UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Chemistry of Inorganic Materials

2526-1-FSM02Q005

Aims

Describe and discuss advanced methods for the synthesis of functional inorganic materials. Focus is on the choice of precursors and process conditions for synthesizing materials with the required composition, structure and physico-chemical properties. Owing to the dominance of crystalline materials students will learn fundamentals of crystal growth from the melt, solution (low and high temperature) and vapor.

This course aims at contributing to the specific theoretical and experimental knowledge on the properties of inorganic materials, as well as their application to their synthesis and characterization. Students will acquire basic knowledge about relevant advanced inorganic materials and synthetic methods with process parameters. This will enable the student to select approach, method and parameters best suited to fully control and optimize the synthesis of inorganic functional materials. This course logically completes the mandatory course Strategies for materials synthesis – Inorganic strategies for materials synthesis.

Knowledge and understanding: The course aims to develop a critical mindset focused on examining and understanding the typical processes for preparation of inorganic materials. Students will be enabled to confidently use concepts and interpretative tools for the topics discussed during the lectures.
Applying knowledge and understanding: By the end of the course, students will be proficient in concepts related to thermodynamics and kinetics applied to synthesis of varied types of inorganic materials, including exploitation of inorganic solids in industrial and research processes.
Making judgements: Through frequent interactions with students in class, the course will encourage the development of independent judgment.
Communication skills: the course aims to improve the communication skills. To this end, exams are performed with oral interaction between student and the instructors. Students are encouraged to focus on communication aspects during their learning process, with particular emphasis on technical and scientific language.
Learning skills: the course seeks to improve the learning abilities through the use of diverse teaching tools (lecture notes, movies, selected chapter of textbooks). The student will develop her/his learning skills by exploiting also the scientific literature, together with the communication skills, which will be evaluated during the exam.

Contents

Distribution of chemical elements within the Earth's crust and their extraction. Advanced synthesis of functional materials (single crystals, polycrystalline powders, films, and ordered porous materials): synthesis of solids from the gas phase, from melts and solutions at low and high temperature, low and high pressure, exploitation of sol-gel processes.
Advanced definitions of acids and bases, acid/base properties of inorganic material, redox properties of inorganic materials, surface properties of inorganic materials.

Detailed program

Availability and distribution of chemical elements within the Earth's crust: environmental and technological issues for extraction of elements involved in synthesis of inorganic materials.

Synthesis of solids from the gas phase: Chemical and Physical Vapor Deposition (with sister techniques such as sputtering, thermal evaporation, vapor phase epitaxy, Chemical Vapor Infiltration, ..) with kinetic models, reactor types, features od reactants

Synthesis of solids from melts and solutions: crystal growth from the melt: general features and special techniques (Verneuil, Bridgman-Stockbarger, Czochralski, Kyroupolos, Skull method, Floating zone). Growth from low and high temperature solutions (solvothermal and hydrothermal processes, flux growth). Precipitation reactions and control of crystal morphology. The role of additives/impurities.

Synthesis of inorganic pigments: general properties of pigment particles (particle size, size distribution, surface area and chemistry). General synthetic methods for pigment particles. Functional pigments.

Reactivity and stability of inorganic materials:: Advanced definitions of acids and bases, acid/base properties of inorganic material, redox properties of inorganic materials, phase diagrams and stability in water and other solvents

Surface Chemistry of inorganic materials: Differences in reactivity of various facets of inorganic materials. Effects of nanostructuring. Surface functionalization. Intercalation phenomena in layered materials-

Prerequisites

Chemistry of inorganic materials is based on an interdisciplinary approach exploiting general and inorganic chemistry, organic chemistry, physical chemistry (thermodynamics and chemical equilibria) and basic knowledge of crystallography.

Teaching form

The course provides 24 two-hour lectures, in person (Delivered Didactics). Lectures will be given in English supported by video projection of text, schemes, diagrams, pictures and movies.

Textbook and teaching resource

Reference general textbook:
Synthesis of inorganic materials - U. Schubert, N. Hüsing - (2019) - ebook

Reference textbooks:

- The inorganic chemistry of materials: how to make things out of elements - P.J. van der Put - (1998)
- Solid state chemistry. Compounds - Eds. A.K. Cheetham, P. Day - (1992)
- Inorganic Pigments - G. Pfaff - (2017) - ebook
- Modern inorganic chemistry synthesis – R. Xu, W. Pang, Q. Huo Eds. - (2017) – ebook
- Inorganic chemistry – D. F. Shriver, P. W. Atkins, C. H. Langford – Oxford University Press (1990)
- Inorganic chemistry – J. E. Huheey – Harper & Row Eds. (1983)

Lecture handouts will be provided as pdf files uploaded on the e-learning platform.

Semester

1?? semester, starting on September 2025

Assessment method

The examination is performed through an oral exam without midterm tests. The teacher assesses if and to what extent the student has reached the course objectives, through a formal knowledge-based evaluation of the general topics delivered together with selected case studies. Parameters analyzed for producing the final score are capability and fluency during the interview to illustrate in a clear and sound way the topics delivered. A positive final graduation ranges from 18/30 to 30/30 cum laude based on quality and completeness level of the answers provided by the student.

Office hours

The teachers are available for help and discussion by arranging a meeting by email to: massimo.moret@unimib.it or sergio.tosoni@unimib.it.

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION