Orientation

강의명: 기계재료공학 (MFA9009)

정영웅

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Outline

- 강의 소개
- 평가
- 강의 진행 방식 및 규칙

강의 소개

- 창원대 기계 설계 공학
- 등급 평가
- 시간
  - 목 (85603)   9:00am – 10:30am
  - 화 (85603) 10:30am – 12:00pm
- 15주
- ¼ 이상 결석시에 자동으로 F 학점 부여

평가

- 등급 평가 (ABCDF)
- 평가 요소
  - 중간, 기말 고사
    - 서술형 질문 위주로
    - 강의 내용에 대한 이해가 중요
  - 출결
    - 수업시작 10분까지 출석 인정
    - 10분-30분까지 지각
    - 30분- 결석
    - 주의: 총 수업의 ¼ 이상 결석시 자동으로 F 학점
- 수업 중 질문에 대한 응답은 평가 항목이 아닙니다.

강의 진행 방식 및 규칙

- 재료과학과 공학 (Callister)가 수업 주교재. 강의 슬라이드로 수업 진행
- 그외 참고 문헌:
  - 재료 과학 / 회중당 백수현 등 공역
  - G. E. Dieter, “Mechanical Metallurgy”
  - Robert E Reed-Hill and R. Abbaschian, “Physical metallurgy Principles”
- 상시 feedback (전, 중, 후) - #52-208
- 강의 노트
  - 되도록 수업 전주 금요일에 업로드 (수업커뮤니티 혹은 홈페이지를 통해)
- 수업후 과제
  - (계획) 되도록 수업후 과제없이 진행

Chapter0
Introduction

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Objectives

- 2017년 2학기 금속 기계 재료 개론 수업에 전반 내용에 대한 개요를 이해한다.

Microstructural parameters, Properties

Properties

- Strength
- Toughness
- Conductivity
- Corrosion Resistance
- Piezoelectric strain
- Dielectric constant
- Magnetic Permeability
- **Formability**

Microstructural Parameters

- Grain size
- Grain shape
- Phase structure
- Composite structure
- Chemical composition (alloying)
- Crystal structure
- Defect structure (e.g. porosity)

Microstructural parameters, properties

- Yes, when we study the plasticity of metals, we now should consider the microstructure of the material of interest
- Q. What is microstructure?
- A. Microstructure = internal structure

Biology was revolutionized when Leeuwenhoek and others started to use microscopes to look at the internal structure of plants. They were able to relate many characteristics of plants to their cell structure, for example.

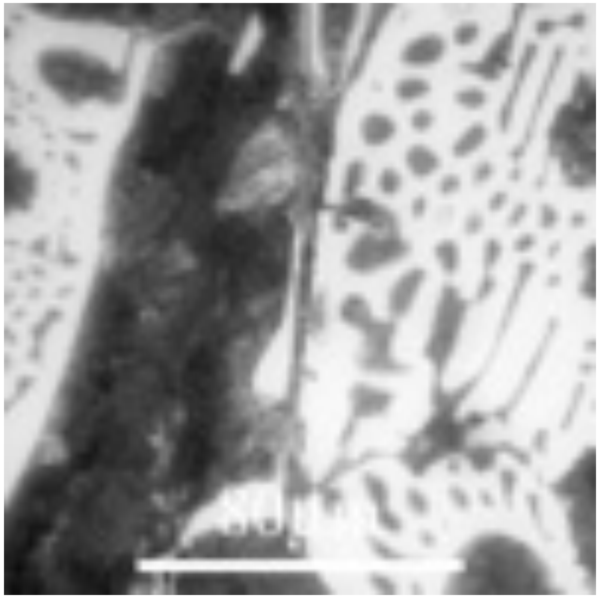
Similarly, Sorby† was one of the first to make cross-sections of materials such as iron and examine them in the microscope, so that he could relate properties to structure.

