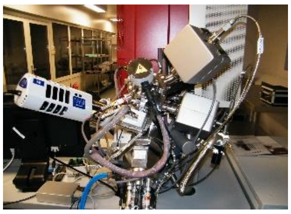
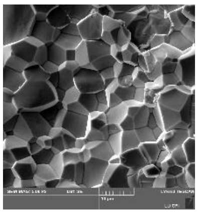
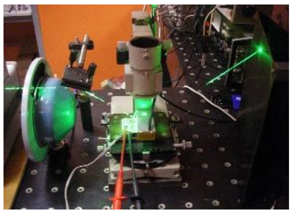
INSTITUTE OF SOLID STATE PHYSICS
UNIVERSITY OF LATVIA

INFRASTRUCTURE DEVELOPMENT AND INVESTMENT PLAN

2017 - 2020







Riga
2017

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Strategic context

According to the European Commission report on Research and Innovation performance in EU Member States and Associated countries, published in 2013, the five key science and technology areas where Latvia has real strengths in a European context are Materials, Health, Nanosciences & Nanotechnologies, Environment, and Energy, Materials being the main scientific field for Latvia.

Institute of Solid State Physics University of Latvia (further ISSP UL) is a leading centre of Latvian research in Material Science, with emphasis on Nanoscience and Nanotechnology of new advanced functional materials, combined with high-level education. The competence of the Institute was highly evaluated already in 2001 by the status of "Excellence Centre of Advanced Materials Research and Technology" - CAMART (further CoE) awarded by the European Commission and has been confirmed recently in 2013 by an external evaluation, performed by Technopolis Group, who positioned ISSP UL at the second place among all research organizations in Latvia.

The present Infrastructure Development and Investment Plan (ID&IP) formulates necessary infrastructure improvement measures for the practical implementation of the **ISSP UL Research Programm**e for the period of 2017-2022. An ID&IP is an important part of the Business Plan (BP) of CAMART^2 project (Centre of Advanced Materials Research and Technology Transfer) for the upgrade of CoE at ISSP UL. It is developed according to the recommendations expressed in **Assessment** (deliverable of CAMART^2 phase 1) for the prioritization of the research activities at ISSP UL and based on the detailed analysis presented in **RoadMap (**deliverable of CAMART^2 phase 1) of the equipment needed for future activities within each theme and research direction as stated in the **Research Program**.

Massive infrastructure development is needed to support ISSP UL Research Program and upgrade of Centre of Excellence at ISSP UL to higher value with increased Technology Transfer abilities. Present Infrastructure Development plan will be supported by ERDF and national funding with totally **16.32** MEUR allocated for ISSP UL by Latvian government. Particularly **8.32** MEUR is allocated by Ministry of Education and Science (MES) by the measure No. 1.1.1.4. "The development of R&D infrastructures in the areas of smart specialization and strengthening the institutional capacity of scientific institutions" of specific support objective No. 1.1.1. "To increase innovative capacity and ability of Latvian scientific research institutions to attract external funding, investing in human resources and infrastructure" within the Operational Programme "Growth and Jobs". In addition, **5.00** MEUR (ERDF resources) is available under the third round of measure No. 1.2.1.1. "Support for the development of new products and technologies within the centres of competence" of specific support objective No.1.2.1. "To increase the investment of private sector in R&D" which would be allocated to the measure No. 1.1.1.4 by Ministry of Economics (ME). University of Latvia has committed to invest 1.00 MEUR (from ERDF measure No. 1.1.1.4) at ISSP for infrastructure devoted to educational purposes. ISSP UL is planning to invest 2.00 MEUR in infrastructure as necessary co-financing for the above mentioned ERDF measures.

Despite the fact that during last decade more than 6 MEUR has been invested to develop research infrastructure at ISSP UL, there is definite requirement for further development in the next years. First of all we should mention that these investments came after long period (1990 - 2005) without sufficient funds available for Latvian scientific infrastructure development and renovation. So, above mentioned investments were made to catch up. Yet, unfortunately, it was not enough to sufficiently reach the current level of instrumentation needed for investigations in solid state physics and material science. Most of the purchased equipment are tools for investigation of solid state matter (material) composition, properties, morphology and structure (further "Analytic instruments" AI). Therefore the Institute has a well-established set of instruments necessary for the above mentioned investigations. At the same time some very useful techniques like TOF-SIMS, SQUID magnetometer, DSC, Spectral Ellipsometry etc. are not available. Some measurement techniques traditionally used at the Institute are relying on equipment purchased (or built) more than 25 years ago and since then have had just some minor upgrades. Among those to mention are EPR and high resolution Raman spectrometers. ISSP UL has a good experience in development and use of laboratory EXAFS-spectrometer during 1989 – 1997. Taking into account the recently appearing novel technologies like liquid metal jet x-ray source, polycapillary optics and novel detectors, it is feasible and useful to make renovation of in-lab XAS system. Part of the above mentioned investments (~1 MEUR) have been used for creation of an 800m^2 ISO6 – ISO8 cleanroom complex. Currently (December 2016) just 50% of this complex is equipped with the tools used for research, academic activities and technology transfer. The rest of the clean room capacity is still available for installation of necessary equipment. Therefore it is a high priority to put in use the rest of these highly expensive clean room facilities. ISSP UL is also planning to extend its collaboration with enterprises (like Sidrabe, GroGlass, BSI, etc.) to equip and use those cleanroom assets.

The infrastructure development will be made in close collaboration with the research and innovation projects and with the need of industry in mind. Within the CAMART^2 project the infrastructure development both at ISSP UL and at KTH/Acreo will be synchronized in a way that expensive tools and specific competences are established on one site and utilized by all through an open access agreement. Based on these infrastructure development actions and realization of CAMART^2 ISSP UL facilities will become an "Open access laboratory" serving needs of public research institutions and high added value SME and industry in the Baltic Sea Region.

Budget estimation and Multicriteria Analysis of Infrastructure Demand.

For each tentative infrastructure item raised by Research Program preliminary quotation (in some cases from several suppliers/contractors) was acquired. The present list (see below) is exceeding the allocated funds of the ID&IP, therefore, to prioritize the list, multicriteria analysis for each position was applied. The following 10 criteria were considered:

1. Compliance with the research programme
2. Costs of the equipment
3. Benefit for ISSP UL
4. Competence present at ISSP UL
5. Benefit for industry
6. Benefit for external academics
7. Uniqueness of the equipment
8. Maintenance costs
9. Complexity of installation
10. Potential and scientific achievements of the personnel interested in the equipment

For such evaluation 30 internal and external experts were involved and evaluation was carried out in scale 1 – 5. Results for each factor are averaged over all experts for every position in the tentative list. Then averaging over all factors was applied for ever position. The obtained values fell in the range of 2,05 – 4,02 making the following "wish list":

- Range 2.05 – 2.74 – excluded from the present ID&IP;
- Range 2.75 – 2.99 – on waiting list in the present ID&I P, will be purchased in the case of additional funds are available (red marked in lists);
- Range 3.00 – 3.24 – low priority in the present ID&I P (orange marked);
- Range 3.25 – 3.49 – medium priority in the present ID&I P (yellow marked);
- Range 3.50 – 4.02 – high priority in the present ID&I P (green marked).

