**SYLLABUS**

**Spring semester 2020-2021 year**

**under the educational program "6V071 - INDUSTRIAL ELECTRONICS AND CONTROL SYSTEMS"**

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| **Discipline code** | **Name of discipline** | **Student Independent Work (SIW)** | **Number of hours** | | | | | **Number of credits** | | **Independent work of a student under the guidance of a teacher (SIWT)** |
| **Lectures (L)** | **Praсt. classes (PC)** | | **Lab. classes (LC)** | |
| MICR2211 | microelectronics | 98 | 15 | 30 | |  | | 5 | | 7 |
| **Academic information about the course** | | | | | | | | | | |
| **Type of training** | **Course type/nature** | **Lecture types** | | | **Practice Types** | | **Number of SIW** | | | **Form of final control** |
| day | elective | online | | | online | | 15 | | | exam |
| **Lecturer** | Turlykozhayeva Dana | | | | | | **of./h.** | | Scheduled | |
| **e-mail** | E-mail: [abdikumarovna.d@gmail.com](mailto:abdikumarovna.d@gmail.com) | | | | | |
| **Phones** | Phones: 87472666916 | | | | | |

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| **Academic course presentation** |

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| **Purpose of the discipline** | **Expected Learning Outcomes (LO)**  **As a result of studying the discipline, the student will be able to:** | **Indicators of achievement LO (IA)**  **(at least 2 indicators for each LO)** |
| The purpose of the discipline is to master the fundamentals of the theory of the basic elements of modern microelectronics. | **LO 1** - demonstrate the acquired knowledge and understanding of the physical nature of the phenomena occurring in the manufacture and operation of modern microelectronic devices;  - general properties, role and prospects for the development of semiconductor electronics; | **IA 1.1** understanding the physical essence of the phenomena occurring during the manufacture and operation of modern microelectronic devices;  **IA 1.2** role and prospects for the development of semiconductor electronics  **IA 1.3** |
| **LO 2** functional: be capable  - include new knowledge in the context of the basic knowledge of the specialty, interpret its content;  - analyze the learning situation, propose a direction for its solution;  - use the methods of research, calculation, analysis, etc., inherent in microelectronics in individual or group educational and research activities; | **IA 2.1** basic knowledge of the specialty, interpret its content;  **IA 2.2** use methods of research, calculation, analysis, etc., inherent in microelectronics |
| **LO 3** systemic: be capable  - generalize, interpret and evaluate the obtained learning outcomes in the context of the discipline, the training module, the content of the midterm exam (specifically);  - analyze the dynamics of solving the scientific problems of the course (scientific reviews of the study of a specific problem);  - make an analysis of the results of the study of the course, summarize them in the form of a scientific essay, presentation,рецензии, scientific review, etc.); | **IA 3.1** interpret and evaluate learning outcomes in the context of the discipline  **IA 3.2**. analyze the dynamics of solving the scientific problems of the course |
| **LO 4** social: be capable  - to constructive educational and social interaction and cooperation in the group;  propose a problem for consideration, argue its importance;  - accept criticism and criticize;  - work in a team; | **IA 4.1** capable of constructive academic and social interaction and collaboration in a group  **IA 4.2** accept criticism and criticize |
| **LO 5** meta-competencies: to be capable  - be aware of the role of the course taken in the implementation of the individual learning trajectory.   When formulating competencies, it is obligatory to use the system of descriptor verbs. (See Appendix 2) | **IA 5.1** be aware of the role of the course taken in the implementation of an individual learning trajectory  **IA 5.2** be sure to use the descriptor verb system  **IA 5.3** |
| **Prerequisites** | Training courses that must be mastered by students before studying this discipline. Fundamentals of semiconductor physics, optics. | |
| **Postrequisites** | Semiconductor devices, digital electronics | |
| **Literature and resources** | **Educational literature:**   1. **Main:** 2. Данилина Т.И. Technology of thin-film microcircuits.- Томск: ТМЦ ДО, 2006. – 152 с. 3. Данилина Т.И. Promising production technologies СБИС. - Томск: ТМЦ ДО, 2000. – 99с. 4. 4. Microprocessor systems: textbook for universities / edited by . Д.В. Пузанкова. – СПб.: Политехника, 2002. – 935 с.   **Дополнительнаялитература**   1. Мартынов В.Н., Кольцов Г.И. Semiconductor optoelectronics. – М.:МИСИС, 1999.-400 с. 2. С.Зи. Physics of semiconductor devices. Т 2, «Мир», 1985 г., 456 с. 3. Игнатов А. Н. Optoelectronics and Nanophotonics: Tutorial .— СПб.: Издательство «Лань», 2011. — 544 с. | |