* http://www.ucmp.berkeley.edu/history/leeuwenhoek.html
† http://www.shu.ac.uk/sorby/hcsorby.shtml

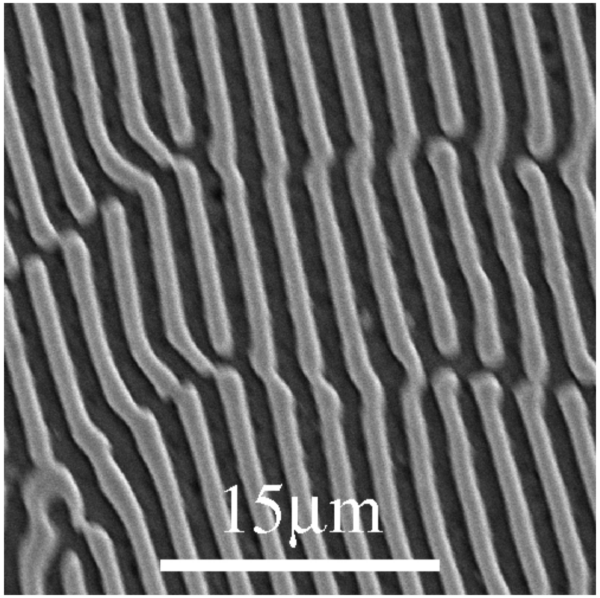
What is microstructure?

- Microstructure originally meant the structure inside a material that could be observed with the aid of a *microscope*.
- In contrast to the crystals that make up materials, which can be approximated as collections of atoms in specific packing arrangements (*crystal structure*), *microstructure* is the collection of *defects* in the material.
- What defects are we interested in? Interfaces (both grain boundaries and interphase boundaries), dislocations (and other line defects), and point defects.
- Since the invention of prefixes for units, the *micrometer* (1 µm) happens to correspond to the wavelength of light. Light, obviously is used to form images in a light/optical microscope. Thus *microstructure* has come to be accepted as those elements of structure with length scale of order 1 µm.
- Since we commonly examine materials in the microscope, we generally observe *grains* as crystallites in *polycrystals*, separated by *grain boundaries*.

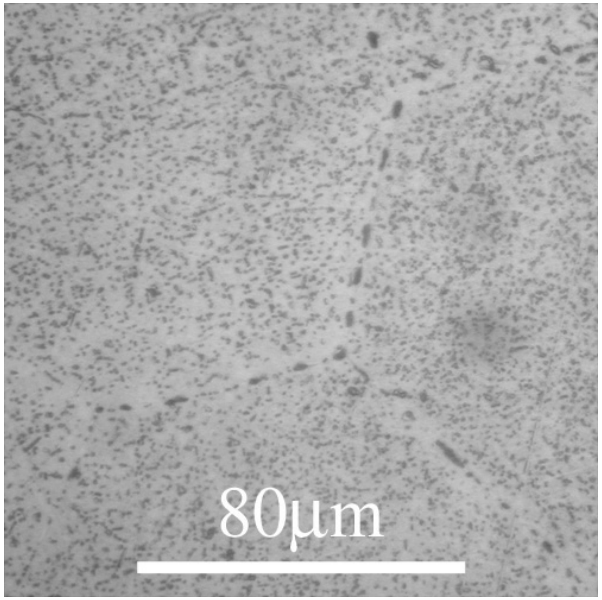
If you look ‘inside’



