香港中文大學
The Chinese University of Hong Kong

DEPARTMENT OF MECHANICAL AND AUTOMATION ENGINEERING

MAEG 5140 Materials Characterization Techniques

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Prof. He Qiguang (何 奇洸)

Employments:

Assistant Professor, Mechanical and Automation Engineering Department, CUHK, 2023 -

Postdoctoral Researcher, Mechanical Engineering and Applied Mechanics, UPenn, 2021 - 2023

Education backgrounds:

Ph.D. Mechanical Engineering, University of California, San Diego (UCSD), 2017 – 2021

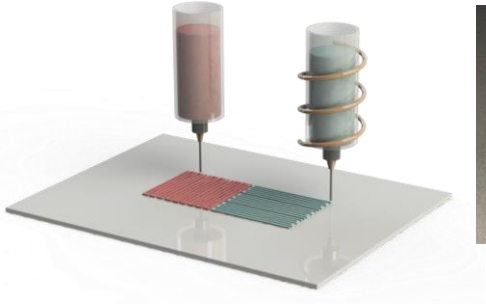
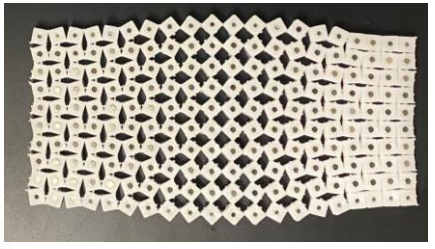
M.S. Mechanical Engineering, University of California, San Diego (UCSD), 2015 - 2016

B.S. Automotive Engineering, Tsinghua University, 2021 - 2015

Research interests:

Soft robotics; actuating materials; artificial muscle; additive manufacturing; metamaterials



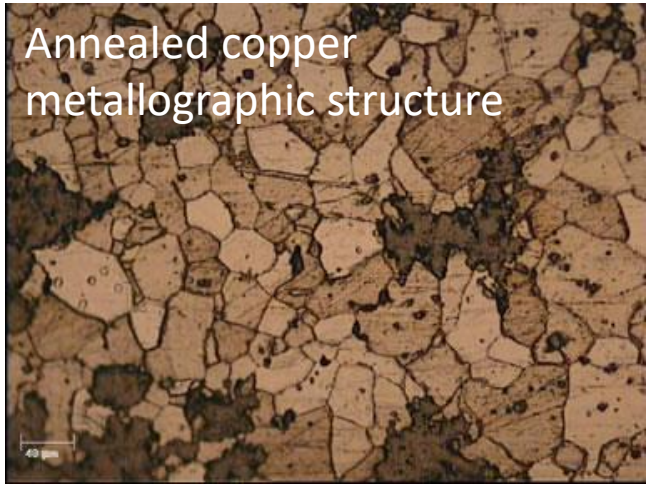
The macroscopic performance, behavior and properties of a material is determined by its microstructure.

Microscopic organization and structure
- Chemical compositions of materials
- Elemental distribution
- Phase and morphology (shape/size/distribution)
- Crystal structure
- Orientation between each phase/component
- Defects
- ……

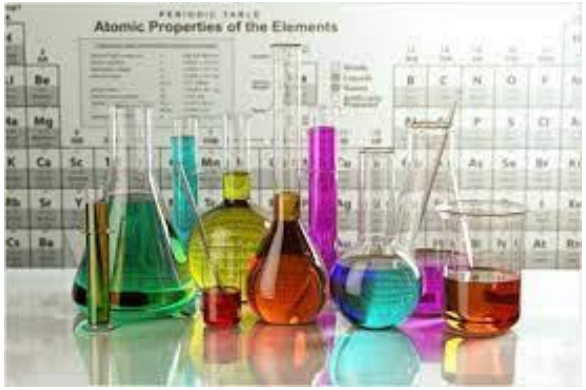
It is crucial to study the microstructure of the materials.

