LV EN RU DE FR
Study Course Code **Fizi5119** Credits **4**

Microscopy and spectroscopy characterization methods

Total Number of Contact Hours	**64**
Number of Lecture Hours	40
Number of Seminar and Practical Assignment Hours	0
Number of Hours for Laboratory Assignments	24
Independent Study Hours	**96**
Course Approval Date	17.01.2019
Responsible Unit	Department of Physics

Course Developer

Aleksejs Kuzmins

Study Course Abstract

The course gives theoretical and experimental backgrounds of microscopy and spectroscopy characterization methods and their application in materials science.

Course Plan

1. Scanning and transmission electron microscopy (L8, Ld8)
2. Scanning probe microscopy (L4, Ld4)
3. Scanning tunneling microscopy (L4)
4. X-ray absorption spectroscopy (L4, Ld4)
5. X-ray and neutron diffraction (L4, Ld4)
6. Mass spectrometry and X-ray fluorescence spectrometry (L4, Ld4)
7. X-ray and ultraviolet photoelectron spectroscopy (L4)

8. Introduction to advanced and emerging techniques (L8)

Learning Outcomes

During the course students will learn fundamental knowledge of advanced experimental methods used to study the electronic and atomic structure of materials and will acquire knowledge which will facilitate their choice and implementation of the Master's thesis.
After completing the course: students
1) students will know and understand fundamental principles and possible applications of electron and scanning microscopies, x-ray absorption and fluorescence spectroscopies, x-ray and ultraviolet photoelectron spectroscopies, mass spectrometry, x-ray, electron and neutron diffraction as well as new advanced and emerging techniques;

2) students will have practical skills in the use of electron and scanning microscopes, x-ray diffractometers, x-ray fluorescence and mass spectrometers as well as in x-ray absorption spectra data analysis.

Requirements for Awarding Credits

Laboratory – 50%, written exam – 50%.

Compulsory Reading List

1. A.Kuzmins, Materiāli kursam „Mikroskopijas un spektroskopijas pētījumu metodes”, Moodle vidē.
2. R. F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM (Springer, 2005).
3. D. Sarid, Scanning Force Microscopy (Oxford University Press, 1994).
4. S. Mobilio, F. Boscherini, C. Meneghini, Synchrotron Radiation: Basics, Methods and Applications (Springer-Verlag, 2015).

Further Reading List

1.sadaļa
1. D. B. Williams, C. B. Carter, Transmission Electron Microscopy: A Textbook for Materials Science (Springer, 2009).

2. P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, Third Edition 3rd Edition (Taylor & Francis, 2001).
3. L. Reimer, H. Kohl, Transmission Electron Microscopy: Physics of Image Formation (Springer, 2008).

2.sadaļa
1. E. Meyer, H. J. Hug, R. Bennewitz, Scanning Probe Microscopy: The Lab on a Tip (Springer-Verlag Berlin Heidelberg, 2004).
2. S. V. Kalinin, A. Gruverman, Scanning Probe Microscopy of Functional Materials: Nanoscale Imaging and Spectroscopy (Springer, 2010).

3.sadaļa
1. R. Wiesendanger, Scanning Probe Microscopy and Spectroscopy: Methods and Applications (Cambridge University Press, 1998).
2. B. Bhushan, H. Fuchs, S. Hosaka (Eds.), Applied Scanning Probe Methods (Springer-Verlag Berlin Heidelberg, 2004).

4.sadaļa
1. P. Willmott, An Introduction to Synchrotron Radiation (John Wiley and Sons, 2011)
2. G. Bunker, Introduction to XAFS (Cambridge University Press, 2010)
3. S. Calvin, XAFS for everyone (CRC Press, 2013)
4. J.A. Van Bokhoven, C. Lamberti, X-Ray Absorption and X-Ray Emission Spectroscopy: Theory and Applications (Wiley, 2016).

5.sadaļa
1. C. Suryanarayana, M. Grant Norton, X-Ray Diffraction: A Practical Approach (Springer, 1998).
2. E. H. Kisi, Ch. J. Howard, Applications of Neutron Powder Diffraction (Oxford University Press, 2008).
3. R. E. Dinnebier, S. J. L. Billinge, Powder Diffraction: Theory and Practice (RSC Publishing, 2008).
4. V. K. Pecharsky, P. Y. Zavalij, Fundamentals of Powder Diffraction and Structural Characterization of Materials (Springer, 2009).