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| **Academic Policy of the Course in the Context of University Moral and Ethical Values** | **Rules of academic conduct:**  All students are required to register for the MOOC. The deadlines for completing the modules of the online course must be strictly observed in accordance with the schedule for studying the discipline**.**  **ATTENTION!** Failure to meet deadlines results in loss of points! The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the training course, as well as in the MOOC**.**  **Academic values:**  - Practical/laboratory exercises, SIW should be independent, creative.  - Plagiarism, forgery, the use of cheat sheets, cheating at all stages of control are unacceptable.  - Students with disabilities can receive consulting assistance at the e-address guliya\_nurbakova@mail.ru, |
| **Assessment and assessment policy** | **Criteria-based assessment:** assessment of learning outcomes in relation to descriptors (checking the formation of competencies at midterm control and exams).  **Summative assessment:** assessment of the activity of work in the audience (at the webinar); evaluation of the completed task.  95-100%: А 90-94 %:A-  85-89 %: В+ 80-84 %:B 75-79 %:B-  70-74 %: С+ 65-69 %:C 60-64 %:C-  55-59 %: D+ 50-54 %:D 0-49 %:F |

**Calendar (schedule) for the implementation of the content of the training course**

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| --- | --- | --- | --- | --- | --- | --- | --- |
| A week | Topic title | LO | **IA** | Number of hours | Maximum score | Knowledge Assessment Form | Form of the lesson  /platform |
| **Module 1** | | | | | | |  |
| 1 | **L1.**. Introduction. History and prospects of planar technology of microelectronics. Technology for obtaining single-crystal silicon and silicon wafers. OSCh materials in microelectronics. | LO 1 | IA 1.1. | 1 |  | SQ 1 | Video lecture  in MS Teams |
| 1 | **PC 1**. Impurity concentration in high-frequency silicon 5N, 6N, 7N, 8N, 9N | LO 3 | IA 3.1. | 2 | 10 | TT 1 | Webinar  in MS Teams |
|  | **Saturday 23.00 - DEADLINE for delivery of aircraft SQ 1, TT 1** | | | | | | |
| 2 | **L 2.** p-n transition. Methods for the formation of p-n junction. Fusion, diffusion, ion implantation, epitaxy**.** | LO 2 | IA 2.2 | 1 |  | SQ 2 | Video lecture  in MS Teams |
| 2 | **PC 2.** Depth and impurity profile during diffusion versus T and during ion implantation versus energy. | LO 4 | IA 4.1. | 2 | 10 | TT 2 | Webinar  in MS Teams |
|  | **Saturday 23.00 - DEADLINE for the delivery of aircraft SQ 2, TT 2** | | | | | | |
| 3 | **L 3.** Fundamentals of planar technology. Photolithography. Photoresists. Photomasks. Contact and projection photolithography. physical restrictions. diffraction limit. Electron beam lithography. | LO 2 | IA 2.1.  IA 2.2 | 1 |  | SQ 3 | Video lecture  in MS Teams |
| 3 | **PC 3.** Diffraction limit of photolithography for red blue and UV light. | LO 4 | IA 4.2. | 2 | 10 | TT 3 | Webinar  in MS Teams |
| 3 | **SIWT 1 Consultation on implementation of SIW 1** |  |  |  |  |  | Chat in МООК ТВ |
| 3 | **SIW 1.**  Contact and projection photolithography. | LO 2  LO 5 | IA 2.2  IA 5.2 |  | 25 | IT 1 |  |
|  | **Saturday 23.00 - DEADLINE for delivery of aircraft SQ 3, TT 3, IT 1** | | | | | | |
| **Module 2** | | | | | | | |
| 4 | **L 4.** Clean rooms. Vacuum in microchip technology. Vacuum pumps. Thermocouple and gas-discharge vacuum gauges. Fore vacuum, high vacuum, super high vacuum. | LO 1 | IA 1.2. | 1 |  | SQ 4 | Video lecture  in MS Teams |
| 4 | **PC 4.** Calculation of the concentration of atoms in a vacuum chamber. | LO 3 | IA 3.1.-3.3 | 2 | 10 | TT 4 | Webinar  in MS Teams |
|  | **Saturday 23.00 - DEADLINE for delivery of SQ 4, TT 4** | | | | | | |
| 5 | **L 5.** Topology of microcircuits. Thin films in microelectronics. Metallic, dielectric, cermet and semiconductor films. Initial stages of film growth. The role of defects. surface resistance. | LO 1 | IA 1.2 | 1 |  | SQ 5 | Video lecture  in MS Teams |
| 5 | **PC 5.**.  Calculation of surface resistance of copper aluminum silver film 1 µm, 10 nm. | LO 4 | IA 4.1 | 2 | 10 | TT 5 | Webinar  in MS Teams |
| 5 | **SIWT 2 Consultation on the implementation of SIW2** |  |  |  |  |  | Chat in МООК ТВ |
| 5 | **SIW**  Thin film resistors in microelectronics. | LO 5 | IA 5.2 |  | 25 | IT 2 |  |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 5, TT 5, IT 5** | | | | | | |
| 5 | **M 1** | | | | 100 |  |  |
| 6 | **L 6.** Monocrystalline, polycrystalline, nanocrystalline and amorphous materials in modern microelectronics. Resistivity of a semiconductor. | LO 1 | IA 1.2 | 1 |  | SQ 6 | Video lecture  in MS Teams |
| 6 | **PC 6.** Surface resistance of 1 mkm silicon film at impurity concentration 1015 to 1021 см-3. | LO 3 | IA 3.1  IA 3.2 | 2 | 10 | TT 6 | Webinar  in MS Teams |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 6, TT 6** | | | | | | |
