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

***Information from KTH regarding the novel Corona virus* (2020-03-17, 13.30)**

Physical access to KTH

Due to the government recommendation of March 17, all entrances to KTH premises in all campuses will be locked as from Wednesday March 18 and students will not have access. Staff (including PhD students) will still have access depending on individual keycard access.

KTH is still available through its standard digital channels, phone and mail.

Studies and exams

Study period 4 started as planned Monday March 16. Forms of teaching and examination may differ from the course plan during this study period. Studies and exams shall take place remotely. The course co-ordinator is asked to make course material and lectures available online. No written examination will be given and should instead be given in an alternative examination form. There is a possibility that the exam date for some courses will be changed in order to ensure that the exam is conducted. Questions regarding alternative forms of exams for students with disabilities, contact: funka@kth.se.

Questions

In the coming time, we will work hard to be able to switch to distance education and will therefore have a high workload. This will mean that we not always will be able to answer your questions via e-mail, but we refer to Canvas for more information.

Lectures (rooms at Brinellvägen 23)

Date	Part	Room	Theme
Monday March 16, 10-12	I	M121(Blå)	Intermetallic materials I
Wednesday March 18, 13-15	I	M121(Blå)	Intermetallic materials II
Monday March 23, 10-12	I	M121(Blå)	Advanced ceramics: Ferroelectrics I
Wednesday March 25, 13-15	I	M121(Blå)	Advanced ceramics: Ferroelectrics II
Wednesday April 1, 13-15	II	M121(Blå)	Magnetic materials
Monday April 6, 10-12	II	M121(Blå)	Shape memory alloys
Wednesday April 8, 13-15	II	M121(Blå)	Catalytic materials
Tuesday April 20, 15-17	II	M121(Blå)	Semiconductors I
Wednesday April 22, 13-15	II	M121(Blå)	Semiconductors II
Monday May 4, 09-12		M121(Blå)	Partial reporting of projects
Monday May 11, 09-12		M121(Blå)	Reporting of projects

Tests (kontrollskrivningar)

On lectures part I: Monday March 30, 08:00-10:00, M121(Blå)

On lectures part II: Monday April 27, 08:00-10:00, M121(Blå)

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 27, 14:00-18:00, V11.

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 4, 15:00-18:00, 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 11, 15-18, M121(**Blå**)	May 10, 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	Cuprous oxide (Cu_2O) crystals with tailored architectures: A comprehensive review on synthesis, fundamental properties, functional modifications and applications, *Progress in Materials Science*, Volume 96 (2018) Pages 111-173, Shaodong Sun, Xiaojing Zhang, Qing Yang, Shuhua Liang, Xiaozhe Zhang, Zhimao Yang	
2	Earth-abundant transition metal and metal oxide nanomaterials: Synthesis and electrochemical applications, *Progress in Materials Science*, Volume 106 (2019) Article 100574, Govindhan Maduraiveeran, Manickam Sasidharan, Wei Jin	
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	Earth-abundant catalysts for electrochemical and photoelectrochemical water splitting, *Nature Reviews Chemistry*, Volume 1 (2017) Article number 0003, I. Roger, M. A. Shipman, M. D. Symes. For background reading: D. J. Martin, *Investigation into High Efficiency Visible Light Photocatalysts for Water Reduction and Oxidation*, Chapter 1 Introduction: Fundamentals of Water Splitting and Literature Survey (Springer, 2015) Pages 1-53.	
5	Spintronics technology: past, present and future, *International Materials Reviews*, Volume 61, Issue 7 (2016) Pages 456-472, J. W. Lu, E. Chen, M. Kabir, M. R. Stan & S. A. Wolf	
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	Beyond solvents and electrolytes: Ionic liquids based advanced functional materials, *Progress in Materials Science*, Volume 77, April 2016, Pages 80-124, S. Zhang, Q. Zhang, Y. Zhang, Z. Chen, M. Watanabe, Y. Deng	

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

No	Theme	Name
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	
9	Development of strong, oxidation and corrosion resistant nickel-based superalloys: critical review of challenges, progress and prospects, *International Materials Reviews*, Volume 64, Issue 6 (2019) Pages 355-380, R. Darolia	
10	Multifunctional nanoplatforms for subcellular delivery of drugs in cancer therapy, *Progress in Materials Science*, Volume 107 (2020) Article 100599, Xing Guo, Xiao Wei, Zi Chen, Xiaobin Zhang, Guang Yang, Shaobing Zhou	
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	PAN precursor fabrication, applications and thermal stabilization process in carbon fiber production: Experimental and mathematical modelling, *Progress in Materials Science*, Volume 107 (2020) Article 100575, H. Khayyam, R. N. Jazar, S. Nunna, G. Golkarnarenji, K. Badii, S. M. Fakhrhoseini, S. Kumar, M. Naebe	
13	Revisiting fundamental welding concepts to improve additive manufacturing: From theory to practice, *Progress in Materials Science*, Volume 107 (2020) Article 100590, J.P. Oliveira, T.G. Santos, R.M. Miranda	
14	Extraterrestrial construction materials, *Progress in Materials Science*, Volume 105 (2019) Article 100577, M.Z. Naser	
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	

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

No	Theme	Name
16	Current trends, challenges, and perspectives of anti-fogging technology: Surface and material design, fabrication strategies, and beyond, *Progress in Materials Science*, Volume 99 (2019) Pages 106-186, Iván Rodríguez Durán, Gaétan Laroche	
17	Twinning-induced plasticity (TWIP) steels, *Acta Materialia*, Volume 142 (2018) Pages 283-362, B. C. De Cooman, Y. Estrin, Sung Kyu Kim	
18	Flexoelectricity in solids: Progress, challenges, and perspectives, *Progress in Materials Science*, Volume 106 (2019) Article 100570, Bo Wang, Yijia Gu, Shujun Zhang, Long-Qing Chen	
19	Transparent heat regulating (THR) materials and coatings for energy saving window applications: Impact of materials design, micro-structural, and interface quality on the THR performance, *Progress in Materials Science*, Volume 95 (2018) Pages 42-131, Goutam Kumar Dalapati, Ajay Kumar Kushwaha, Mohit Sharma, Vignesh Suresh, Santiranjan Shannigrahi, Siarhei Zhuk, Saeid Masudy-Panah	
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	Electrically conducting fibres for e-textiles: An open playground for conjugated polymers and carbon nanomaterials, *Materials Science & Engineering R*, Volume 126 (2018) Pages 1-29, Anja Lund, Natascha M. van der Velden, Nils-Krister Persson, Mahiar M. Hamedi, Christian Müller	

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