

# Advanced ceramics for strategic applications - Video course

## COURSE OUTLINE

"Advanced Ceramics" constitute a group of materials other than the clay minerals based "traditional ceramics" and are one of the fastest growing groups of materials particularly for advanced technology applications replacing, in many cases, conventional metals and alloys. While "traditional ceramics" are based primarily on naturally occurring raw materials, the "advanced ceramics" use mostly synthetic or specially prepared raw materials. Therefore, preparation of synthetic raw material constitutes an important part of this course.

Consolidation of the powdery raw materials into desirable and in many cases complex shapes requires understanding the basic principles of different techniques of ceramic processing and fabrication.

Advanced ceramic materials are used not only in the bulk shapes but also in the form of thick or thin films as well as in single crystals. In addition, ceramics are also used in the fiber form.

From the chemistry point of view the materials cover a very wide spectrum of compounds e.g. oxides, carbides, nitrides, oxy-nitrides, silicides as well as their combinations. Their properties and consequently the area of applications vary quite significantly.

Many new and exotic properties are possible to be developed in these materials and therefore, one can think of several exotic applications. Advanced ceramics are known for their unusual electrical, magnetic, mechanical, optical and electro-optic properties.

Their importance lies in their extra-ordinary strength at high temperatures, much better abrasion and tribological properties, insulating, semi-conducting, conducting and even superconducting properties, dielectric and piezoelectric properties, soft and hard magnetic properties. Besides one can make ionically conducting ceramics for electrochemical applications.

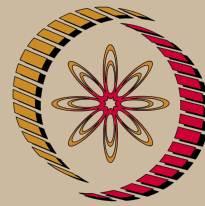
Ceramics can be fabricated with controlled pores size and porosity particularly for different types of separation technologies. It is also possible to develop either bio-inert or bio-active ceramics for use as bio-medical implants.

Advanced ceramic products are commonly used in a variety of engineering industries, microelectronics, thermal engineering, sensor and actuator technology, environmental engineering, energy technology, water purification technology, biomedical engineering etc. covering different sectors like atomic energy, defence, space and civilian applications.

Exotic ceramics such as functionally graded, smart/ Intelligent, bio-mimetic and nano- ceramics are also becoming important for different applications. All these aspects will be covered in details.

## COURSE DETAIL

Sl. No	Topic	Hours
1.	Introduction: oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, non-stoichiometry and typical properties.	4



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# NPTEL

<http://nptel.iitm.ac.in>

## Metallurgy and Material Science

### Pre-requisites:

Physics and Chemistry of Solid

### Coordinators:

**Prof. H.S. Maiti**

Department of Materials and  
Metallurgical Engineering  
Central Glass & Ceramic Research Institute

2.	Powder Preparation: Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).	4
3.	Basic principles and techniques of consolidation and shaping of ceramics: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering.	3
4.	Sintering: different mechanisms and development of microstructure (including microwave sintering)	3
5.	Preparation of single crystal, thick and thin film ceramics	2
6.	Mechanical behaviour: fracture mechanics and tribology	2
7.	Engineering applications: at room and high temperatures (including armour application)	3
8.	Electrical behaviour: insulating (dielectric, ferroelectric, piezoelectric, pyroelectric) semiconducting, conducting, superconducting and ionically conducting, specific materials and their applications.	4
9.	Magnetic behaviour: basic principles, materials and their applications.	2
10.	Transparent ceramics, coatings and films: preparation and applications	2
11.	Porous ceramics and ceramic membrane: fabrication techniques and applications in separation technology.	3
12.	Bio-medical applications of ceramic materials	2
13.	Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support)	2
14.	Ceramics matrix composites: different types, their preparation and properties (including nano-composites)	2
15.	Exotic ceramics: functionally graded, smart/ Intelligent, bio-mimetic and nano- ceramics - basic principles, preparation and applications	2

**References:**

1. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
2. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
3. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003
4. Handbook of Advanced Ceramics by S. Somiya, Academic Press 2003
5. Handbook of Advanced Ceramics, Parts 1 and 2, S. Somiya, Aacademic Press, 2006