| 7 | **L 7.** Technology of thin films in microelectronics. Thermal and electron-beam evaporation. Molecular beam epitaxy. | LO 3 | IA 3.1  IA 3.2 | 1 |  | SQ 7 | Video lecture  in MS Teams |
| 7 | **PC 7.**  Calculation of the weight of the sample for the thickness of the sprayed film 0.1 - 1 mkm for distances of 5-15 cm from the evaporator. | LO 2 | IA 2.1 | 2 | 10 | TT 7 | Webinar  in MS Teams |
| 7 | **SIWT 3 Consultation on the implementation of SIW 3** |  |  |  |  |  | Chat in МООК ТВ |
| 7 | **SIW 3** Multilayer films in microelectronics | LO 5 | IA 5.2 |  | 25 | IT 3 |  |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ7, TT 7, IT 3** | | | | | | |
| 8 | **L 8.** Gas discharge in film deposition technology. Cathode and magnetron sputtering at direct current. Microwave magnetron sputtering. | LO 2 | IA 2.1  IA 2.2 | 1 |  | SQ 8 | Video lecture  in MS Teams |
| 8 | **PC 8.**  Industrial installation of magnetron sputtering. | LO 3 | IA 3.1  IA 3.2 | 2 | 10 | TT 8 | Webinar  in MS Teams |
|  | **Saturday 23.00 - DEADLINE for delivery of SQ 8, TT 8** | | | | | | |
| 9 | **L 9.** Technological route for the manufacture of microcircuits. | LO 1 | IA 1.1  IA 1.2 | 1 |  | SQ 9 | Video lecture  in MS Teams |
| 9 | **PC 9.**  Technological route for the manufacture of a thin-film capacitor. | LO 3 | IA 3.1  IA 3.2 | 2 | 10 | TT 9 | Webinar  in MS Teams |
| 9 | **SIWT 4 Consultation on the implementation of SIWT 4** |  |  |  |  |  | Chat in МООК ТВ |
| 9 | **SIW4.** Technological route for manufacturing a field-effect transistor. | LO 5 | IA 5.2 |  | 25 | IT 4 |  |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 9, TT 9, IT 4** | | | | | | |
| 10 | **L 10.**  Formation of films by the method of gas transport reactions. Film growth by the vapor-crystal and vapor-liquid-crystal mechanisms. | LO 1  LO 2 | IA 1.1  IA 2.2 | 1 |  | SQ 10 | Video lecture  in MS Teams |
| 10 | **PC 10.** Calculation of film thickness in CVD method. | LO 3 | IA 3.1  IA 3.2 | 2 | 10 | TT 10 | Webinar  in MS Teams |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 10, TT 10** | | | | | | |
| 10 | **МТ (MidtermExam)** | | | | 100 |  |  |
| 11 | **L 11.** Nanotechnology and nanoelectronics. Island film. Nanotubes and nanorods. Anodizing in solutions. Porous silicon. Nanotemplates. Nanopowders. | LO 4 | IA 4.1  IA 4.2 | 1 |  | SQ 11 | Video lecture  in MS Teams |
| 11 | **PC 11.** Calculation of metal islands to ensure the growth of nanotubes 0.5-1 nm. | LO 2 | IA 2.1 | 2 | 10 | TT 11 | Webinar  in MS Teams |
| 11 | **SIW**T **5 Implementation advice SIW 5** |  |  |  |  |  | Chat in МООК ТВ |
| 11 | **SIW 5.**  Field effect transistor from a nanotube. | LO 5 | IA 5.1 |  | 25 | IT 5 |  |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 11, TT 11, IT 5** | | | | | | |
| 12 | **L 12.** Fundamentals of the zone theory. Formation of the valence band. Conduction band and forbidden band. Native and doped semiconductors.. | LO 4 | IA 4.1 | 1 |  | SQ 12 | Video lecture  in MS Teams |
| 12 | **PC 12.** The height of the p-n junction barrier. | LO 3 | IA 3.1 | 2 | 10 | TT 12 | Webinar  in MS Teams |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 12, TT 12** | | | | | | |
| 13 | **L 13.** Fermi level. p-n transition. Thickness of p-n junction Tunnel thin p-n junction. Multilayer nano films. Semiconductor superlattices. | LO 1 | IA 1.2 | 1 |  | SQ 13 | Video lecture  in MS Teams |
| 13 | **PC 13.** Calculation of the capacitance p-n transition. | LO 4 | IA 4.2 | 2 | 10 | TT 13 | Webinar  in MS Teams |
| 13 | **SIWT 6 Consultation on implementation of SIW6** |  |  |  |  |  | Chat in МООК ТВ |
| 13 | **СРС 6.** | LO 5 | IA 5.2 |  | 25 | IT 6 |  |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 13, TT 13, IT 6** | | | | | | |
| 14 | **L 14.** Multilayer transparencies. Dielectric mirrors and light filters. Applications in lasers, fiber communications, optical spectrometers and astronomy. | LO 4 | IA 4.1  IA 4.2 | 1 |  | SQ 14 | Video lecture  in MS Teams |
| 14 | **PC 14.** Calculation of the thickness of a dielectric antireflection or mirror film. | LO 4. 5 | IA 4.1  IA 4.2 | 2 | 10 | TT 14 | Webinar  in MS Teams |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 14, TT 14** | | | | | | |
| 15 | **L 15.** Programmable microelectronics. Computer-aided design environment Xilinx ISE 2. Simulation environment MatLab/Simulink. Optoelectronic microcircuits. Purely optical microcircuits. Photonics. | LO 5 | IA 5.1  IA 5.2 | 1 |  | SQ 15 | Video lecture  in MS Teams |
|  | **PC 15.** | LO 2 | IA 2.1  IA 2.2 | 2 | 10 | TT 15 | Webinar  in MS Teams |
|  | **SIWT 7 Consultation on the implementation of SIW 7** |  |  |  |  |  | Chat in МООК ТВ |
|  | **SIW 7.**  Photonic microcircuits. | LO 5 | IA 5.1  IA 5.2  IA 5.3 |  | 25 | IT 7 |  |
|  | **Saturday 23.00 - DEADLINE for the delivery of SQ 15, TT 15, IT 6** | | | | | | |
|  | **M 2** | | | | 100 |  |  |