Cost benefit analysis will be performed before the submission of the Infrastructure development project under activity SAM 1.1.1.4.

1. Infrastructure for Laboratory of Composition, Structure and Morphology Investigations

The knowledge of composition, atomic structure and surface morphology is of fundamental importance for development, understanding and optimization of novel materials and functional devices. This information is crucial for theoretical simulations as well as for technological processes optimization and is requested by all ISSP UL laboratories. To address the needs of the Research Program, an installation and development of new modern equipment and substantial upgrade of existing microscope infrastructure will be performed.

We plan to develop new multifunctional experimental tool, which will allow one to study the structure and composition of materials with submicron and nanoscale lateral resolution using a combination of X-ray absorption spectroscopy (XAS) with confocal optical (Raman and luminescence) spectroscopies, confocal imaging and X-ray fluorescence (XRF) spectroscopy. A novel confocal-XEOL-XAS (XEOL is X-ray excited optical luminescence) spectromicroscope for the use at synchrotron radiation facilities will be developed. The instrument will implement 2D and, possibly, 3D sample imaging via simultaneous detection of structural (XEOL-XAS), chemical (XEOL-XAS, XRF) and optical (reflectivity, luminescence, Raman scattering) information from the sample with a resolution down to 200-300 nm.

The upgrade of existing transmission electron microscope (TEM) with the electron energy loss spectroscopy (EELS) unit will strongly increase the materials characterization possibilities at ISSP. It will substantially improve the chemical element analysis, provided currently by EDX (EDAX) detector, and extend available possibilities with imaging and spectroscopic detection channels. The obtained spectroscopic information will be complementary to data from synchrotron radiation facilities and will be processed based on the strong competence of the ISSP UL in the field.

Upgrade of existing scanning and transmission electron microscopes (SEM & TEM) with nanomanipulators, atomic force microscope and scanning probe microscope controller will provide new experimental possibilities and modes of operation. Such improvement will enable in situ characterization of bulk and nanostructured materials and assembling and testing of MEMS and NEMS devices. These methods are complimentary to simple electron microscopy and will expand functionality of electron microscopes. Temperature control and electrical measurements inside TEM will allow one to study such phenomena as glass crystallization, crystal growth and phase transition.

It is planned to purchase low-temperature vacuum scanning probe microscope (AFM/STM) for visualization of surface structures with atomic scale, allowing both high quality topographic images and optimized spectroscopic data. At present moment, no such equipment is available at ISSP UL, and it is highly demanding for nanostructured materials characterization and modification in controlled environment with atomic resolution.

It is planned to purchase a new SEM/STEM with extremely high resolution (below 1nm). Such resolution is not available currently anywhere in Latvia and is crucial for studies of very thin films and coatings. In addition to the high resolution, microscope will also allow to get volumetric elemental distribution in samples - very important data for in-depth analysis of ceramics, thin films and coatings. Moreover, this device will allow much better sample preparation for TEM studies. The ion column of new generation that is built in the new SEM allows preparation of extremely thin samples for further research.

It is planned to upgrade the existing Nanoindentor G200 device with new interface and software to guarantee its usability during next years. It is an important system used at ISSP UL for many years for nanomechanical characterization of thin films and coatings, nanomaterials and surface layers of bulk materials. Therefore, it is essential to guarantee its operation for the Research Program implementation.

It is planned to purchase a decontaminator and magnetic field cancelling systems for existing SEM & TEM systems to improve their performance and resistivity to ambient magnetic fields, thus improving their lifetime for the Research Program duration.

It is planned to expand the list of available characterization techniques with Electron Spectroscopy for Chemical Analysis (XPS), which is the most widely used surface analysis technique. It will be applied to a broad range of materials (nanomaterials, ceramics, thin films) and provides valuable information on the elemental composition, empirical formula, surface contaminants, chemical state and electronic state of the elements within about 0-10 nm surface layer of the material being studied. The obtained information will be used for a validation of first-principles electronic structure simulations.

It is planned to purchase a Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS) system, which provides elemental, chemical state, and molecular information from surfaces of solid materials at nanoscale. The method is complementary to XPS and is the most surface sensitive, but provides only qualitative information and is destructive to the surface due to it uses an ion sputtering process.

The information provided by XPS and TOF-SIMS techniques about surface layers or thin film structures is important for many industrial and research applications where surface or thin film composition plays a critical role in performance including: nanomaterials, photovoltaics, polymer surface modification, catalysis, corrosion, adhesion, semiconductor devices and packaging, magnetic media, display technology, thin film coatings, and medical materials used for numerous applications.

	Responsible Person	Upgrade/ New/ Extension	Quotation value	Averaged MF Value	Multifactor Evaluation									
			kEUR		1	2	3	4	5	6	7	8	9	10
Composition, Structure and Morphology Investigations	**A. Kuzmins**		**4,436**											
X-ray absorption spectrometer with nano-scale resolution (confocal-XEOL-XAS), to be used at synchrotron radiation sources	A. Kuzmins	N	270	**3.56**	3.77	3.16	2.92	4.31	2.59	3.30	4.09	3.74	3.50	4.26
EELS spectrometer for TEM	B. Poļakovs K. Šmits	U	350	**3.84**	4.36	2.85	3.89	4.07	3.42	3.67	4.00	4.00	4.04	4.08
Inside SEM nanomanipulators	B. Poļakovs	U	125	**3.76**	4.15	3.36	3.63	4.15	3.04	3.57	3.73	4.05	3.91	4.04
Inside SEM AFM microscope	B. Poļakovs	U	110	**3.70**	4.04	3.44	3.52	4.11	2.86	3.52	3.95	3.86	3.74	3.96
Low-temperature vacuum AFM/STM (RHK company)	B. Poļakovs, K. Kundzi	N	350	**3.46**	3.88	2.79	3.38	3.77	2.71	3.38	3.91	3.50	3.53	3.78
SEM+FIB FEI Helios NanoLab DualBeam G4 UX	K. Šmits	N	1,244	**3.58**	4.25	2.52	3.92	4.21	3.65	3.57	3.76	2.95	2.81	4.14
Inside TEM SPM Scanning Probe Microscope (only controller)	B. Poļakovs	U	30	**3.72**	3.89	4.04	3.44	3.96	2.83	3.42	3.75	4.00	3.83	4.00
Nanoindentora G200 programatūras atjaunošana	J. Maniks	U	20	**3.78**	3.85	3.77	3.26	4.52	3.54	3.22	3.62	4.14	4.17	3.71
SEM+TEM dekontominātors (1 gab.), SC24 magnetic field cancelling system (2 gab.)	K. Kundziņš	U	82	**3.55**	4.00	3.72	3.63		3.09	3.30	3.29	3.81	3.52	3.61
Thermo Fisher Scientific K-Alpha™+ X-ray Photoelectron Spectrometer (XPS) System	A. Šarakovskis	N	855	**3.76**	4.48	3.32	3.90	3.30	3.52	3.75	4.12	3.48	3.67	4.08
TOF-SIMS	M. Rutkis	N	1,000	**2.75**	3.04	1.88	2.42	2.09	2.90	3.15	3.42	2.44	2.65	3.45

2. Analytic instruments for Laboratory of Optical Spectroscopy

Optical spectroscopy is a key technology to characterize optical and electronic processes of solids. It has a long history of development at ISSP UL and is widely used by many laboratories throughout their research activities.