Fe-C-X; Hypoeutectic white cast iron

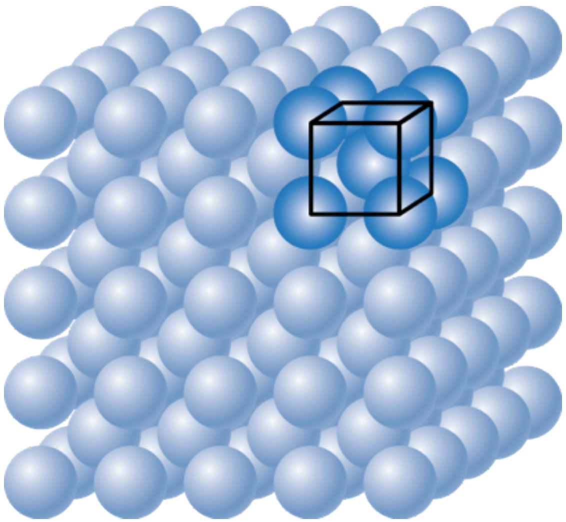


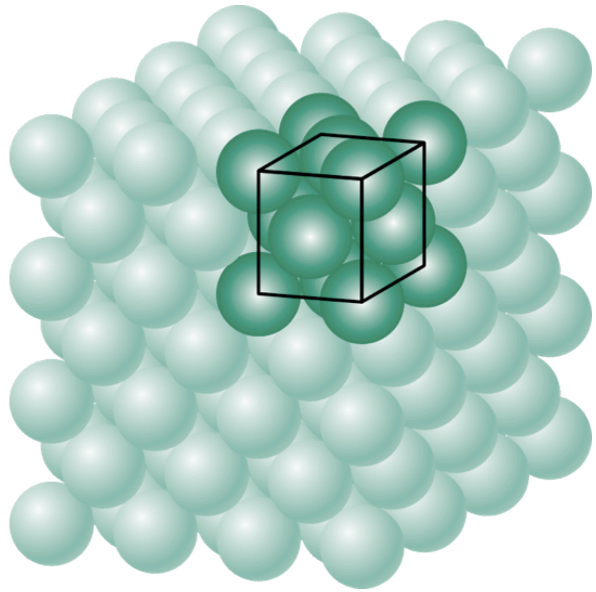
Al 67wt% Cu 33wt%, Eutectic alloy

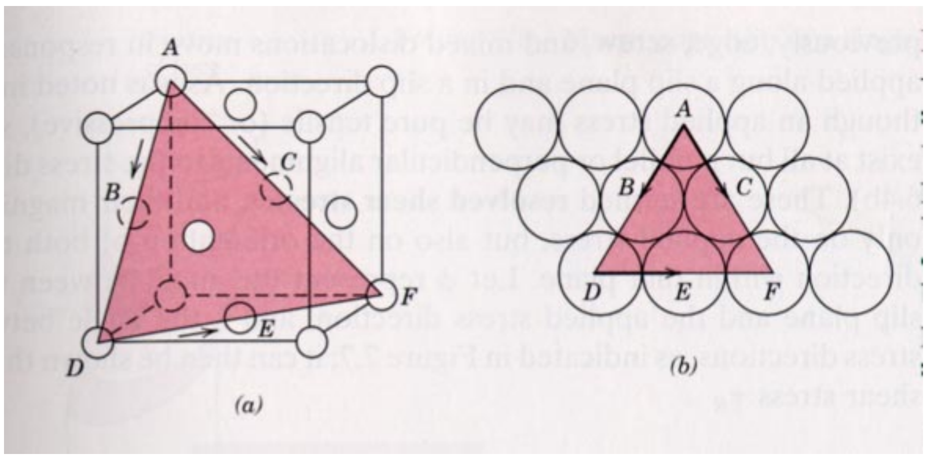


Al 96wt% Cu 4wt% Precipitates

If you look ‘inside’ (crystal structure)







If you look ‘inside’ (crystal structure)

- HCP is more ‘anisotropic’ than cubic structures.

Basal
(0002) <2 -1 -1 0>

Prism
{0 -1 1 0}<2 -1 -1 0>
Also:
(2 -1 -1 0)

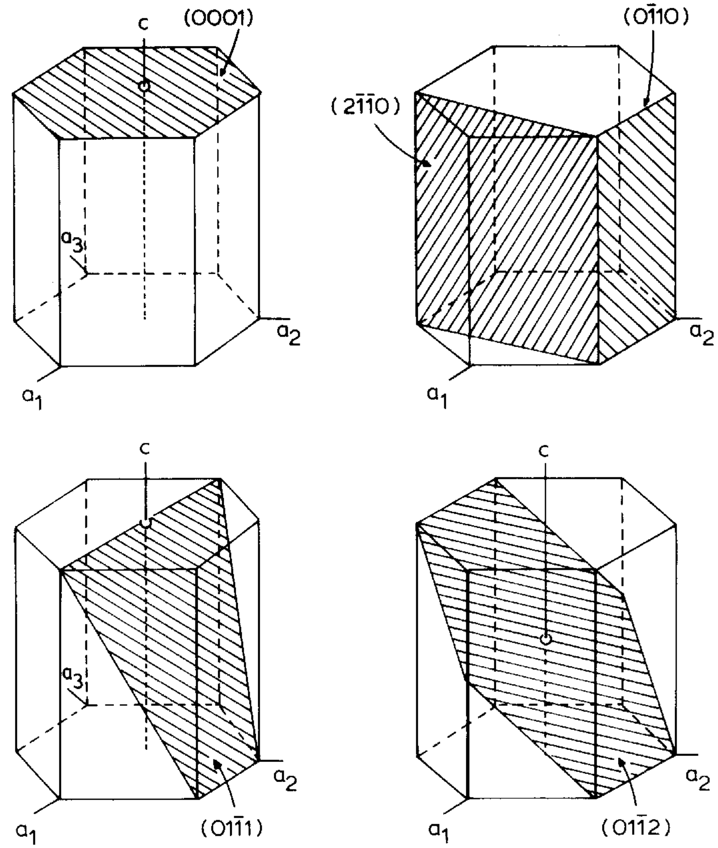


FIG. IV-5—*Some important planes in the hcp system and their Miller-Bravais indices.*