[Abbreviations: SQ – self-test questions; TT – typical tasks; IT – individual tasks; CW – control work; M – midterm.

З а м е ч а н и я:

- The form of the lesson L and PC**:** webinar in MS Team /Zoom (presentation of video materials for 10-15 minutes, then its discussion / consolidation in the form of discussion /problem solving / ...)

- The form of the lesson CW**:** webinar (at the end, students submit screenshots of the work to the headman, the headman sends them to the teacher) / test in the Moodle.

- All course materials (L, SQ, TT, IT, etc.) can be found at the link (see Literature and Resources, item 6)

.- After each deadline, the tasks of the next week open.

- The teacher gives tasks for the CW at the beginning of the webinar.]

Reviewed and recommended at the meeting of the Department of Solid State Physics and Nonlinear Physics

от « \_\_ » \_\_\_2020 г., протокол № \_\_

Зав. кафедрой \_\_\_\_\_\_\_\_\_\_\_\_ М.К. Ибраимов

(подпись)

Одобрена на заседании методического бюро факультета.

« \_\_» \_\_\_\_ 2020 г., протокол № \_\_

Председатель методбюро факультета \_\_\_\_\_\_\_\_\_\_\_\_\_\_ А.Т.Габдуллина

(подпись)

Программа утверждена на Ученом совете факультета .

« \_\_» \_\_\_\_ 2020 г., протокол № \_\_

Председатель ученого совета,

Декан факультета\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ А.Е. Давлетов

Лектор \_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Д. А. Турлыкожаева