During the infrastructure development process new, modern equipment will be obtained and the existing parts will be substantially upgraded. The infrastructure development of optical spectroscopy domain will address the needs of the specialization fields defined in the research programme.

It is planned to obtain spectral ellipsometer and high performance absorption spectrometer, which will be used to characterize the optical properties of different types of materials. These techniques are particularly essential for characterization of thin films and will have a high demand not only from academics (inside and outside ISSP UL) but also from industrial partners. Fluorescence spectrometer equipped with various excitation and detection components as well as double excitation and luminescence monochromators will be used for precise characterization of stationary and time-resolved luminescence of different materials including measurement of luminescence quantum yield. The modular nature of the system will allow to adapt it to specificities and needs dictated by different research objects.

It is also planned to install optical microscope with coherent anti-Stokes Raman scattering spectroscopy tool, which is a unique method for chemical imaging based on vibrational spectroscopy with ultra-high sensitivity, high-speed and 3D nearly diffraction limited spatial resolution.

The newest generation Raman spectrometer combining ultra-high spectral resolution and mapping options will be irreplaceable characterization tool for thin films, solid state devices and biological chemistry.

Thermostimulated luminescence/optically stimulated luminescence reader, which enables automated measurements of thermoluminescence and optically stimulated luminescence signals will be procured. As the measurement system is highly sensitive and includes a reference radiation source, it will be used for determining radiation doses in natural and artificial materials with applications in geological and archaeological dating, forensic and accident dosimetry, and radiation protection.

Time-resolved absorption spectrum analysis system will enable to analyze the formation and decay process of a reactive intermediate in a photoreaction in solutions, solids, membranes etc.

Upgrades of several existing systems are also planned. NanoFinder, a 3D scanning confocal microscope with spectrometer used to perform studies with submicrometer resolution (about 250-500 nm) of solid bulk materials, thin films, nanopowders and solutions, will be upgraded to include optical low-temperature cryostat and high-temperature furnace to allow measurements at different temperatures. Excitation and detection systems of the system will also be upgraded.

Additionally, the setup of Vertex 80v, a vacuum FTIR spectrometer, will be improved to extend the detection limit of the system in the infrared region.

In addition, some of the older custom-built spectroscopic systems will be upgraded to include new excitation sources and detection units.

Generally, the foreseen development and upgrade of the optical spectroscopy equipment will substantially improve the efficiency and quality of the research process at the Institute and cope with the growing demand from industrial partners.

	Responsible Person	Upgrade/ New/ Extension	Quotation value	Averaged MF Value	Multifactor Evaluation									
			kEUR		1	2	3	4	5	6	7	8	9	10
Optical Spectroscopy	**A. Šarakovskis**		**2,256**											
Spectrometers														
Spectral ellipsometer (RC2-temperature-translational-tilting stage)	M. Rutkis	**N**	200	**3.85**	4.19	3.70	3.72	3.88	3.59	3.50	3.83	4.00	3.86	4.25
High performance absorption spectrometer (Cary7000)	M. Rutkis	**N**	130	**4.02**	4.29	3.77	4.29	4.50	3.54	3.50	3.44	4.21	4.23	4.39
Fluorescence spectrometer FLS 980 (Edinburg Instruments)	K. Šmits	**N**	220	**3.95**	4.32	3.54	4.11	4.36	3.38	3.63	3.80	4.10	4.08	4.22
Nonlinear multiphoton excited spectroscopy (CARS, TPA, TPL)	M. Rutkis	**N**	250	**3.67**	4.08	3.33	3.08	3.75	3.05	3.52	3.91	3.79	3.85	4.32
Thermo- and optically stimulated luminescence (RISO TL/OSL)	L. Trinklere	**N**	150	**3.65**	3.93	3.42	3.36	4.29	3.33	3.26	3.15	4.10	4.00	3.63
Ramana spektrometrs ar mikroskopu T64000	A. Kuzmins	**N**	300	**3.85**	4.14	3.23	3.89	4.36	3.45	3.95	3.20	3.74	4.05	4.50
Pump-probe spectroscopy	D. Millers	**N**	250	**3.37**	3.63	2.96	2.96	3.52	2.59	3.22	3.77	3.35	3.57	4.16
Kolorimetrija un attēlu optiskās intensitātes un fāzes analīze														
System for photometric and radiometric characterization of light emitters and optical coatings	M. Ozoliņš	**N**	90	**3.28**	2.89	3.48	2.81	3.82	2.96	2.91	3.21	4.05	3.96	2.74
System for multispectroscopic imaging and data analysis	M. Ozoliņš	**N**	20	**3.20**	2.69	3.92	2.36	3.85	2.54	2.75	3.38	4.00	3.96	2.52
Adaptive optics and light modulation system for optical quality control	M. Ozoliņš	**N**	140	**2.80**	1.74	1.92	1.77	3.65	2.22	2.22	4.04	4.14	4.13	2.15
Upgrade for NanoFinder														
Optical low-temperature cryostat and high-temperature furnace for micro-Raman measurements	A. Kuzmins	**E**	23	**3.62**	3.82	3.69	3.56		2.80	3.39	3.61			4.48
SLM solid state laser sources (532 nm, 442 nm, 633 nm)	A. Kuzmins	**E**	53	**3.59**	3.82	3.69	3.59		2.88	3.26	3.35			4.52
Deep-cooled CCD camera(s) with single-photon-sensitivity	A. Kuzmins	**E**	30	**3.64**	3.86	3.78	3.61		2.88	3.29	3.56			4.46
Nano-positioning sample stage(s) for development of TERS mode	A. Kuzmins	**E**	15	**3.47**	3.61	3.62	3.37		2.60	3.26	3.50			4.37
Upgrades of IR spectrometer Vertex80v														
Far IR detector (Bolometer) for FTIR spectrometer Vertex 80v	G. Čikvaidze	**U**	33	**3.63**	4.00	3.81	3.57		3.40	3.56	3.54			3.50
Turbo-Molecular Pump Systems for FTIR upgrade	G. Čikvaidze	**U**	11	**3.61**	4.04	3.88	3.50		3.36	3.56	3.38			3.54
Temperature controlled table for microscope (77K - 600K)	Mironova-Ulmane	**U**	20	**3.52**	3.93	3.73	3.46		3.13	3.44	3.33			3.64
Excitation sources														
Powerful UV light source for excitation	M. Rutkis	**N**	25	**3.43**	3.82	3.69	3.59		2.86	3.09	3.08			3.86
Tunable nanosecond laser (210nm-2600nm) EKSPLA (1kHz)	A. Šarakovskis	**N**	86	**3.99**	4.45	4.19	4.29		3.23	3.88	3.62			4.28
Detection systems														
Gated iCCD camera (ANDOR)	J. Grūbe	**N**	50	**3.35**	3.81	3.54	3.58		2.62	3.17	3.08			3.67
Accessories														
X-ray power source(s) (50kV 1200W) for X-ray excitation Spellman	L. Skuja	**N**	10	**3.52**	4.00	4.31	3.29		2.88	3.15	3.04			3.96
Opto-mechanical components	Visi	**N**	100	**3.68**	4.15	4.12	4.30		3.09	3.17	3.13			3.79
Noslēgtā cikla kriostats 10 K - 800 K ar turbomolekularo sūkni	B. Bērziņa	**N**	50	**3.29**	3.89	3.73	3.37		2.61	3.13	2.85			3.46

