Lattice Symmetry
- o Crystallographic families
  - • Directions: <hkl>
  - • Plane: {hkl}
  - • Implies permutation rule



Equivalent Directions
<110>

2 Hexagonal Lattice Symmetry
- o Why (hkil) indexing scheme?
  - • Allows permutation rule!
  - • (hkil)
  - • Permute over (hki)



Equivalent Planes: {10$\bar{1}$0}

[1] Li, J. Modeling Simul. Mater. Sci. Eng. 11 (2003) 173. (AtomEye Visualization Software)

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Basic Crystallography

Crystal Symmetry and Stereographic Projection

1. What symmetry exists in cubic crystals?
   - Rotational
     - 2 fold - ⬭
     - 3 fold - ▲
     - 4 fold – ■

Image removed due to copyright restrictions.
Please see p. 3 in Schlom, Darrell G.
"Stereographic Projection."
MatSE535 Course Notes, 2009.

2. What symmetry exists in hexagonal crystals?
   - Rotational
     - 6 fold – ⬢

Image removed due to copyright restrictions.
Please see Fig 16.4
in Henderson, David, and Daina Taimina.
Experiencing Geometry: Euclidean and Non-Euclidean With History.
3rd Ed. Upper Saddle River, NJ: Prentice-Hall, 2005.

3. How do we keep track of crystal symmetries?
   - Answer: Stereographic Projection

[4]Schlom, D. G. Stereographic Projection Notes. <http://www.ems.psu.edu/~schlom/MatSE535/StereoProjection.pdf>.
[5] Henderson, D. W. (1999) <http://www.math.cornell.edu/~dwh/books/eg99/Ch16/Ch16.html

Basic Crystallography

Stereographic Projection of Crystal Directions

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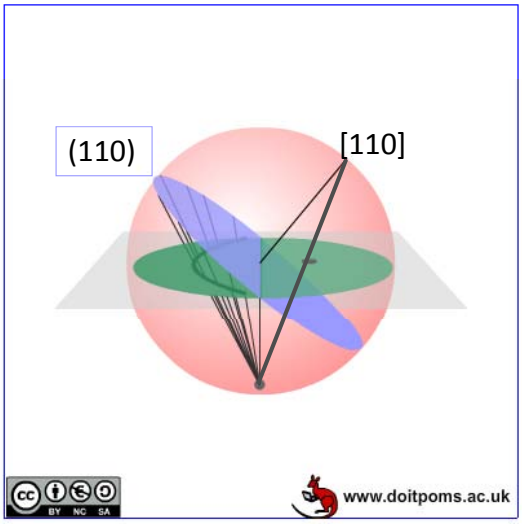
Please see p. 3, 10 in Schlom, Darrell G.
"Stereographic Projection."
MatSE535 Course Notes, 2009.

[1] www.ems.psu.edu/~schlom/MatSE535/StereoProjection.pdf

Basic Crystallography

Stereographic Projection of Crystal Planes



[1] http://www.doitpoms.ac.uk/tlplib/stereographic/index.php

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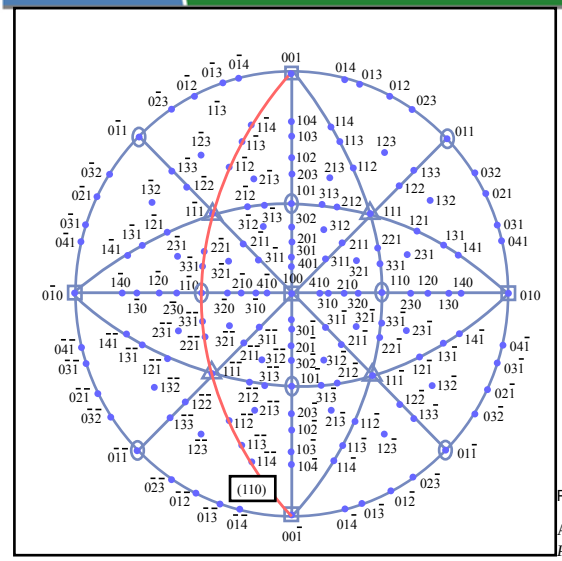
Basic Crystallography

Reading a Stereographic Projection



1. The plane is 90 degrees from the pole direction on a longitudinal line
2. The directions on a plane are in the plane
3. Symmetry markers reflect the point symmetry of the crystal

Figure by MIT OpenCourseWare.