Traditional methods of studying the microstructure and composition of materials

- Optical Metallographic Microanalysis



- Chemical analysis method



Elements		% Composition by weight	Others	Values
SiO_2		40.95	Cl	0
Al_2O_3		20.38	L.O.I	
Fe_2O_3		21.95	SUM	83.76
CaO		-0.65	LSF	-0.34
MgO		-0.62	SR	0.97
K_2O		0.32	AR	0.93
Na_2O		0.23	C3S	-487.34
P_2O_5		0.03	C2S	-481.23
TiO_2		1.14	C3A	16.92
Mn_2O_3		0.16	C4AF	36.45
SO_3		-0.14	$Al_2O_3+Fe_2O_3$	42.33
Total	$SiO_2+Al_2O_3+Fe_2O_3$	83.28		

Source: *Olawuyi (2008)*

Characteristics of traditional analysis methods

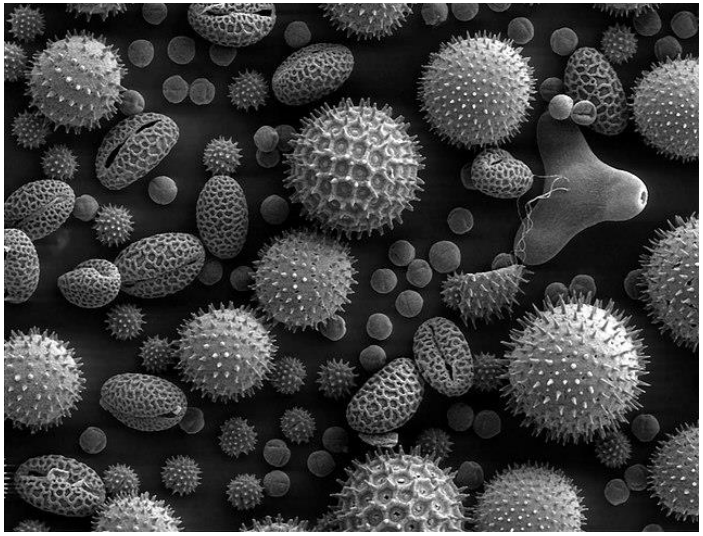
- Optical Metallographic Microanalysis
- Chemical analysis method

Analysis methods	Organizational morphology	Crystal structure	Chemical composition	Spatial resolution	Operation
Optical microscope	Yes	No	No	Low (0.2 μm)	Easy
Chemical analysis	No	No	Average Composition	—	Easy

X-ray diffraction and electron microscope

- X-ray diffraction

- Electron microscope



Characteristics of different analytical methods

Analysis methods	Organizational morphology	Crystal structure	Chemical composition	Spatial resolution	Operation
Optical microscope	Yes	No	No	Low (0.2 μm)	Easy
Chemical analysis	No	No	Average Composition	—	Easy
X-ray diffraction	No	Yes	No	Submillimeter	Easy
Electron microscope	Yes	Yes	Yes	Micro and nano meter	Complex

Syllabus

- Fundamental physics of X-ray
- Direction of X-ray diffraction
- Intensity of X-ray diffraction
- Analysis of polycrystal
- Phase analysis and lattice parameter determination
- Determination of residual stress

Midterm exam

- Fundamentals of electron optics
- Transmission electron microscope
- Electron diffraction
- Scanning electron microscope
- Electron micro probe analyzer
- Other analysis methods (Infrared spectroscopy, Raman spectroscopy, Ultraviolet–visible spectroscopy)

Final exam

Course objective

- Know the basic knowledge, skills and theoretical foundation of modern material analysis and testing techniques such as X-ray diffraction (XRD), transmission electron microscopy (TEM) and scanning electron microscopy (SEM), and have the ability to select material analysis methods and testing methods;
- Have a preliminary foundation for professional material analysis and testing work;
- Possess the self-learning ability to study new methods and technologies of material analysis through continuous learning and cultivate the scientific research ability of selecting modern analysis techniques in order to carry out the relationship between material composition, structure and performance.

Grading

- Homework (40%) + Midterm exam (30%) + Final exam (30%)

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