6.sadaļa
1. B. Beckoff, B. Kanngiesser, N. Langhoff, R.Vedell, H.Wolff (eds.) Handbook of practical X-ray Fluorescence analysis (Springer, Berlin Heidelberg New York 2006, 863 pages).
2. R.Tertian, F.Claisse Principles of quantitative X-ray fluorescence analysis (Heyden London, Philadelphia, Rheine, 1982, 385 pages).
3. E. de Hoffmann, V. Stroobant, Mass Spectrometry: Principles and Applications (3rd Edition,Wiley 2007, 489 pages).

7.sadaļa
1. Paul van der Heide, X-ray Photoelectron Spectroscopy: An introduction to Principles and Practices (Wiley, 2012).
2. J. M. Wagner, X-ray photoelectron spectroscopy (Nova Science Publishers, 2011).
3. S. Hofmann, Auger- and X-Ray Photoelectron Spectroscopy in Materials Science (Springer-Verlag Berlin Heidelberg, 2013).

8.sadaļa
1. P. Willmott, An Introduction to Synchrotron Radiation (John Wiley and Sons, 2011)
2. J. Guo, X-Rays in Nanoscience Spectroscopy, Spectromicroscopy, and Scattering Techniques (WILEY-VCH, 2010).
3. L. A. Feigin, D. I. Svergun, Structure Analysis by Small-Angle X-Ray and Neutron Scattering (Springer, 1987).
4. W. Reimers, A. R. Pyzalla, A. Schreyer, H. Clemens, Neutrons and Synchrotron Radiation in Engineering Materials Science (WILEY-VCH, 2008).

5. C.S.S.R. Kumar, X-ray and Neutron Techniques for Nanomaterials Characterization (Springer-Verlag, 2016).

Periodicals and Other Sources

1.sadaļa
1. A.Blelocha, A.Lupini, Imaging at the picoscale, Materials Today 7 (2004) 42-48. DOI: 10.1016/S1369-7021(04)00570-X.
2. G.M. Vanacore, A.W.P. Fitzpatrick, A.H. Zewail, Four-dimensional electron microscopy: Ultrafast imaging, diffraction and spectroscopy in materials science and biology, Nano Today 11 (2016) 228-249. DOI: 10.1016/j.nantod.2016.04.009.

2.sadaļa
1. Journal of Microscopy, http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1365-2818
2. Microscopy and Analysis, http://www.microscopy-analysis.com/
3. AFM bibliography (On request), http://nano.em.keysight.com/index.php/afm-bibliography
4. Free SPM image processing software, http://gwyddion.net/
5. http://www.ntmdt-si.com/spm-principles/view/atomic-force-microscopy

3.sadaļa
1. https://www.youtube.com/watch?v=BcgG3Cp8QQY
2. http://www.eng.utah.edu/~lzang/images/Lecture_6_STM.pdf
3. http://www.ntmdt-si.com/spm-principles/view/constant-current-mode

4. un 5.sadaļas
1. Synchrotron Radiation News, A Taylor & Francis Journal. http://www.tandfonline.com/
2. Neutron News, A Taylor & Francis Journal, http://www.tandfonline.com/
3. European Synchrotron Radiation Facility (ESRF), http://www.esrf.eu/
4. European XFEL facility, http://www.xfel.eu/

6.sadaļa
1. M. West, A.T. Ellis, P. Kregsamer, P.J.Potts, Ch. Streli, Ch. Vanhoof, P. Wobrauschek, Atomic spectrometry update. X-ray fluorescence spectrometry, J. Analytical. Atomic Spectrometry 22 (2007) 1304-1332, DOI: 10.1039/b712079f.
2. E. J. Finehout, K H. Lee, An Introduction to Mass Spectrometry Applications in Biological Research, Biochem. Mol. Biol. Edu. 32, 93-100 (2004). DOI: 10.1002/bmb.2004.494032020331.
3. http://www.spectroscopyonline.com/x-ray-spectroscopy
4. http://www.spectroscopyonline.com/mass-spectrometry-13
5. https://www.nist.gov/pml/x-ray-form-factor-attenuation-and-scattering-tables

7.sadaļa
1. https://srdata.nist.gov/xps/Default.aspx (NIST X-ray Photoelectron Spectroscopy Database)
2. https://www.journals.elsevier.com/journal-of-electron-spectroscopy-and-related-phenomena (Journal of Electron Spectroscopy and Related Phenomena)
3. http://avs.scitation.org/journal/sss (Surface Science Spectra)

8.sadaļa
1. European Synchrotron Radiation Facility (ESRF), http://www.esrf.eu/

2. European XFEL facility, http://www.xfel.eu/