3. Infrastructure for Laboratory of Electrical and magnetic characterization

Magnetic resonance spectroscopy is one of the key investigation methods in solid state physics for characterization of local structure of electronic centers in solid state materials. The Laboratory of magnetic resonances at ISSP provides electron paramagnetic resonance (EPR) and optically detected magnetic resonance (ODMR) methods. However, current infrastructure of the laboratory needs an urgent upgrade.

Currently EPR spectrometer at ISSP is morally and technically outdated. A new state of art **EPR spectrometer** will enormously increase capacity and productivity of Laboratory of magnetic resonances. With its superior sensitivity and resolution it will be suitable for large variety of defect investigations in nearly all types of inorganic insulation materials – single crystals, ceramics, glass ceramics and thin films. Equipping with liquid helium cryostat and extending the frequency range to **Q-band** will further increase amount of spectral information and vastly improve the interpretation of the data. Adding **the electron-nuclear double resonance option** (ENDOR) will allow unique measurements of nuclear spin interactions thus further increasing characterization possibilities of the paramagnetic defect species allowing us to compete with the world class magnetic resonance laboratories.

In addition magnetic resonance signals are observed via optical excitation of the paramagnetic defects. Currently for ODMR measurements there is contemporary liquid helium cryostat at laboratory disposal. However, detection system and microwave excitation units need an urgent upgrade. New cooled and magnetically screened photoelectron multiplier will help to gain higher sensitivity. High frequency oscillator will help to increase the resolution of the ODMR spectra.

Magnetic resonance methods largely rely on measurements at low temperatures. The EPR and ODMR cryostats are cooled with liquid helium. A locally sustained **liquid helium plant** will help to provide top laboratory performance independently of liquid helium supplies, supply delays and frequent and inevitable price rises. Chosen solution is cost effective, automated and doesn't require considerable maintenance attention.

The Laue camera is an X-ray device which allows detection of orientation of single crystals. In magnetic resonance spectroscopy it is crucial to know crystallographic axes of single crystals. Currently there are no direct opportunities in our state to carry out single crystal orientation tasks.

Priority research directions of ISSP UL II (Nanotechnology, nanocomposites and ceramics) includes the R&D activities of novel nanomaterials and nanostructures, polymer nanocomposites for applications in carbon-free energy technologies and energy storage (electrodes for rechargeable batteries, hydrogen production, storage and application). These activities will, in particular, pursue investigations of new sodium ion batteries, supercapacitors and new materials and innovative technologies for hydrogen energetics. In this field electrochemical measurements are necessary, and planned equipment - **potentiostat/galvanostat** with extreme low current (ECD) and frequency analysis (FRA) modules and cuvettes for special applications, including in-situ X-Ray cell, is an indispensable in research of electrode, catalyst coating, membrane materials with different compositions and applications. One from recent research activity Worldwide is development of new photo-catalytically active materials for water splitting with Sun light, and at ISSP UL both - experimenters and theorists are participating in it. Planned **potentiostat/galvanostat** will be equipped also with special electrochemical cell and set with LED light sources especially for research of light sensitive materials.

Researchers at ISSP UL also are working with development of innovative materials for electrodes of rechargeable batteries, and indispensable in studies of such materials are battery tester with more than one channel, permitting measurements of number of electrodes for batteries, supercapacitors, fuel cells at the same time. Planned **BioLogic battery Test Station** is necessary to perform tests of electrode materials with different catalysts and electrolytes, as well as prototype battery and supercapacitor samples for demonstration innovations in R&D. Interest in electrochemical potentiostat/galvanostat and battery test station have also couple laboratories at the ISSP UL, as well as several institutes (universities) in Latvia.

Priority research directions of ISSP UL II and III (II. Nanotechnology, nanocomposites and ceramics; III. Thin films and coating technologies) includes the R&D activities of novel nanomaterials and nanostructures, polymer nanocomposites for applications in gas sensing systems and gas sensors. Different properties of materials (electrical resistivity, light absorption/reflection, luminescence etc) can be used to signalize about the presence of particular gas in an environment. Planned **Gas Sensor Testing System KSGAS1S** is constructed to generate mixtures of defined gases (carrier gas and sensitive gas) and to supply in the form of pulses with adjustable width in time scale. Sample holder is designed to one sensor sample with possibility to measure resistivity. Number of laboratories at the ISSP UL, as well as several institutes from Riga Technical University has interest in Gas Sensor Testing System. .

According to international agreements and protocols the Governmental institutions and Industrial Enterprises are interested to reduce CO_2 emissions, and one possibility is carbon dioxide disposal and/or reformation to fuels. To realize such tasks new materials are necessary with high CO2 adsorption capability, and according to priority research directions of ISSP UL - nanotechnology, nanocomposites and ceramic for applications in energy related technologies, the **XEMIS Gas Sorption Analyzer** is right instrument for researchers in this field. The XEMIS gas sorption analyzer is a high accuracy sorption microbalance for precision weighing in extreme environments with application areas including gas sorption analysis, isotherm determination; kinetic analysis; thermodynamic studies, hydrogen storage analysis; carbon dioxide sequestration and more. Analyzer performs classical BET analysis and determines active surface area of nanopowders, porous and nanostructured materials as well.

A custom built system for measuring dielectric properties of new materials, as ferroelectric ceramics, organic and inorganic films under state of development is in use for more than 20 years. Upgrade of system hardware (high voltage supplies, multimeters, electrometers, LCR meters, measuring cells with temperarure control, accessories) and software is necessary to increase functionality and provide efficient organisation of research.

Upgrade and diversifying of existing partially custom made measuring systems is necessary for investigation of electromehanical properties of solid materials as ferroelectric and other ceramics, polymers etc.

Dynamic mechanical analysis (DMA) instrument will be used to study and characterize materials, allowing to determine the complex modulus and thermal expansion as sensitive probes of structural phase transitions. The temperature of the sample or the frequency of the stress can be varied, allowing to locate the structural phase transition temperature.

Since advanced electromechanical properties are in spot of research of ferroelectric materials, different methods for measurement of coefficients of piezoelectric tensor, will be developed, such as d_{33}-meter and impedance analyzer for resonance/antiresonance technique, precision linear position sensors and laser interferometer with spatial modulator and high sensitive detecting system together with programmable high voltage source.

Characterization of the magnetic properties of nano-crystalline materials, nanocomposites and ceramics is done with the use of **vibrating sample magnetometer**, which currently is not available at ISSP. Magnetic permeability, magnetic hysteresis curve can be measured for different materials and information about their belonging to diamagnetic, paramagnetic, ferromagnetic or ferrimagnetic class could be obtained. This information is very important in magnetic technologies, and also in many other different applications, including health care.

	Responsible Person	Upgrade/ New/ Extension	Quotation value	Averaged MF Value	Multifactor Evaluation									
			kEUR		1	2	3	4	5	6	7	8	9	10
Electrical and magnetic characterization	**A. Fedotovs**		**1,823**											
EPR spectrometer with low temperature accessories (Bruker) (X-band)	A. Fedotovs	N	337	**3.66**	4.07	3.52	3.62	4.42	2.45	3.19	3.91	3.74	3.76	3.96
EPR spektrometra Q-band papildinājums (iesk. Q-band LHe kriostats.)	A. Fedotovs	N	140	**3.64**	3.96	3.39	3.50	4.42	2.45	3.27	3.86	3.79	3.90	3.85
EPR spektrometra ENDOR papildinājums (X&Q-band)	A. Fedotovs	N	132	**3.64**	3.96	3.39	3.50	4.23	2.59	3.17	4.00	3.81	3.87	3.85
Upgrade of the ODMR, incl. upgrade to 93 GHz frequencies	A. Fedotovs	U	30	**3.66**	3.96	3.75	3.41	4.41	2.43	3.08	4.17	3.55	3.86	3.93
Laues kristālu orientēšanas iekārta MWL 120 (kamera, X-ray)	A. Fedotovs	N	140	**3.15**	3.25	2.40	3.00	3.57	2.37	2.70	3.38	3.56	3.68	3.61
LHe sistēma ATL160 - iekļauj pilnīgu automatizāciju	A. Fedotovs	N	300	**3.12**	3.35	2.55	3.21	3.50	2.26	2.58	3.83	3.00	3.22	3.68
Potentiostat/galvanostat Metrohm Autolab PGSTAT 302N with ECD and FRA modules and multiplexer	J. Kleperis, G. Bajārs	N	69	**3.56**	3.65	3.76	2.96	4.23	3.15	3.20	3.33	4.00	4.05	3.26
BioLogic battery Test Station	G. Bajārs	N	51	**3.58**	3.57	3.81	2.92	4.14	3.15	3.10	3.56	4.11	4.00	3.47
Gas Sensor testing System KSGAS1S (J. Kleperis)	J. Kleperis	N	60	**3.57**	3.63	3.77	3.15	4.17	3.20	3.15	3.39	3.95	4.00	3.25
XEMIS gas sorption analyzer (J. Kleperis)	J. Kleperis	N	215	**3.28**	3.50	2.45	2.83	4.00	2.94	2.89	3.50	3.71	3.82	3.17
Laboratory equipment for electromechanical properties Perkin Elmer DMA (Dynamic Mechanical Analyzer), TESA UPC – for Comparative Measurement IMPEDANCE ANALYZER HIOKII Wide band ACCESSORIES	M. Kundziņš	N	50.00	**3.56**	3.96	4.00	3.15	3.92	3.08	2.96	3.26	3.95	4.00	3.28
Laboratory equipment for dielecteric properties LCR Meter HIOKI Electrometers - KEITHLEY High Voltage Power Supplies - Tektronix ACCESSORIES	M. Kundziņš	U	50.00	**3.52**	3.85	4.00	3.23	4.00	2.96	2.81	3.17	3.91	4.00	3.32
Vibrating sample magnetometer (Lakeshore vai Toeikogyo)	M. Kundziņš	N	250.00	**2.79**	3.04	2.27	2.61	2.52	2.40	2.33	2.94	3.35	3.32	3.15

4. Infrastructure for Laboratory of Chemical Technologies

The need for a common unit of Laboratory of Chemical Technologies (LCT) at ISSP UL is determined by the need for obtaining various materials and samples for R&D&I conducted at the Institute. Mostly samples are complex chemical substances in various thermodynamic and physical states, such as nanoparticles of metals and their salts, polymers and ceramics, composite materials, complex-structured organic compounds etc. At the moment, every laboratory of the ISSP UL independently solves the problem of preparing samples and auxiliary chemicals.

An important aspect is to ensure environmental, toxic and fire safety of chemical works. Common LCT will reduce risks and costs associated with air emission and wastewater and will accomplish a secure storage of chemical reagents.

LCT will be of a crucial importance, supplying materials for further studies and making new or modified materials with advanced properties as a feedback of such studies. The materials for film deposition to large extent will also be produced in LCT.

Completion of laboratory consists of a few functional blocks, such as general chemical equipment and furniture, advanced high-temperature processing, operative testing of produced materials and treatment of produced materials according to requirements of measurements of physical properties and applications.

General chemical equipment and furniture includes a wet chemistry facility with fume hoods, a glove box, chemical processing tools, taking care of cleaning and activation of surfaces, when it is requested (a vacuum microwave furnace, a microwave Xe2 excimer lamp, a CO_2 laser), and storage of chemicals and being a necessary part of any chemical laboratory. It is a basic facility for producing any material in ISSP LU, intended for R&D&I.

High-temperature processing is a core functionality for obtaining various inorganic materials and composites. Producing of such materials with advanced properties is one of the main directions of research in ISSP LU. Due to narrow stability windows in terms of temperature, atmosphere and pressure and, as a consequence, complicated producing conditions of a large variety of materials, necessary for R&D&I, the equipment for high-temperature processing with various functionalities, like controlled atmosphere and high pressure, is necessary. The existing facilities are not in line with such urgent demands. Restrictions related to processing of different kinds of materials in the same processing camera, should also be taken into account.

A completely new functionality is preliminary testing to confirm that obtained materials correspond to what was expected and to modify parameters of processing if necessary. Since materials being developed frequently are very sensitive to parameters of producing, processing has to be repeated several times to obtain a high quality material. In such circumstances, time saving of testing is an important advantage to provide continuous process of producing and reduce total time of obtaining a final result. Spectroscopic methods, especially for organic compounds, and x-ray diffraction are very fruitful for this aim. In order to produce high quality coatings for applications in carbon-free energy technologies and energy storage by electrophoretic deposition method the control of different parameters (zeta potential, particle size, viscosity) of suspension is required.

There are a few items which are outside of these large functional groups. Combined DSC/DTG equipment, which allows one to follow temperatures and the kind of chemical reactions during processing, is closely related to processing. Study of various, like polymorphic, phase transitions is another important field of application of DSC. The equipment of preparing of ceramic and composite samples includes sawing and grinding of produced materials according to requirements of particular studies of structure and physical properties. The new equipment will allow us to reduce waste produced by this process, as well as improve quality of obtained samples. Ultrasonic spraying system is intended mainly for preparation of electrode, catalyst coating, membrane materials with larger area which is required to prepare equal electrodes for batteries, supercapacitors, fuel cells to perform tests with different catalysts and electrolytes, as well as prototype samples for R&D&I.

	Responsible Person	Upgrade/ New/ Extension	Quotation value	Averaged MF Value	Multifactor Evaluation									
			kEUR		1	2	3	4	5	6	7	8	9	10
Laboratory Chemical Technologies	**E. Birks**		**1,725**											
Chemical laboratory furniture (fume cupboards, laboratory tables, cabinets ,shelfs, etc)		N	90	**3.85**	4.48	4.12	4.15		3.14	3.14	5.00		3.22	3.55
Small equipment for LCT (balances, stirrers, hotplates, ovens, evaporators, centrifuges, etc.)		N	50	**3.95**	4.44	4.24	4.19		3.18	3.18	5.00		3.70	3.64
Glovebox Workstation			25	**3.88**	4.41	4.12	4.00		3.27	3.27	5.00		3.33	3.61
Vacuum microwave furnace (200 °C)		N	10	**3.82**	4.16	4.17	3.96		3.21	3.25	5.00		3.29	3.52
Eksimeru lampa virsmu attīrīšanai un aktivēšanai		N	6	**3.76**	4.04	4.13	3.80		3.05	3.05	5.00		3.43	3.55
Small x-ray difractometer, (Brucker Phaser D2)		N	123	**3.59**	3.82	3.81	3.79	4.11	3.35	3.21	2.79	3.74	3.64	3.67
LC-MS chromatograph		N	140	**2.88**	3.08	2.59	2.67	2.79	2.58	2.70	2.90	2.89	3.29	3.30
IR Spectrometer		N	30	**3.40**	3.27	3.52	3.00		2.71	2.77	5.00		3.41	3.50
UV-VIS Spectrometer		E	20	**3.33**	3.35	3.38	3.00		2.62	2.68	5.00		3.23	3.41
DSC (1600 °C), DTG upgrade (DTG detector, gas analyzer)		N	90	**3.67**	4.11	3.88	3.89	3.88	3.13	3.36	3.48	3.64	3.68	3.67
Zeta potenc., rheological viscometer, particle analysis		N	66	**3.50**	3.92	3.91	3.32	3.40	3.16	3.26	3.33	3.58	3.59	3.55
New Carbolyte furnace x2 (1800 °C)		N	42	**3.71**	4.31	4.20	3.86	4.00	3.14	3.27	3.21	3.52	3.73	3.83
Tube furnace (1800 °C)		N	33	**3.67**	4.21	4.20	3.76	4.07	3.22	3.21	3.28	3.55	3.61	3.64
Optical furnace (FZ-T-800-H-I-S-PC, Crystal Systems Corp.)		N	400	**3.06**	3.33	1.91	2.88	3.36	2.81	3.00	3.60	2.88	3.22	3.58
Isostatic hot press HP 20-4560 (THERMAL TECHNOLOGY, LLC)		N	298	**3.73**	4.37	3.42	3.89	4.26	3.58	3.33	3.92	3.21	3.30	4.00
High temperature furnace with controlled atmosphere, upgrade of furnaces		N/U	52	**3.66**	4.33	3.88	3.85	4.04	3.33	3.33	3.54	3.36	3.38	3.52
Microwave synthesis system		N	96	**3.69**	4.23	3.60	3.73	3.69	3.30	3.50	3.84	3.67	3.73	3.65
CO_2 laser for thermal proces. of nanoparticles and optical fibers		N	18	**3.43**	3.72	3.86	3.36	3.27	3.33	3.06	3.19	3.40	3.64	3.50
Equipment for preparing of polycrystallic samples (sawing, grinding, manual hydraulic press , planetary ball mill)		N/U	60	**3.80**	4.21	4.08	4.19	4.33	3.63	3.43	3.14	3.57	3.55	3.87
Exactacoat Fuel Cell Coating System - pirolīzes izsmidzināšanas iekārta paraugiem līdz 40x40 cm		N	76	**3.43**	3.85	3.50	3.20	3.46	3.27	3.32	3.53	3.25	3.44	3.45

5. Infrastructure for Laboratory of Thin Films and Coatings technologies

Thin Films vacuum technology is a key method to produce functional materials at the ISSP UL, with Latvia, having one of the largest vacuum technology industry (SIDRABE, Inc., GROGLASS, Ltd., ALFA, Inc.) among the Baltic countries. Vacuum plasma deposition technologies developed in the last years at the ISSP UL are widely and extensively used for thin films and coatings production in the framework of the EU FP6 (X-TIP) projects and FP7 (EUROFusion enabling research project CfP-WP15-ENR-01/UL-01) as well as Competence centre BKC. Magnetron sputtering has become the process of choice in many applications. Especially High Power Impulse Magnetron Sputtering(HIPIMS) processes will be developed at ISSP LU using highly ionised pulse plasmas source for sputtering and modification of material properties.

The Laboratory of Thin Films and Coatings will provide services in the form of depositions of a wide variety of materials based on different techniques from existing and new deposition tools, including a multifunctional R&D cluster plant, PLD epitaxial growth, and several other deposition techniques (ALD, MOCVD). The deposition tools will be operated by highly skilled staff and processes, enabling the deposition of novel materials as demanded from internal projects or external customers. New plasma technologies of HIPIMS and plasma processes will be available.

The SAF25/50 multifunctional R&D cluster plant (installed in the clean rooms) will be further developed for research and development works as well as for feasibility studies and more general academic work in the field of thin film technologies. The plant is a multifunctional, expandable, modular and flexible system comprising an input/output chamber with ion gun, a central substrate transfer chamber with a radial telescopic transport arm and up to 7 deposition chambers.The multifunctional, modular plant will be further equipped by new chambers for HIPIMS and e-beam processes as well as for control of the sputtering process by Optical Emission Spectroscopy (OES), quadrupole mass spectroscopy and in-situ characterisation thin films by ellipsometry. For the industrial realisation of the HIPIMS processes further improvement and adjustment will be performed with the focus on pulse generation.

The HIPIMS plasma sputtering technology laboratory will be renovated: (i) the existing sputtering equipment will be upgraded with two HIPIMS sources and a two channel Time resolved Plasma Optical Emission Spectroscopy (OES) system for process control, which will be used for development of novel thin film deposition methods; (ii) the RF-OES multifunctional R&D plant will be developed with OES plasma regulation and process control.The RF-OES multifunctional R&D plant is intended for research and development works as well as for feasibility studies and more general academic work in the field of thin film technologies. The plant comprises a RF magnetron vacuum chamber with OES plasma regulation and process control. The HIPIMS related activity package includes purchase and installation of two magnetrons and two power sources. Capitalizing on HIPIMS advantages, this will open new venues for the development of thin film deposition methods even for coatings of more complex compositions and/or layer structures than obtainable with a single deposition source.

PLDwill be developed for production of thin films and heterostructures from various materials with complicated stoichiometry. PLD will allow a one-to-one transfer of elements from target to substrate, which is a strong advantage for the deposition of multiple element systems. Different atmospheres of deposition allow for varying of film properties in a wide range. We plan to made high-quality thin films of perovskite structures by PLD, studying structure, surface topology (by AFM), dielectric and electromechanical properties.