Adapted from Fig. 1.33 in Reed-Hill and Abbaschian, *Physical Metallurgy Principles*

[1 Abbaschian, R. et al. Physical Metallurgy Principles 4th ed. (2009).

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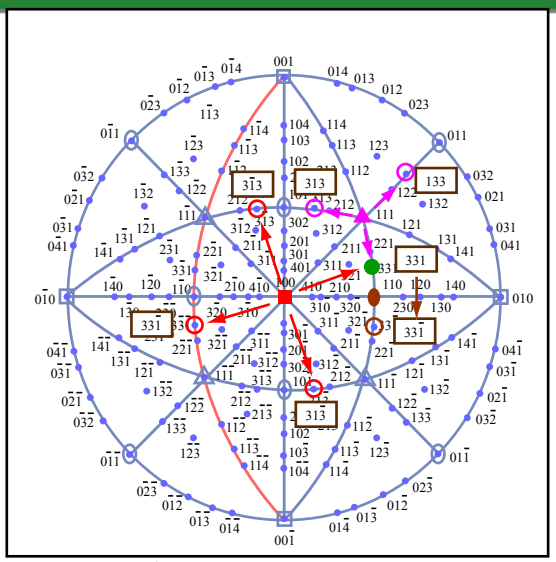
Basic Crystallography

Symmetry on the Stereographic Projection



Adapted from Fig. 1.33 in Reed-Hill and Abbaschian, *Physical Metallurgy Principles*

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[1] Abbaschian, R. et al. Physical Metallurgy Principles 4th ed. (2009).

Figure by MIT OpenCourseWare.

Basic Crystallography

Standard Stereographic Triangle

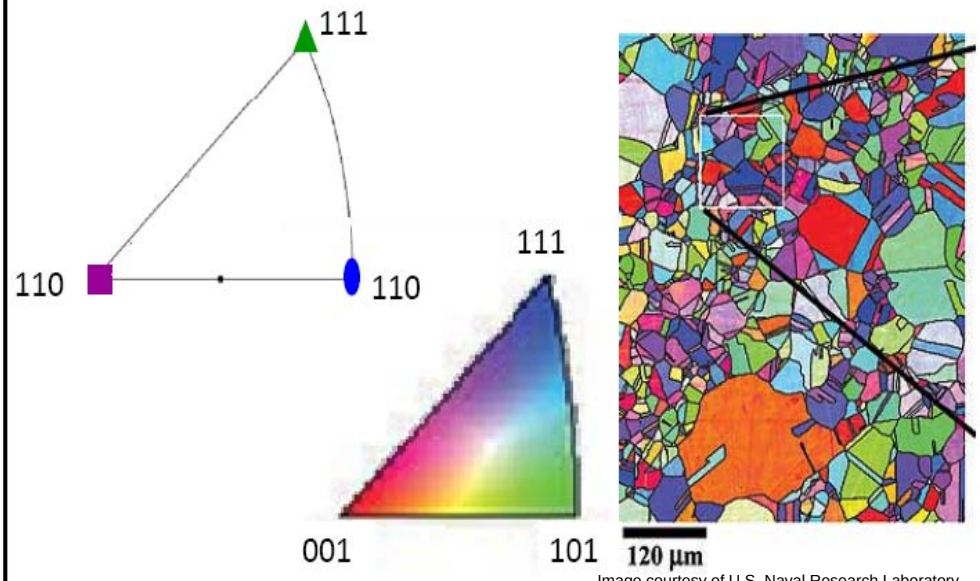

Image courtesy of U.S. Naval Research Laboratory.

[1] Geltmacher.,A.B. et al. Image-based Modeling of Naval Steels (2003) http://www.nrl.navy.mil/content.php?P=03REVIEW163

[2] Ferry, Michael. "Appendix B - Representation of Textures and their Interpretation". Direct Strip Casting of Metals and Alloys: Processing, Microstructure and Properties. Woodhead Publishing. (2006)

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Basic Crystallography

Other Resources

"The Stereographic Projection."
DoITPoMS, University of Cambridge.

[1] http://www.doitpoms.ac.uk/tlplib/stereographic/index.php

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3.40J / 22.71J / 3.14 Physical Metallurgy

Fall 2009