MSE-326

Ceramic and colloidal processing

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Cursus	Sem.	Type
Materials Science and Engineering	BA5	Obl.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	3 weekly
TP	1 weekly
Number of positions	

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 cassting, 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 liquide phase sintering

6. Thin and thick ceramic films
- Synthesis of colloidal sols : dispersion, precipitation
- Manufacturing methods, dip-coating, plasma spraying.

7.

Laboratory work

1. Milling, granulometry, spray drying, flowability of powders, classification
2. Forming methods - dry pressing, dispersion + slip casting, analysis of compaction
3. Sintering, density and microstructures, modelling of sintering

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, tranfer 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 the colloidal stability of a suspension using the DLVO theory.
- Describe the key characteristics of a ceramic powder needed to make a ceramic
- Explain the mechanisms behind the different sintering phenomena.
- Describe the different methods of synthesizing a ceramic powder.

Transversal skills

- Use both general and domain specific IT resources and tools
- Write a scientific or technical report.
- Take responsibility for health and safety of self and others in a working context.
- Negotiate effectively within the group.

Teaching methods

Lectures and exercises in class (3 h) and laboratory work (1 h)

Expected student activities

Attendance of lectures, doing exercises during class and at home, reading written material, discussion in class, doing experimental exercises, writing reports on experimental work and analyzing results

Assessment methods

The final grade is attributed based on the final oral exam 75% and the practical class reports 25%.

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
- Céramiques et verres : principes et techniques d'élaboration / Haussone
- Ceramic Processing and Sintering / Rahaman
- Fundamentals of ceramic powder processing and synthesis / Ring T.A.
- Principles of Ceramics Processing / Stalford

Notes/Handbook

Copy of slides presented during lectures; Wriiten text based on lectures; Text for each TP;