The present MOCVD reactor Aixtron (AIX-200RF) is available for the synthesis of thin films which involves existing metals, using corresponding liquid metal-organic compounds and gaseous non-metal chemical hydride and oxide gases. The Control of the rate of reactants flow is provided using thermostats for liquid metal-organic compounds, and carrier gas (N2, H2) flow. The control of non-metal chemical hydride gases flows involves both the carrier gas and precursor flow. The Present MOCVD equipment has the following chemical reactants installed: SiH4 (6N), SiH4 200ppm H2 mixture, NH3 – nitrogen source (6N), N2, H2 carrier gases (purity 2ppb), metal-organic lines: metal sources (Ga, Al, Zn, Mg, In) – TMGa, 2 x TMIn, TEGa, 2 x TMAl, CpMg, DEZn, oxygen sources – NO, N2O. The equipment will be renovated for the synthesis of classic LED structures, as well as for the synthesis of Si, ZnO, and group III nitride 1D nanostructures. There is a possibility to dope the materials, in order to obtain n- or p-conductivity. MOCVD equipment will be used to manipulate chemical reactants creating different 1D, 2D, and hybrid structures.

Atomic layer deposition (ALD) is a subclass of chemical vapour deposition that is based on the sequential use of a gas phase chemical process. The majority of ALD reactions use two precursors, reacting with the surface of a material one at a time in a sequential, self-limiting, manner. Through the repeated exposure to separate precursors, a thin film is deposited.

A purchase of an ALD system is planned with the features including the substrate stage prepared for 8” wafers / carriers, and the substrate stage and reactor wall temperature controlled up to 400°C and 150°C, respectively. The system will be used for fabrication of semiconductor devices, and for synthesis of nanomaterials.

	Responsible Person	Upgrade/ New/ Extension	Quotation value	Averaged MF Value	Multifactor Evaluation									
			kEUR		1	2	3	4	5	6	7	8	9	10
Thin films and coatings technologies	**J. Purāns**		**1,659**											
New chambers for HIPIMS + e-beam processes and for characterisation of thin films at PVD SAF25/50 R&D cluster	J. Purāns	U	400	**3.73**	4.16	2.87	3.52	4.24	4.12	3.45	3.91	3.52	3.24	4.28
PVD HIPIMS plasma sputtering technology laboratory renovation:	J. Purāns	U	400	**3.56**	3.58	2.95	3.18	4.09	4.00	3.28	3.47	3.50	3.32	4.18
PLD equipment to extend functionality	K. Kundziņš	N	419	**3.42**	4.00	2.70	3.33	3.38	3.46	3.30	3.64	3.48	3.38	3.54
ALD equipment to extend functionality	L. Dimitročenko	N	200	**3.10**	3.33	3.04	2.67	2.92	3.14	3.05	3.81	2.80	3.20	3.00
Renaissance of the existing MOCVD technology	L. Dimitročenko	U	200	**3.14**	3.54	3.00	2.83	3.46	3.08	2.95	3.55	2.71	3.24	3.00

6. Infrastructure for Laboratory of Prototyping and Application Assessment

The development of ISSP into an application-driven institute implies a need for fabrication processes; therefore, a laboratory will be established for prototyping of photonic and microelectronic devices including nonlinear optics, nanowires for sensing, hybrid waveguide devices, and various novel luminescent materials. The new lab will be developed in close collaboration with KTH/Acreo to ensure that the synergies within the consortium of CAMART[2] project are taken into consideration and that the new process and organisation are developed based on deep knowledge for devising research and innovation processes at the Electrum Laboratory.

The prototyping laboratory will be equipped with all the necessary tools for wide range resolution patterning, testing and packaging.

Many rapidly developing technologies such as photonic integrated circuits based on semiconductor waveguides, plasmonics, microelectromechanical systems and others require sophisticated high resolution writing and processing tools. We will install a state-of-the-art large area electron beam lithography (EBL) system which will be used for creation of masks with the resolution down to 10 nm. In order to fully utilize the EBL system capabilities, some additional technology will be implemented. For high quality resist coatings specific substrate handling is necessary. High-performance cleaning, rinsing and drying will be ensured by a spin rinse and dryer tool. The oxidation oven will allow the development of hard masks on silicon, while the reactive ion etching system will ensure high resolution etching of silicon, silicon dioxide, polymer and other materials. Additionally low temperature plasma enhanced chemical vapour deposition system will allow the introduction of lithography stopping layers as well as functional amorphous silicon, silicon dioxide and silicon nitride layers into prototypes.

The ISSP currently owns a laser writer which is used in the submicron resolution lithography workflow for creation of all-organic waveguide devices, electrode masks and others. The main strength of the tool lies within its precision and mask writing flexibility. However, single mask batch processing with the laser writer is very time-consuming and resourceful. Therefore a mask aligner will be obtained. By using a mask aligner the masks developed by the laser writer will be transferable to new substrates within couple of minutes. Such tool will significantly reduce the time necessary for establishing the prototype development process.

Additional equipment for prototype preparation, testing and packaging will also be installed. The on-chip testing will be enabled by the probe station. Using high resolution stages and probe positioning hardware it will be possible to do precise electrical and optical characterization of the developed chips. A dicing saw, polishing tool and a microwire bonder are then used for chip final preparation as well as packaging. The packaged chip can afterwards be used for prototype demonstration in a relevant environment. The prototyping laboratory will greatly benefit from overall development of infrastructure in other laboratories of ISSP. For example, additional and specific material deposition will be done at the Laboratory of Thin Films and Coatings, whereas a dielectrics deposition system will be placed in the process lab along with dry etching systems and wet chemistry facilities for etching and cleaning.

Process support systems such as DI water, chemical waste handling, and media supply systems will be installed as well.

The new process line will support research and prototype fabrication and will be open for both academic and industrial users in the framework of Open Access Laboratory. The need for larger production volumes initially will be covered by the Electrum Lab.

