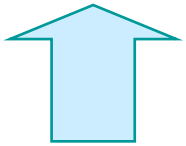
Crystal Micro-Mechanics

Lecture 1 – Introduction

Heung Nam Han
Associate Professor
Department of Materials Science & Engineering
College of Engineering
Seoul National University
Seoul 151-744, Korea
Tel : +82-2-880-9240
Fax : +82-2-885-9647
email : hnhan@snu.ac.kr
Homepage : http://plaza.snu.ac.kr/~mmmpdl

Summary of Course

- **Crystal Elasticity**
- **Crystal Plasticity**

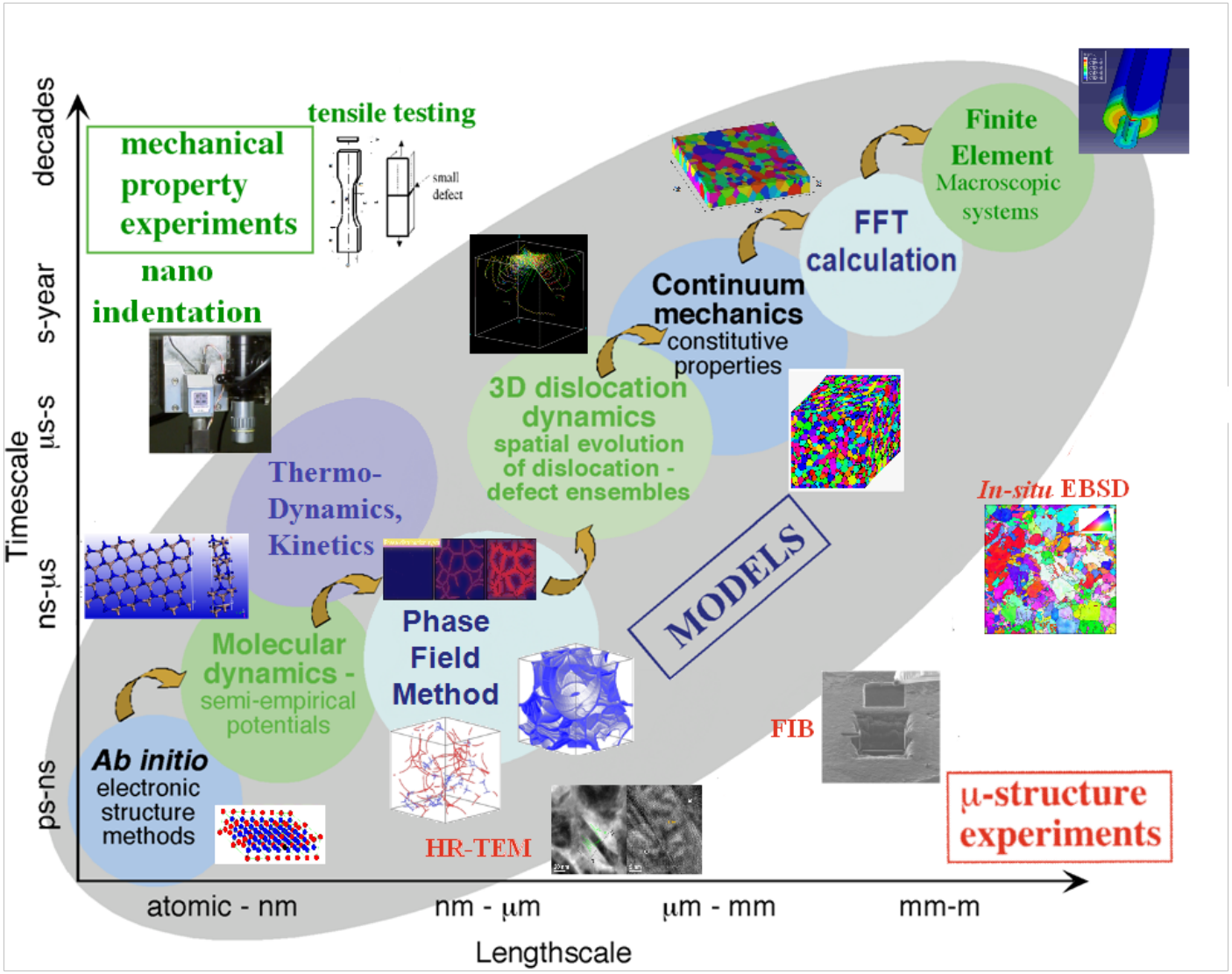


- **Basic of Continuum Mechanics**

Requirements:

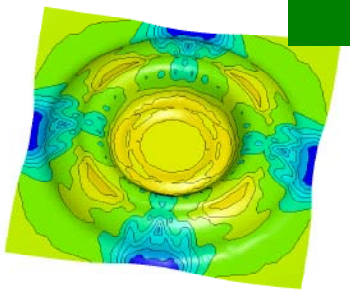
- Theory of Linear Elasticity
- Basic Mechanics of Materials

Multi-Scale Approach



Scale for Mechanical Analysis

Continuum

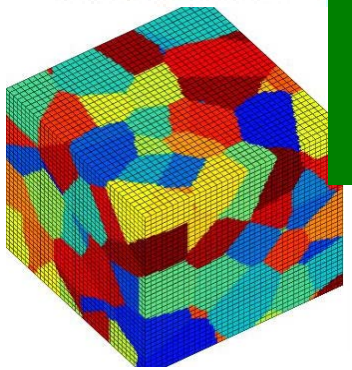


Anisotropic yield surface

millimeters and above

Polycrystalline plasticity

Mesoscale

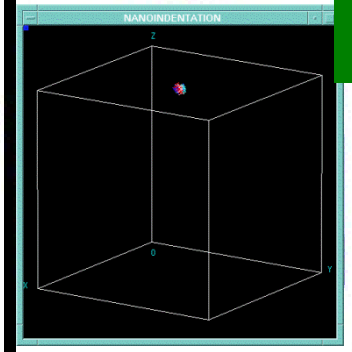


Deformation texture prediction

10s -100s micrometers

Crystal Plasticity

Microscale

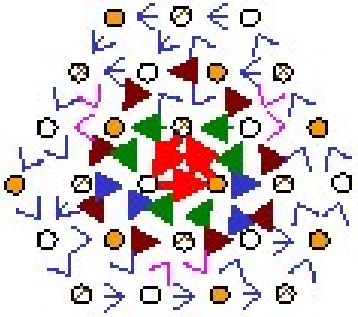


3D Dislocation Dynamics

micrometers

Dislocation Interaction and mobility

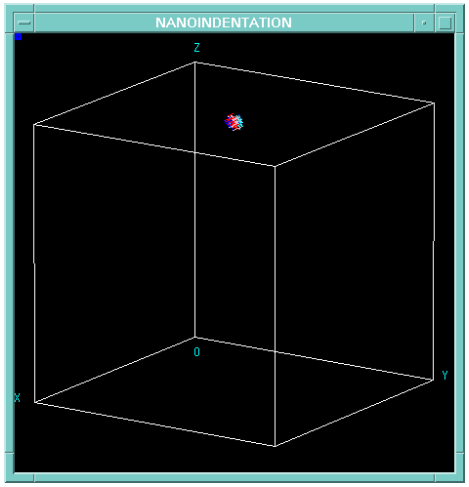
Atomic Scale

