City University of Hong Kong
Course Syllabus

offered by Department of Physics
with effect from Semester A 2020/21

Part I Course Overview

Course Title:	**Modern Characterization Techniques for Materials Physics**
Course Code:	**PHY5501**
Course Duration:	**One Semester**
Credit Units:	**3**
Level:	**P5**
Medium of Instruction:	**English**
Medium of Assessment:	**English**
Prerequisites: *(Course Code and Title)*	**Nil**
Precursors: *(Course Code and Title)*	**Nil**
Equivalent Courses: *(Course Code and Title)*	**AP5301 Instrumental Methods of Analysis and Laboratory**
Exclusive Courses: *(Course Code and Title)*	**PHY8501 Modern Characterization Techniques for Materials Physics**

Part II Course Details

1. Abstract

This is a survey course for discussing both the physical principles and practical applications of modern methods for materials characterization. The course is designed for graduate students in applied physics and engineering disciplines related to materials research. The goal is to provide students with a foundation in the use of characterization techniques to solve and diagnose material problems that can be identified and potentially resolved with materials characterization.

The course covers techniques of microstructural analysis (OM, SEM, TEM, electron diffraction, XRD), microchemical characterization (EDS, XPS, AES, SIMS, RBS, and Raman spectroscopy), various scanning probe microscopy techniques (AFM, STM, EFM, and MFM) as well as electrical (Hall, CV, Seebeck) and optical measurements (UV-Vis-NIR, Ellipsometry, PL, etc). It emphasizes on the information that can be obtained together with the advantages and limitations of each technique. The course has a laboratory component with written lab reports and a term paper.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Describe the physical principles of various analytical instruments.			√	
2.	Apply physical principles to the structural design of each element of the instruments, in particular to those involving electron beam and ion beam.			√	
3.	Apply selected analytical techniques to common applications.		√		√
4.	Develop an in-depth knowledge in selected techniques and how they can be applied to specific problems in research in materials physics		√	√	√
		100%			

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to self-life problems.

A3: *Accomplishments*
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

3. Teaching and Learning Activities (TLAs)

(TLAs designed to facilitate students' achievement of the CILOs.)

TLA	Brief Description	CILO No.				Hours/week (if applicable)
		1	2	3	4	
Lectures	Introduce various techniques, explain the relevant concepts and applications	√	√	√		3
Term paper	Apply the knowledge to solve practical problems.	√	√	√	√	
Laboratories	Conduct relevant experiments to obtain practical understanding on selected techniques	√	√	√	√	

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.				Weighting	Remarks
	1	2	3	4		
Continuous Assessment: 50%						
Laboratories	√	√	√	√	30%	
Term paper	√	√	√	√	20%	
Examination: 50% (duration: 2 hours)	√	√	√	√	50%	
					100%	

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Laboratories and Term Paper	Ability to understand and explain the relevant materials, apply textbook knowledge in engineering problems	High	Significant	Moderate	basic	Not reaching marginal levels
2. Final Examination	Ability to understand and explain the relevant materials	High	Significant	Moderate	basic	Not reaching marginal levels

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

- Materials characterization
- Overview of analytical techniques
- Microscopy
- Spectroscopy
- Optical microscopy
- Electron microscopy: scanning and transmission
- Scanning probe microscopy
- Electron probe microanalysis
- X-ray diffraction
- Ion beam techniques
- Secondary ion mass spectrometry
- Rutherford backscattering spectrometry
- Hall effect
- Capacitance-voltage measurement
- Seebeck effect
- Spectrophotometry
- Spectroscopic ellipsometry
- Modulated spectroscopy
- Photoluminescence
- X-ray photoelectron spectroscopy

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

1.	Encyclopedia of Materials Characterization, edited by C Richard Brundle, Charles A Evans, Jr, and Shaun Wilson, Butterworth-Heinemann (1992)

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

1.	X-ray Microanalysis in the Electron Microscope (4th Edition), by J A Chandler, North Holland (1987)
2.	Methods of Surface Analysis: Techniques and Applications, edited J M E Walls, Cambridge University Press (1990)
3.	Analysis of Microelectronic Materials and Devices, edited by M. Grasserbauer and H W Werner, John Wiley & Sons (1991)
4.	Dopants and Defects in Semiconductors, Matthew D. McCluskey and Eugene E. Haller, Taylor & Francis Group (2012).
5.	Principles and Applications of Ion Beam Techniques for the Analysis of Solids and Thin Films, W. K. Chu, J. W> Mayer, M-A. Nicolet, T. M. Buck, G. Amsel, and F. Eisen, Thin Solid Films **17**, 1-41 (1973).
6.	Secondary Ion Mass Spectrometry, by Benninghoven, Rudenauer, and Werner, John Wiley & Sons (1987)
7.	Atomic and Nuclear Analytical Methods: XRF, Myssbauer, XPS, NAA and Ion-Beam Spectroscopic Techniques, Hem Raj Verma, Springer (2007).