City University of Hong Kong
Course Syllabus

offered by Department of Physics
with effect from Semester B 2017 / 18

Part I Course Overview

Course Title:	**Functional Ceramics**
Course Code:	**AP6126**
Course Duration:	**One Semester**
Credit Units:	**3**
Level:	**P6**
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)*	**Nil**
Exclusive Courses: *(Course Code and Title)*	**AP8126 Functional Ceramics**

Part II Course Details

1. Abstract

This course will provide students with a fundamental understanding and working knowledge of modern functional ceramics. It includes coverage of insulators, conductors, dielectric/pyroelectric/ferroelectric/ piezoelectric, electro-optic, magnetic, and other functional ceramic materials. Students will explore devices based on functional ceramics such as capacitors, resistor, varistors, thermistors, transducers, actuators, memory elements, multilayered components, and their applications. At the end of this course, students should be able to explain the basic phenomena underlying the particular properties of functional ceramics in terms of their crystal structure, defect state and microstructure as well as to design useful products for real applications.

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.	Classify different families of functional ceramics and describe their properties and applications.	10%			
2.	Describe the basic phenomena underlying the particular properties of functional ceramics in terms of crystal chemistry, crystal structure, defect state and microstructure.	20%	√		
3.	Relate the chemical composition, crystal structure and microstructure of functional ceramics to the particular conductive, dielectric, ferroelectric, piezoelectric and pyroelectric, electro-optic and magnetic properties.	20%	√		
4.	Recognize the basic principles of design and fabrication of useful products such as capacitors, resistors, insulators, sensors, actuators, memories devices, microwave filters, etc.	20%		√	
5.	Identify the latest technological developments in functional ceramic materials and innovatively apply the above knowledge to applications	30%			√
		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	5		
1	Lectures	√	√	√	√	√		2hrs/ wk
2	Tutorials		√	√	√			0.5hr/wk
3	Group discussions		√	√	√			1hr/wks for 2wks
4	Term paper	√	√	√	√	√		

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	5			
Continuous Assessment: 40%								
Home work assignments	√	√	√	√	√		10%	
Mid-term Test	√	√	√				10%	
Term paper	√	√	√	√	√		20%	
Examination: 60% (duration: 2 hrs)								
							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. Home work assignments	• Classify different families of functional ceramics and describe their properties and applications. • Describe the basic phenomena underlying the particular properties of functional ceramics in terms of crystal chemistry, crystal structure, defect state and microstructure. • Relate the chemical composition, crystal structure and microstructure of functional ceramics to the particular conductive, dielectric, ferroelectric, piezoelectric and pyroelectric, electro-optic and magnetic properties. • Recognize the basic principles of design and fabrication of useful products such as capacitors, resistors, insulators, sensors, actuators, memories devices, microwave filters, etc. • Identify the latest technological developments in functional ceramic materials and innovatively apply the above knowledge to applications.	High	Significant	Moderate	Basic	Not reaching marginal level

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
2. Mid-term test	• Classify different families of functional ceramics and describe their properties and applications. • Describe the basic phenomena underlying the particular properties of functional ceramics in terms of crystal chemistry, crystal structure, defect state and microstructure. • Relate the chemical composition, crystal structure and microstructure of functional ceramics to the particular conductive, dielectric, ferroelectric, piezoelectric and pyroelectric, electro-optic and magnetic properties.	High	Significant	Moderate	Basic	Not reaching marginal level

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
3. Term paper	• Classify different families of functional ceramics and describe their properties and applications. • Describe the basic phenomena underlying the particular properties of functional ceramics in terms of crystal chemistry, crystal structure, defect state and microstructure. • Relate the chemical composition, crystal structure and microstructure of functional ceramics to the particular conductive, dielectric, ferroelectric, piezoelectric and pyroelectric, electro-optic and magnetic properties. • Recognize the basic principles of design and fabrication of useful products such as capacitors, resistors, insulators, sensors, actuators, memories devices, microwave filters, etc. • Identify the latest technological developments in functional ceramic materials and innovatively apply the above knowledge to applications.	High	Significant	Moderate	Basic	Not reaching marginal level

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
4. Examination	• Classify different families of functional ceramics and describe their properties and applications. • Describe the basic phenomena underlying the particular properties of functional ceramics in terms of crystal chemistry, crystal structure, defect state and microstructure. • Relate the chemical composition, crystal structure and microstructure of functional ceramics to the particular conductive, dielectric, ferroelectric, piezoelectric and pyroelectric, electro-optic and magnetic properties. • Recognize the basic principles of design and fabrication of useful products such as capacitors, resistors, insulators, sensors, actuators, memories devices, microwave filters, etc. • Identify the latest technological developments in functional ceramic materials and innovatively apply the above knowledge to applications.	High	Significant	Moderate	Basic	Not reaching marginal level

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.)

- Introduction

  This lecture provides a historical account of the discovery and development of ceramic materials for electrical and electronic applications. It gives a summary of various types of electroceramics along with fundamental concepts as well as general processes and their applications.
- Elementary Solid State Science

  Underlying physical principles of electrical and electronic properties of ceramics will be presented. It covers the ionic structure in ceramics, defects in crystals, spontaneous polarization, phase transitions, electrical conduction and charge displacement processes.
- Measurement techniques

  Basic principles and techniques for dielectric, ferroelectric and piezoelectric property measurements.
- Fabrication of Ceramics

  General methods and new development of ceramic processing.
- Ceramic Conductors

  Following topics will be covered: high-temperature heating elements and electrodes, Ohmic resistors, voltage-dependent resistors, thermally sensitive resistors, solid fast-ion conductors, sensors, and high temperature superconductors.
- Dielectrics and Insulators

  This chapter shall cover capacitative applications and ferroelectric applications. Dielectric properties for low-, medium- and high-permittivity ceramics will be discussed.
- Piezoelectric Ceramics

  General characteristics of piezoelectric materials using examples, morphotropic phase boundary and methods for enhancing piezoelectric properties. Typical piezoelectric materials, such as PZT, and their applications will be discussed. Definition of piezoelectric coefficeints and their measurements methods.
- Pyroelectric Materials

  Properties and measurements of pyroelectric coefficients of ceramics will be presented. Applications to thermal and infrared detection will be discussed.
- Electro-optic Ceramics

  The electro-optic effect, non-linear optics of ceramics and applications form the basis of this chapter.
- Magnetic Ceramics

  Basic concepts, properties and applications of model ferrites.

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.	A J Moulson and J M Herbert, "Electroceramics – Materials, Properties, Applications", (2nd Edition) Chapman & Hall, 2003. e-book

2.2 Additional Readings

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

1.	"A fascination with oxides" Nature Materials 2007
2.	"Ferroelectric Ceramics: History and Technology" J. American Ceramic Society 1999
3.	"Still in Suspense" Nature 2011
4.	"Lead –free at last" Nature 2004
5.	"The light and shade of perovskite solar cells" Nature 2014