Pyramidal (c+a)
(1 0 -1 1) <1 -2 1 3>
Pyramidal (a)
(1 0 -1 1) <1 -2 1 0>

Pyramidal
(1 0 -1 2)

Berquist & Burke: Zr alloys

Slip systems

The slip systems for FCC, BCC and hexagonal crystals are:

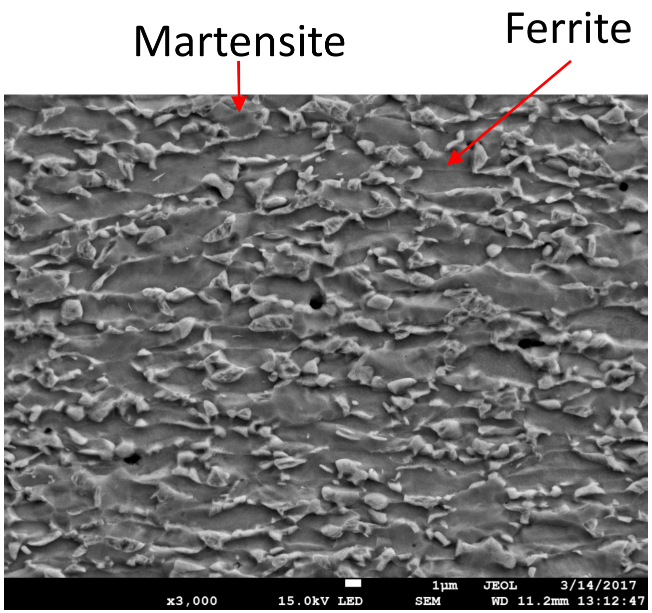
Metals	*Slip Plane*	*Slip Direction*	*Number of Slip Systems*
	Face-Centered Cubic		
Cu, Al, Ni, Ag, Au	$\{111\}$	$\langle 1\bar{1}0 \rangle$	12
	Body-Centered Cubic		
α-Fe, W, Mo	$\{110\}$	$\langle \bar{1}11 \rangle$	12
α-Fe, W	$\{211\}$	$\langle \bar{1}11 \rangle$	12
α-Fe, K	$\{321\}$	$\langle \bar{1}11 \rangle$	24
	Hexagonal Close-Packed		
Cd, Zn, Mg, Ti, Be	$\{0001\}$	$\langle 11\bar{2}0 \rangle$	3
Ti, Mg, Zr	$\{10\bar{1}0\}$	$\langle 11\bar{2}0 \rangle$	3
Ti, Mg	$\{10\bar{1}1\}$	$\langle 11\bar{2}0 \rangle$	6

