University of Gdańsk

Subject card

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| Subject name and code | Solid State Physics in Medical Applications, PG_00182179 | | | | | | |
| Field of study | Medical Physics | | | | | | |
| Date of commencement of studies | October 2025 | | Academic year of realisation of subject | 2025/2026 | | | |
| Education level | Master's studies | | Subject group | Obligatory subject group in the field of study<br>Subject group related to scientific research in the field of study | | | |
| Mode of study | full-time studies | | Mode of delivery | at the university | | | |
| Year of study | 1 | | Language of instruction | Polish | | | |
| Semester of study | 1 | | ECTS credits | 7.0 | | | |
| Learning profile | academic | | Assessment form | exam | | | |
| Conducting unit | Division of Condensed Matter Spectroscopy -> Institute of Experimental Physics -> Faculty of Mathematics, Physics and Informatics -> Rector | | | | | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | | dr hab. Sebastian Mahlik | | | | |
| | Teachers | | | | | | |
| Lesson types | Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
| | Number of study hours | 45.0 | 45.0 | 0.0 | 0.0 | 0.0 | 90 |
| | E-learning hours included: 0.0 | | | | | | |
| Learning activity and number of study hours | Learning activity | Participation in didactic classes included in study plan | | Participation in consultation hours | Self-study | SUM | |
| | Number of study hours | 90 | | 0.0 | 85.0 | 175 | |
| Subject objectives | To acquire fundamental knowledge of crystallography, band structure, and the electrical and thermal properties of solids, to understand the processes of radiationmatter interactions, and to develop the ability to independently predict the effects of these interactions and their practical applications in medical diagnostics and therapy, with particular emphasis on the properties of materials used in biomedicine, imaging techniques, detection methods, and the use of radiation in medicine. | | | | | | |

| Learning outcomes | Course outcome | Subject outcome | Method of verification |
|---|---|---|---|
| | [FIZMEDMU2_U01] Can apply the scientific method in solving physical and medical problems, carrying out experiments and drawing conclusions in the field of physics, medical physics and other fields, based on in-depth knowledge, appropriate selection of sources, and mathematical and computer science methods and tools. | The student is able to analyze and explain physical phenomena and processes in matter at the level of electromagnetic interactions and the quantum model of electrons in the lattice potential and phonons, apply approximation methods to describe complex physical processes while understanding the applicability limits of models, use quantum mechanics to analyze processes in solids, and utilize phenomena occurring in solids for the design of radiation detectors. The student can also apply the scientific method to solve physical and medical problems, carry out experiments, and draw conclusions using appropriate methods, sources, and mathematical and computational tools. | [SU3] text preparation/written work<br>[SU4] test/exam - oral or written |
| | [FIZMEDMU2_W01] Knows and understands in depth selected issues in the field of physics and medicine, the complex relationships between them, and development trends in the exact and natural sciences, health sciences, and others. | The student has extended knowledge of general physics and advanced knowledge of solid state physics and its applications in medicine, knows the history of physics and its significance for the development of the natural sciences and society, understands the fundamental principles of the structure of matter and the interactions responsible for crystal bonding, is familiar with concepts defining structure (direct and reciprocal lattices), methods of studying the structure of matter (X-ray diffraction, electron diffraction), the concept of phonons, polarization, and the magnetic properties of solids, understands the band structure and its influence on the electrical, thermal, and optical properties of solids, the electrical properties of metals, semiconductors, and p–n junctions, the role of defects and impurities in crystals, as well as the phenomena of radiation–matter interactions (absorption, luminescence, scintillation, thermoluminescence) and the basic principles of radiation detectors and their applications. | [SW4] test/exam - oral or written<br>[SW3] text preparation/written work |

**Subject contents**

**Lecture topics:**

1. **Structure of solids (crystals):** types of crystal bonding, crystal structures, X-ray diffraction in crystals, reciprocal lattice, pseudomomentum, Brillouin zones, crystal lattice defects.

2. **Mechanical, electrical, and thermal properties of crystals:** lattice vibrations in the quantum approach phonons (optical and acoustic branches), Raman effect.

3. **Electrical properties of solids:** energy structure (phenomenological approach), Fermi electron gas, band structure (quantum approach).

4. **Semiconductors and dielectrics:** carrier dynamics (electrons and holes), effective mass, Hall effect, intrinsic semiconductors in thermodynamic equilibrium, density of states, doped semiconductors, donor and acceptor states, semiconductor junctions pn, pnp, npn.

5. **Interaction of electromagnetic radiation with solids:** absorption, luminescence, scintillation.

6. **Materials and phenomena in biomedical applications:** solids used in therapy and diagnostics (e.g. scintillators, semiconductor detectors, medical lasers, ferroelectrics and piezoelectrics in ultrasonography, superconductors in MRI).

7. **Detectors of ionizing radiation:** dielectric crystals, semiconductor detectors, other types of detectors.

8. **Detector systems for diagnostics and imaging:** computed tomography (CT), PET, SPECT, digital X-ray detectors.

9. **Thermoluminescence and its application in dosimetry.**

10. **Modern materials and nanomaterials in medicine:** luminescence of nanocrystals, bioactive implants, materials for photo- and electroactive biosensors.

11. **Superconductivity and its applications**: high-temperature superconductors, superconducting magnets in MRI imaging, cryomagnets, SQUID detectors in biomagnetism, and potential therapeutic applications and uses in ultra-sensitive imaging.

**Prerequisites and co-requisites**

**Assessment methods and criteria**

| Subject passing criteria | Passing threshold | Percentage of the final grade |
|---|---|---|
| not applicable | 51.0% | 50.0% |
| not applicable | 0.0% | 10.0% |
| not applicable | 51.0% | 40.0% |

**Recommended reading**

Basic literature

**A. Required literature for passing the course (final exam):**

**A.1. Used during classes**

- C. Kittel, *Introduction to Solid State Physics*, Wiley.
- *Radiation Detectors for Medical Applications*, ed. S. Tavernier, A. Getkin, B. Grinyov, W.W. Moses, Springer

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| | Supplementary literature | • S. Cherry, J. Sorenson, M. Phelps, *Physics in Nuclear Medicine*, Elsevier, 2012.<br>• M. LAnnunziata, *Handbook of Radioactivity Analysis*, Elsevier, 2012. |
| | eResources addresses | |
| Example issues/ example questions/ tasks being completed | not applicable | |
| Work placement | Not applicable | |

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