MH 2300 Functional materials 6 hp

Aim
To gain deep knowledge about materials which are not primarily used for their mechanical properties, but for other properties such as physical, chemical, *etc.* To know what "functions" can be built into the materials and how to maximise their performance.

Learning objectives. After passing the course the student should be able to:

LO1. Describe the properties of various functional materials and formulate models of the underlying physical and chemical phenomena.
LO2. Indicate the most important properties of functional materials including availability, price, manufacturing capacity, durability, recyclability and environmental impact. Compare different materials according to these properties.
LO3. Search and critically analyze literature data on the properties of functional materials.
LO4. Rationally select functional materials for existing and new applications.

Syllabus
Specific properties of functional materials are covered, which are used in high-tech applications. The course includes:

- Intermetallic materials including
  - superalloys
  - shape memory alloys
  - coating materials
- Biomaterials
- Advanced ceramics, including
  - ferroelectric and piezoelectric materials
  - insulating materials
  - thermal barrier coatings
- Magnetic materials
- Electronic materials, including
  - elemental and compound semiconductors
  - conductive polymers
  - ionic conductors
- Catalytic materials

Pre-requisites

Basic knowledge in materials science corresponding to the course MH1024 Fundamentals of Materials Science - Metallic Materials.

Language
The course is given in English.

Teachers
Lectures and seminars: Pavel Korzhavyi, pavelk@kth.se, tel. 790 9193
Projects and guest lecture: Claudio Lousada, cmlp@kth.se, tel. 790 8789

Lectures (rooms at Brinellvägen 23)

Date	Part	Room	Theme
Monday March 22, 13-15	I	Zoom	Intermetallic materials I
Wednesday March 24, 08-10	I	Zoom	Intermetallic materials II
Monday March 29, 13-15	I	Zoom	Advanced ceramics: Ferroelectrics I
Wednesday March 31, 08-10	I	Zoom	Advanced ceramics: Ferroelectrics II
Wednesday April 14, 08-10	II	Zoom	Magnetic materials
Monday April 19, 13-15	II	Zoom	Shape memory alloys
Wednesday April 21, 08-10	II	Zoom	Catalytic materials
Monday April 26, 13-15	II	Zoom	Semiconductors I
Wednesday April 28, 08-10	II	Zoom	Semiconductors II
Monday May 10, 13-16		Zoom	Partial reporting of projects
Monday May 17, 13-16		Zoom	Reporting of projects

Tests (kontrollskrivningar)

On lectures part I: Monday April 12, 13:00-15:00, (Digital)

On lectures part II: Monday May 03, 13:00-15:00, (Digital)

Examination

For all students:

i) written report to be presented at the seminars (see special instruction)

ii) participation in seminars

iii) approved tests

Those who could not attend or pass tests I or II, may (re)write tests on the exam week,

Voluntarily examination: Wednesday May 31, 14:00-18:00, (Digital, Zoom).

Course literature

Compendium on Functional materials (excl. chapters 4 to 6 on biomaterials)

Distributed articles

Results of a literature search should be used for the preparation of the report.

Short layout of the reports to be written

- Register for a report topic as soon as possible
- Use the listed literature review as a starting point. Use Elsevier's Science Direct to search for more literature.
- Summarise the scientific knowledge about the chosen topic. Always use your own words, do never copy text.
- Summarise the potential industrial applications for materials or techniques covers. Describe how knowledge could be commercialised.
- When you use a specific source you should always give a reference at that point.
- The report should be written as educational material at your own level. Thus the material should be suitable for a forthcoming course. Figures should be placed in the text, each with a caption below it. Each table, also in the text should have a heading above it.
- The expected size of each report is 10 A4 pages per student with 1.5 p line spacing, Times New Roman, 12 p (~10 A4 pages per student)
- Follow the guidelines[1] for how to write scientific reports.

Schedule

Each group should present an **outline of the report** at the seminar on **Monday, May 10, 13:00-16:00, M121(Blå)**.

The final reports should be delivered strictly according to the schedule below in electronic form by email.

Presentation date	Report ready by	Send to
Monday May 17, 13-16, Zoom	May 16, 15:00	cmlp@kth.se

[1] Writing scientific reports, R. Sandström, D. Andersson (MS&E, KTH, 2008).

