

MSE-326

**Ceramic and colloidal processing**

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Cursus	Sem.	Type
Materials Science and Engineering	BA5	Obl.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Oral
Workload	90h
Weeks	14
<b>Hours</b>	<b>3 weekly</b>
Lecture	3 weekly
<b>Number of positions</b>	

**Summary**

The course covers the production of ceramics and colloids from the basic scientific concepts and theories needed to understand the forming processes to the mechanisms and methods of sintering (firing) ceramics. Including the scientific principles behind the formation of colloidal dispersions.

**Content****1. Powder synthesis and Characterization**

- Thermodynamics of solutions: ideal solutions, high ionic strength, complexation.
- Nature and preparation of raw ceramic materials (natural and synthetic).
- Production routes for synthetic ceramic powders. Precipitation, gas phase synthesis and solid-state reactions.
- Powder characterization, physical, chemical and morphological properties with reference to underlying theory. Including particle size measurement, specific surfaces area, porosity and morphology.

**2. Milling and classification.**

- Crushing, Ball milling, high energy milling. Modelling of milling. Sieves and air classifiers

**3. Powder processing (dispersion, forming, drying)**

- Thermodynamics of surfaces and interfaces: surface tension, adhesion and cohesion, wettability, capillary condensation.
- Adsorption at interfaces: solid/liquid, liquid/liquid, solid/gas and liquid/gas.
- Intermolecular interactions: electrostatic, dispersion and van der Waals forces; interaction energy and entropy.
- Distribution of ions in solution: influence of a charged interface.
- Interactions between colloidal particles; colloidal stability: the DLVO model. Kinetics of agglomeration.
- Polymers in solution: solubility, conformation, adsorption at interfaces, steric stabilisation of colloidal particles.
- Ceramic forming : pressing, tape casting, slip casting, injection moulding and others
- Drying and binder burnout

**4. Surfactants, micelles and micellar solutions.****5. Sintering**

- Origin and phenomenology, Kinetics, Microstructural control.
- Solid-state and liquid phase sintering

**6. Thin and thick ceramic films**

- Synthesis of colloidal sols : dispersion, precipitation
- Manufacturing methods, dip-coating, plasma spraying.

**7. Virtual TPs**

- Every third week, during the exercise hour: virtual TP / practical session

**Keywords**

Ceramics, colloids, forming, interparticle interactions, sintering, powder characterisation, processing, steric stabilization, adsorption, powder synthesis.

**Learning Prerequisites**

**Required courses**

General physics;  
General inorganic chemistry;  
Mathematical analysis;  
Introduction to materials;

**Recommended courses**

Thermodynamics for materials science

**Important concepts to start the course**

chemical bonds; phase transitions; thermodynamics; microstructure of materials; statistics, transfer phenomena

**Learning Outcomes**

By the end of the course, the student must be able to:

- Apply The acquired notions of the dispersion of particulate matter for any application.
- Produce Acquired the knowledge, skills and practice necessary to produce a ceramic in an industrial environment or a laboratory
- Choose To produce a ceramic of a particular geometry in connection with an application.
- Demonstrate Understand the colloidal stability of a suspension using the DLVO theory.
- Describe Assess the key characteristics of a ceramic powder needed to make a ceramic
- Explain Explain the mechanisms behind the different sintering phenomena.
- Describe Know the different methods of synthesizing a ceramic powder.

**Transversal skills**

- Use both general and domain specific IT resources and tools
- Take responsibility for health and safety of self and others in a working context.
- Negotiate effectively within the group.
- Give feedback (critique) in an appropriate fashion.
- Take feedback (critique) and respond in an appropriate manner.

**Teaching methods**

Lectures and exercises in class (3 h). Exercises with calculation will be done in class and they will serve as typical example of questions during the oral exam. Nevertheless, during the oral exam no calculations will be required but a clear understanding of concepts and the logical connections of the arguments of the course.

**Expected student activities**

Attendance of lectures, doing exercises during class and at home, reading written material, active participation to discussions during classes.

**Assessment methods**

The final grade is attributed based on the final oral exam and the active participation during lectures. "Plus" (+) is assigned during third hour based questions and replies. An example will be given during the first class. (+++) will count in the final grade as +0.5 max.

Oral exam will start with a free topic, among those proposed during the course.

Additional information:

During the classes, mainly at the third hour, the major concepts of the slides presented that day will be summarized. Students are asked to formulate questions on the topic of that day. The questions are then used to initiate a discussion among students. Questions and discussion will be assessed providing "+" to students. No "-" are considered in any

circumstances. During the oral exam the gained + will be evaluated as follow: +++ = 0.50; ++ = 0.25 . The gained points will be added to the grade achieved at the oral exam.

Example:

Oral exam: 4.5

Participation to discussion: ++

Final grade: 4.75

## Resources

### Bibliography

English

The Colloidal Domain: where physics, chemistry, biology, and technology meet. D. F. Evans and H. Wennerström. Wiley-VCM, New York, Year:1999. ISBN:0-471-24247-0

CERAMIC PROCESSING AND SINTERING M. N. Rahaman Taylor & Francis, London, 2003 0: ISBN - 10-8247-0988-8

French

Traité des Matériaux, vol 16, Céramiques et Verres, Principes et techniques d'élaboration, J-M Haussonne, C.P.Carry, P. Bowen, J. Barton, Press Polytechnique et Universitaires Romandes2005

### Ressources en bibliothèque

- [The Colloidal Domain: where physics, chemistry, biology, and technology meet/ Evans](#)
- [Principles of Ceramics Processing / Stalford](#)
- [Fundamentals of ceramic powder processing and synthesis / Ring T.A.](#)
- [Céramiques et verres : principes et techniques d'élaboration / Haussone](#)
- [Ceramic Processing and Sintering / Rahaman](#)

### Notes/Handbook

Copy of slides presented during lectures; Written text based on lectures.

### Moodle Link

- <https://go.epfl.ch/MSE-326>