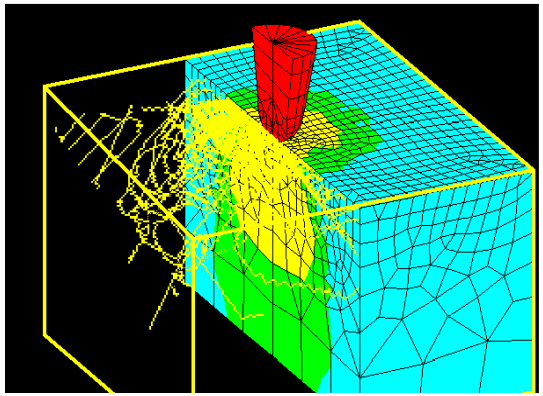


Molecular Statics and Dynamics

nanometers

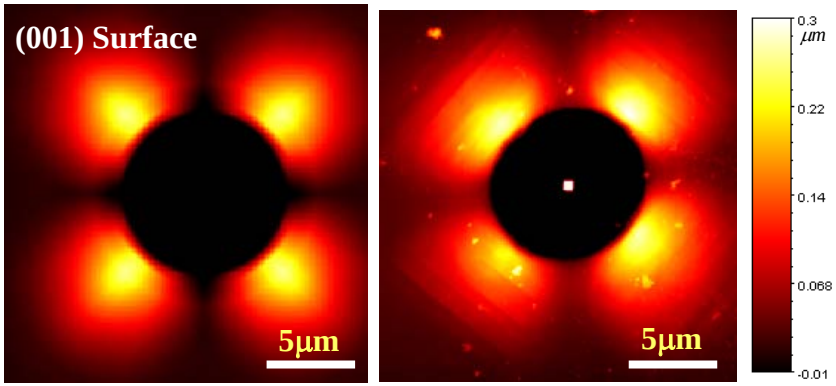
Nano indentation

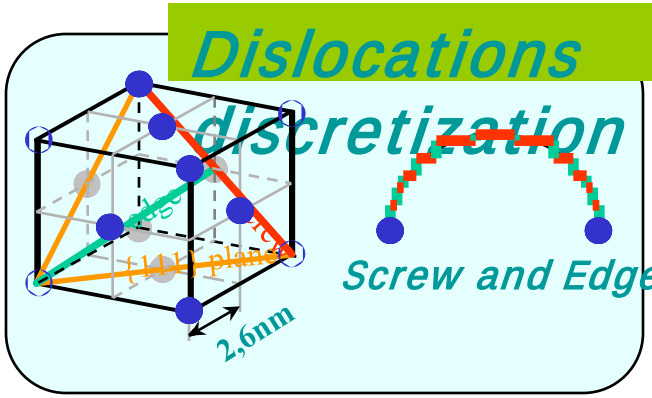


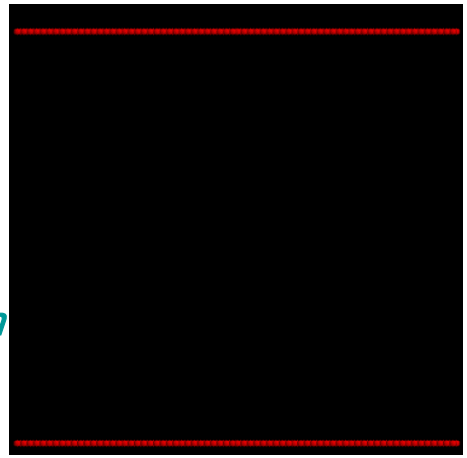


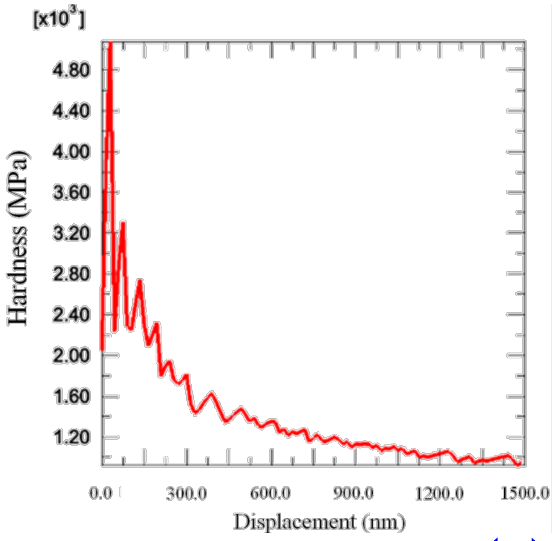
DDD+CP-FEM

EXP



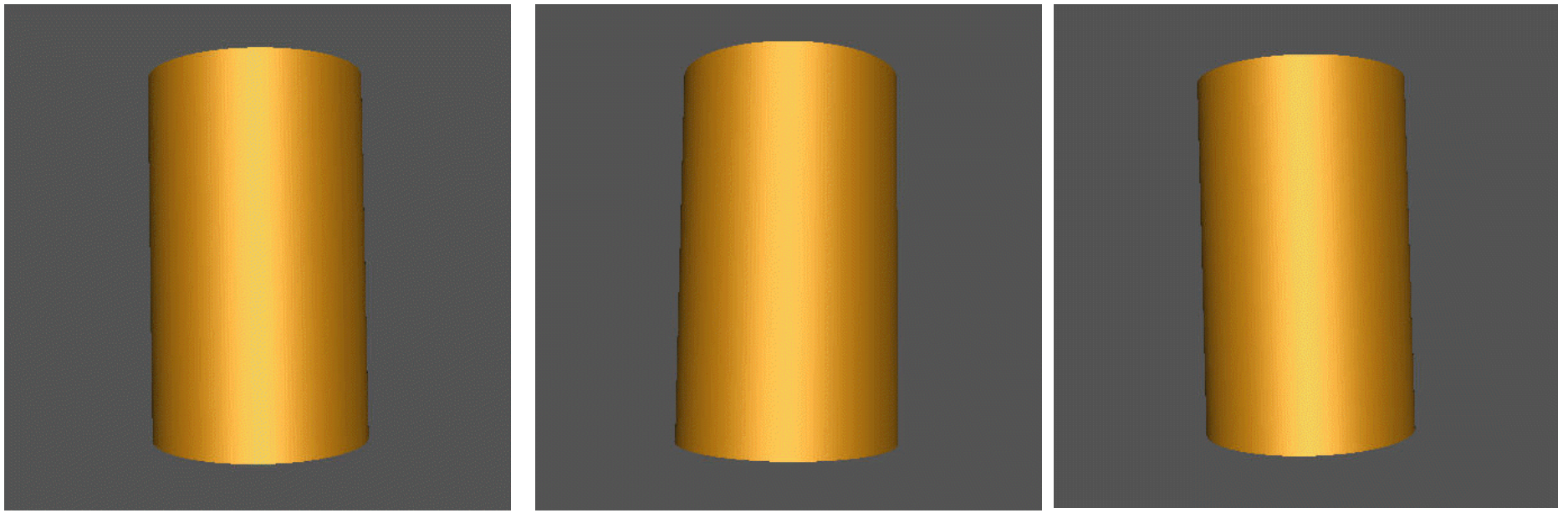




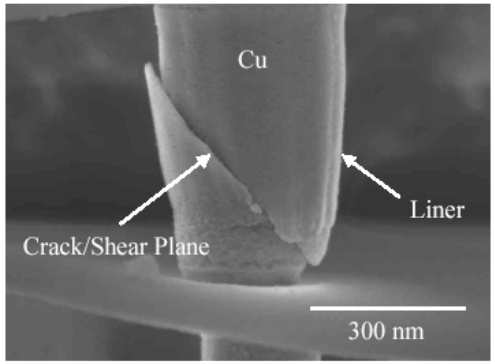


Nano-compression and tension (fatigue)

(001) (110) (-112)



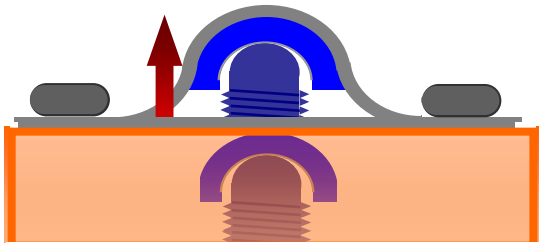
Scripta Materialia, (2010)



Cycle : 0, 1, 2, 5, 10, 15, 25, 35, 45
Stress = 0
Magnification Factor : ×20
Out of via → low-k