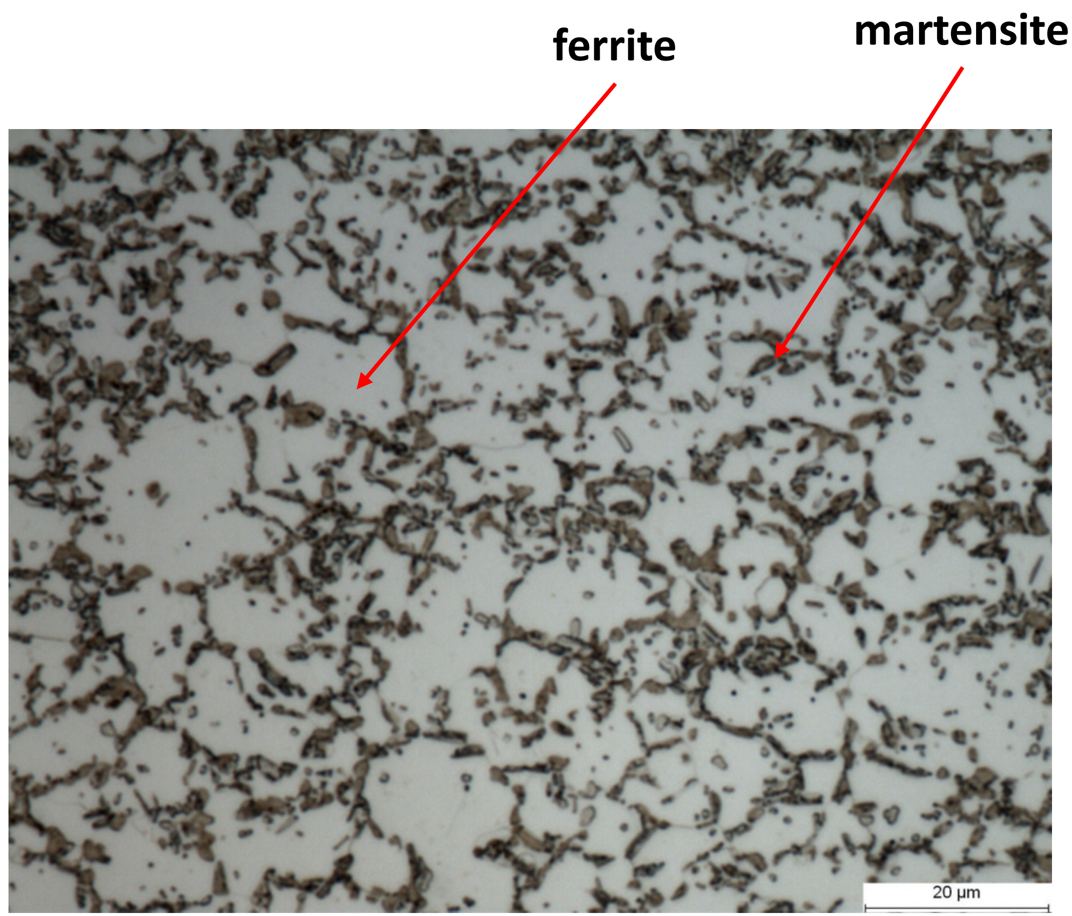
Also: Pyramidal (c+a) (1 0 -1 1) <1 -2 1 3>

Note: In the case of FCC crystals we can see in the table that there are 12 slip systems. However if forward and reverse systems are treated as independent, there are then 24 slip systems.

If you look ‘inside’ (multiphase)

Modern steels are often multiphase alloys





Important microstructural features

Examples of quantitative microstructural parameters:

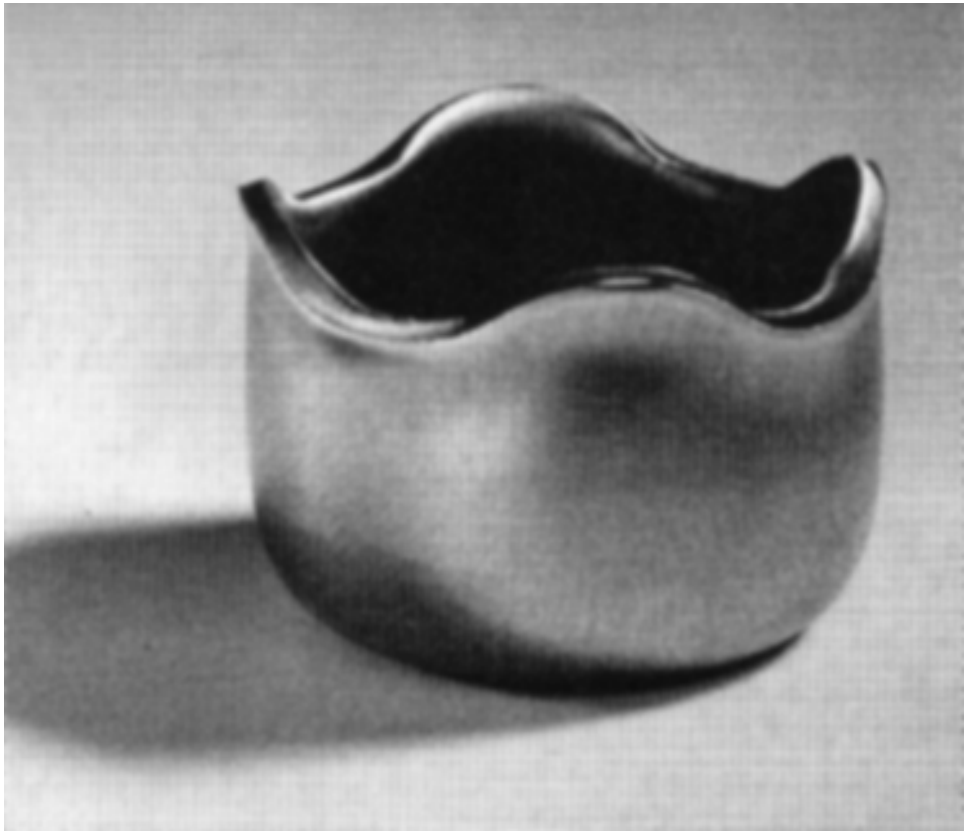
- Grain size
- Void fraction
- Aspect ratio of second phase particles or grains
- Crystal orientation distribution (crystallographic texture)