Topics for Reports and Seminars (15 mins presentations by the students)

No	Theme	Name
1	Layered ternary metal oxides: Performance degradation mechanisms as cathodes, and design strategies for high-performance batteries, *Progress in Materials Science*, Volume 111 (2020) Article 100655, L. Liu, M. Li, L. Chu, B. Jiang, L. Ruoxu, Z. Xiaopei, G. Cao	
2	Multifunctional magneto-polymer matrix composites for electromagnetic interference suppression, sensors and actuators, *Progress in Materials Science*, Volume 115 (2021) Article 100705, A.D.M. Charles, A.N. Rider, S.A. Brown, C.H. Wang	
3	Magnetocaloric effect: From materials research to refrigeration devices, *Progress in Materials Science*, Volume 93, June 2018, Pages 112-232, V. Franco, J.S. Blázquez, J.J. Ipus, J.Y. Law, L.M. Moreno-Ramírez, A. Conde	
4	FeO-based nanostructures and nanohybrids for photoelectrochemical water splitting, *Progress in Materials Science*, Volume 110 (2020) Article 100632, Š. Kment, K. Sivula, A. Naldoni, S.P. Sarmah, H. Kmentová, M. Kulkarni, Y. Rambabu, P. Schmuki, R. Zbořil	
5	Additive manufacturing of magnetic materials, *Progress in Materials Science*, Volume 114 (2020) Article 100688, V. Chaudhary, S.A. Mantri, R.V. Ramanujan, R. Banerjee	
6	Conductive nitrides: Growth principles, optical and electronic properties, and their perspectives in photonics and plasmonics, *Materials Science and Engineering R*, Volume 123 (2018) Pages 1-55, P. Patsalas, N. Kalfagiannis, S. Kassavetis, G. Abadias, D.V. Bellas, Ch. Lekka, E. Lidorikis	
7	Metal oxides based electrochemical pH sensors: Current progress and future perspectives, *Progress in Materials Science*, Volume 109 (2020) Article 100635, L. Manjakkal, D. Szwagierczak, R. Dahiya	
8	Anisotropic magnetic nanoparticles: A review of their properties, syntheses and potential applications, *Progress in Materials Science*, Volume 95 (2018) Pages 286-328, Darja Lisjak, Alenka Mertelj	

Two or three students write a report on their topic (annotated, about 10 pages/student).

No	Theme	Name
9	Review on ultra-high temperature boride ceramics, *Progress in Materials Science*, Volume 111 (2020) Article 100651, Brahma Raju Golla, Amartya Mukhopadhyay, Bikramjit Basu, Sravan Kumar Thimmappa	
10	The materials science of skin: Analysis, characterization, and modeling, *Progress in Materials Science*, Volume 110 (2020) Article 100634, A. Pissarenko, M.A. Meyers	
11	Bioprocess-inspired fabrication of materials with new structures and functions, *Progress in Materials Science*, Volume 105 (2019) Article 100571, Jingjing Xie, Hang Ping, Tiening Tan, Liwen Lei, Hao Xie, Xiao-Yu Yang, Zhengyi Fu	
12	Memory formation in matter, *Reviews of Modern Physics*, Volume 91 (2019) Article 91 (2019) Article 035002, N.C. Keim, J.D. Paulsen, Z. Zeravcic, S. Sastry, S.R. Nagel	
13	Additive manufacturing of advanced ceramic materials, *Progress in Materials Science*, Volume 116 (2021) Article 100736, Y. Lakhdar, C. Tuck, J. Binner, A. Terry, R. Goodridge	
14	Design and engineering of magneto-responsive devices for cancer theranostics: Nano to macro perspective, *Progress in Materials Science*, Volume 116 (2021) Article 100742, P.I.P. Soares, J. Romão, R. Matos, J.C. Silva, J.P. Borges	
15	Progress in high-strain perovskite piezoelectric ceramics, *Materials Science & Engineering R*, Volume 135 (2019) Pages 1-57, Jigong Hao, Wei Li, Jiwei Zhai, Haydn Chen	
16	Recent progress on single atom/sub-nano electrocatalysts for energy applications, *Progress in Materials Science*, Volume 115 (2021) Article 100711, D.T. Tran, D.C. Nguyen, H.T. Le, T. Kshetri, V.H. Hoa, T.L.L. Doan, N.H. Kim, J.H. Lee	

Two or three students write a report on their topic (annotated, about 10 pages/student).

No	Theme	Name
17	Computational thermodynamics and its applications, *Acta Materialia*, Volume 200 (2020) Pages 745-792, Zi-Kui Liu	
18	Perspective and Prospects for Rare Earth Permanent Magnets, *Engineering*, Volume 6 (2020) Pages 119-131, J.M.D. Coey	
19	Recent progress on flexible and stretchable piezoresistive strain sensors: From design to application, *Progress in Materials Science*, Volume 114 (2020) Article 100617, L. Duan, D.R. D'hooge, L. Cardon	
20	Multiple and two-way reversible shape memory polymers: Design strategies and applications, *Progress in Materials Science*, Volume 105 (2019) Article 100 572, Kaojin Wang, Yong-Guang Jia, Chuanzhuang Zhao, X.X. Zhu	
21	Two-dimensional materials for energy conversion and storage, *Progress in Materials Science*, Volume 111 (2020) Article 100637, H. Tao, Q. Fan, T. Ma, S. Liu, H. Gysling, J. Texter, F. Guo, Z. Sun	
22	Theoretical perspectives on biological machines, *Reviews of Modern Physics*, Volume 92 (2020) Article 025001, M.L. Mugnai, C. Hyeon, M. Hinczewski, D. Thirumalai	

Two or three students write a report on their topic (annotated, about 10 pages/student).