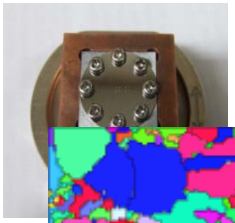
Subgrain evolution during deformation

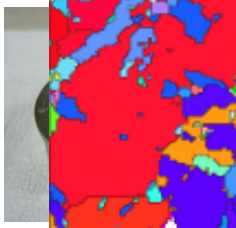
In-situ EBSD



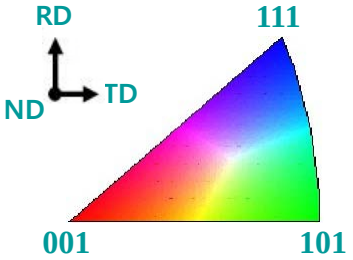
Biaxial Tensile Deformation

Before



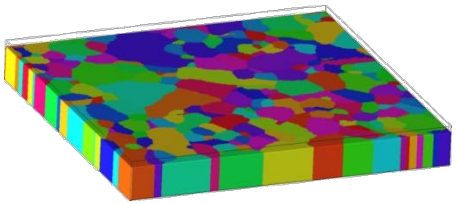


ND



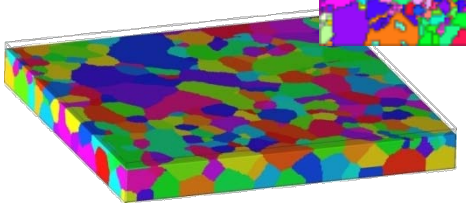
Measured OIM

Strain ≒ 0 %



Input mi

3D



Columnar

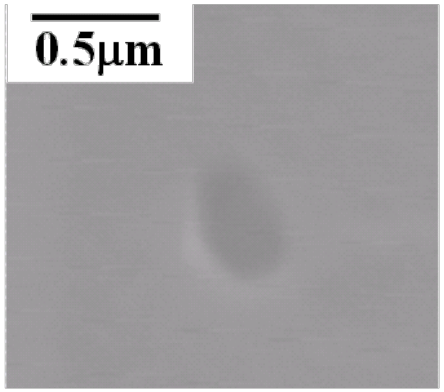
FFT-calculated

50μm

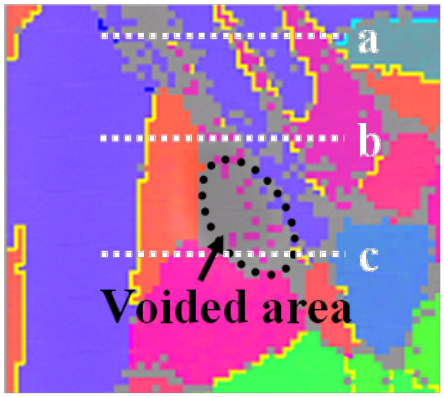
MS&T 2009, PRICM 2010

SNU+CMU

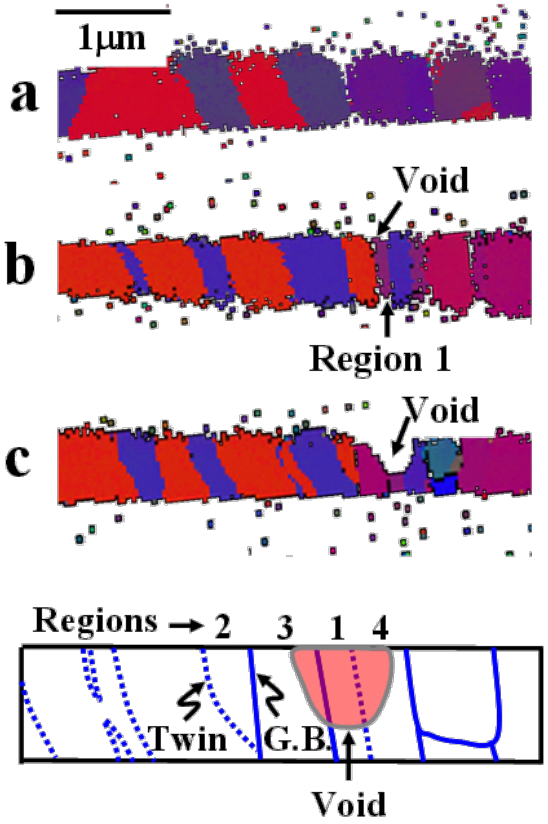
Crystal Elasticity Calculation



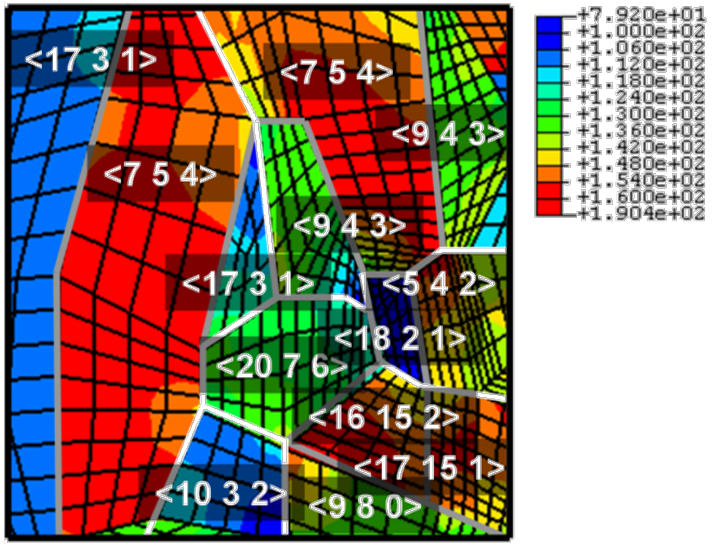
SEM Image



EBSD Orientation Map



Stepwise Cross-sections



Stress distribution

Applied physics letters, (2008)

Text & References

Text

- class note

References

1. Continuum Theory of Plasticity, A.S. Khan and S. Huang, 1995
2. Texture and Related Phenomena, Dong Nyung Lee, 2005
3. Deformation Geometry for Materials Scientists, C.N. Reid, 1973
4. Martensitic Transformation, Z. Nishiyama et al., 1978
5. Texture and Anisotropy, U.F. Kocks, C.N. Tome and H.-R. Wenk, 1998
6. Mesoplasticity and its Applications, W. Yang and W.B. Lee, 1993

Contents

- Classical definition of stress and strain
- Strain measures
- Stress measures
- Orientation of crystals
- Elastic deformation in anisotropic material
- Elastic properties of thin films
- Single and Duplex slip
- Multiple slip
- Plastic deformation of polycrystalline materials
- Plasticity for crystals by twinning (?)
- Deformation in martensitic transformation (?)

Evaluation

- Mid-term exam 1 (25%) – ?
- Mid-term exam 2 (25%) – 11/10
- Final exam (30%) - ?
- Homework or Seminar (10%)
- Attendance (10%)