Anisotropy

- All crystal structure is intrinsically anisotropic.
- Q: Should polycrystalline materials consisting of many crystals anisotropic?
- Q: If not, what makes polycrystal material anisotropic?

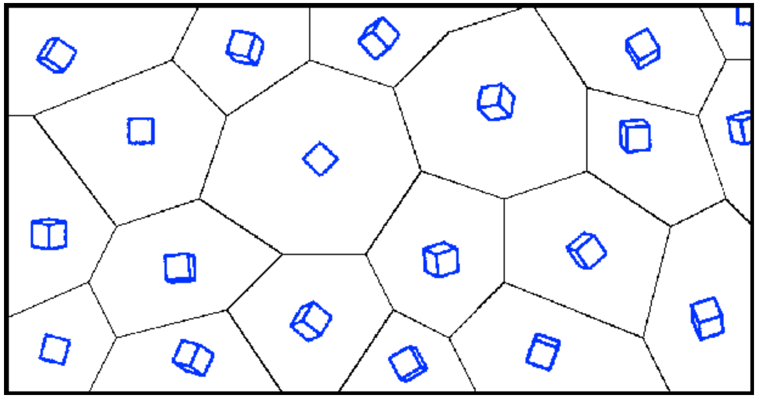
Plastic anisotropy

Figure shows example of a cup that has been deep drawn. The plastic anisotropy of the aluminum sheet resulted in non-uniform deformation and “ears.”



Randle, Engler, p.340

Grain orientation



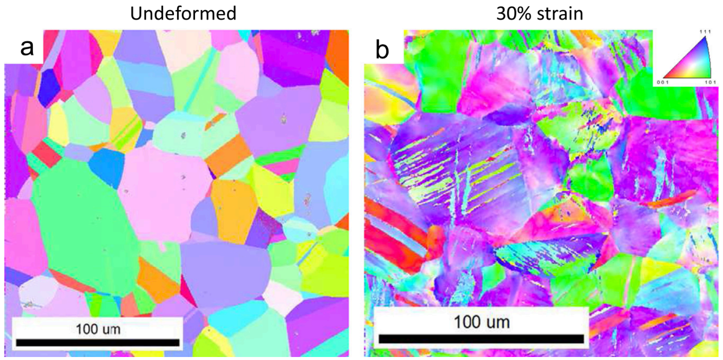
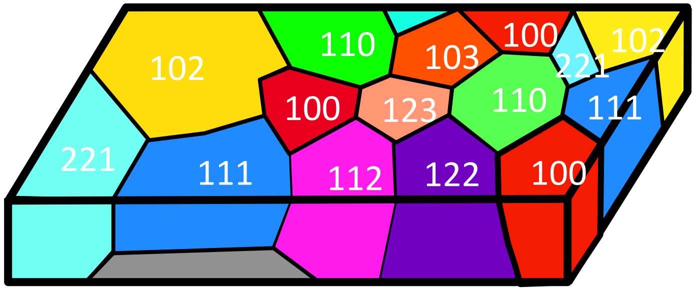


Fig. 1. EBSD orientation map of 304 stainless steel sheet at tensile strains of (a) 0% (undeformed) and (b) 30%.



Blue cubes denote unit cells representative of the pertaining grain bounded by gray lines (Q. What is the gray lines here?)

An orientation is a 'relative term'.
상대적인 개념. 기준(reference)이 되는 방향이 갖춰져야 한다.

** H Wang, Y Jeong, B Clausen, Y Liu, RJ McCabe, F Barlat, CN Tome, MSEA 649, 2016*

Recap

- What is microstructure?
- Multiphase steel?
- Anisotropy?
- What is grain orientation?