	Responsible Person	Upgrade/ New/ Extension	Quotation value	Averaged MF Value	Multifactor Evaluation									
			kEUR		1	2	3	4	5	6	7	8	9	10
Prototyping, application assessment, small scale production	**E. Nitišs**		**2,147**											
Large area electron beam lithography system		N	1229	**3.08**	3.96	2.32	3.09	2.78	3.19	3.15	3.67	2.68	2.80	3.17
Mask aligner		N	74	**3.16**	3.92	2.91	3.26	2.91	3.19	3.00	3.35	2.76	3.06	3.25
Oxidation oven		N	100	**3.15**	4.00	2.86	3.27	2.95	3.14	2.94	3.16	2.83	3.06	3.26
Reactive ion etching system		N	110	**3.15**	4.00	2.81	3.27	2.81	3.10	3.00	3.44	2.76	3.06	3.22
Plasma Enhanced Chemical Vapour Deposition: PECVD		N	190	**3.02**	3.50	2.71	2.86	2.64	3.15	2.88	3.37	2.71	3.00	3.33
Wet bench		N	40	**3.09**	4.00	3.05	3.05	2.80	3.20	2.94	2.94	2.82	2.82	3.22
Rinser/Dryer		N	22.08	**3.07**	3.96	3.00	3.10	2.85	3.16	2.81	3.00	2.81	2.88	3.18
Probe station		N	40	**3.03**	3.86	2.84	3.15	2.75	3.05	2.69	2.94	2.88	2.94	3.24
Microwire bonding station		N	30	**3.02**	3.83	2.85	3.14	2.67	2.95	2.71	3.00	2.88	2.94	3.24
Dicing saw		N	90	**3.03**	3.78	2.75	3.19	2.81	3.05	2.71	3.00	2.81	2.94	3.24
Polishing tool		N	10	**3.06**	3.65	3.15	3.38	2.95	3.00	2.71	2.89	2.69	2.81	3.35
Chip electrical testing tools		N	43	**3.19**	4.04	3.10	3.33	2.95	3.16	2.94	3.06	2.94	3.00	3.35
DI water production station		N	20	**3.18**	4.00	3.30	3.54	3.46	2.64	2.50	2.48	3.20	3.15	3.55
266 nm CW laser FQCW266-200mW	J. Teteris	N	99	**3.35**	3.37	3.08	2.78	4.27	2.81	2.65	2.78	3.95	4.43	3.39
405, 457, 473, 514, 660, 1064 nm lāzeru un to optisko detaļu nodrošinājums	J. Teteris	U	50	**3.35**	3.37	3.36	2.81	4.31	2.81	2.70	2.70	3.95	4.05	3.43

7. Development of IT infrastructure for Theoretical Material Sciences

High-performance computing (HPC) infrastructure is nowadays a crucial component of research process, which provides a background for materials modelling and device simulations. Besides, it helps the experimentalists to interpret the experimental results and to access information that would not be available otherwise. Moreover, modelling of the system evolution is often a quicker and/or cheaper way than with trial and error method, thus allowing one to speed up the R&D activities at reduced cost.

From 2002 the ISSP UL has continuously developed one of the most powerful HPC cluster in Latvia - Latvian SuperCluster (LASC). Its theoretical peak performance reached about 12 TFlops in 2016, and it is intensively used by ISSP UL research staff as well as by UL undergraduate and graduate students within national and international research projects. The activities involving LASC address (i) large-scale electronic and atomic structure modelling, important for a wide range of high-tech applications in new sources of energy, catalysis, nanoelectronics, sensorics, spintronics, among others, as well as self-assembled systems, which can serve as building blocks of nanoscale 'switches' and machines and (ii) interpretation of experimental data (for example, X-ray absorption spectra, infrared and Raman spectra, electronic paramagnetic resonance spectra, X-ray photoemission spectra, etc) from a number of spectroscopic experiments.

Currently available HPC resources allows one to simulate from first-principles the static structure and properties of crystalline materials, to perform empirical-potential simulations as well as experimental data analysis and interpretation based on early mentioned theoretical approaches. These tasks are realised using a wide range of commercial, non-commercial and in-house developed software installed currently on LASC.

The implementation of the Research Program demands to perform first-principles modelling of temperature and time dependent properties of materials and to extend their range down to nanoscale as well as to perform device simulations based on theoretical materials models (e.g. for device performance, heat dissipation, current distribution). Such challenging tasks require much larger computing resources, among which the computing speed and memory volume are at the first place. Therefore, we plan to upgrade the LASC cluster to at least 100 TFlops computing power using the last-generation multi-core processors and high-speed solid-state drive technology. The memory volume available to users will be increased from about 4 TB in 2016 to at least 12 TB after upgrade.

	Responsible Person	Upgrade/ New/ Extension	Quotation value	Averaged MF Value	Multifactor Evaluation									
			kEUR		1	2	3	4	5	6	7	8	9	10
IT support	**M. Kundziņš**		**600**											
High-performance computing (HPC) cluster "LASC" upgrade up to at least 100 Tflops		**U**	600	**3.71**	4.04	3.17	3.38	4.56	2.78	3.87	3.73	3.20	3.84	4.52

8. Renovation of laboratory and office space and construction for to ensure fire safety and environmental requirements.

During the last decade over than 1 MEUR was invested in renovation of the building in ISSP UL. Most of those investments have been used to rebuild engineering networks, particularly ventilation, heating, water supply and sewerage systems, which were completely rebuilt. In addition about 1 MEUR has been invested for to rebuilt half of one floor, 600 m^2, where cleanrooms are located equipped with autonomous heating and ventilation system, and each individual room has air purification and conditioning systems.

In 2016 energy certification of the building has been made and energy certification had been approved (Reg. No. BIS / EED-1-2016-464). Currently, within the framework of the ERAF activity 4.2.1.2. "Promoting energy efficiency in public buildings" the building project for improvement of energy efficiency of the institute is developed. The main aspects of the project are envelope insulation with adding extra insulation or its inserting in the places where it is absent, as well as utilization of heat emitted by the data center servers 20-25 kW for the house heating during the heating season. The total investments for the building energy efficiency improvement measures is designed as 320 thousand EUR.

Since 1975, when the building was put into operation and started to be used, practically almost no improvement, with few exceptions, have been performed in laboratory and cabinet rooms. It is planned to build fireproof, soundproof partition walls, change the doors to Al-type glazed doors or fireproof doors, where necessary, change the ceiling and flooring coatings. Restoring lighting elements, they should be replaced with LED luminaires, thus significantly saving electricity consumed and improving fire safety.

Most of laboratories fume cupboards space had not been restored before, or due to damage the systems could not be used. There must be constructed new fume cupboards and exhaust cones, including exhaust-air channels and fans, which will be deployed on the sixth floor of the building. We plan to upgrade partly the cabinet furnishings too.

Previously residing in building of ISSP UL Optometry Department of Faculty of Physics and Mathematics UL has been reallocated to a new building of Academic Center for Natural Sciences of the University of Latvia opened in Torņakalns. As a result an extra space of ~ 500 m^2 of office and laboratory rooms became available for use by ISSP UL. These rooms are planned to renovate first of all, adjusting them for the research equipment procured. Afterwards these rooms will be used for relocation of laboratories and offices now occupied by ISSP UL researchers.

Restoring the building facilities, special attention will be paid to fire safety and environmental requirements to ensure accessibility. Fire safety issues will be addressed, building dividing fire compartments, rebuilding stairwells into safe evacuation areas and replacing elevators, both passenger and the passenger - cargo, with the fire-resistant ones. To ensure environmental accessibility requirements the elevators will be rebuilt for easy usage by wheelchair users. Elevators and stairs will be equipped with information in Braille script and will also be implemented in other measures. The modern lobby renovation will be realized.

8 to 10 renovation stages should be accomplished until all building is finished. The process could be started in 2017 and finished by the 2019.

It is important to proceed ASAP because this renovation somehow challenges realization of second stage of CAMART2 to sharply raise human resources, develop tools and radically increase scientific, innovation and academic productivity.

	Responsible Person	Upgrade/ New/ Extension	Quotation value	Averaged MF Value	Multifactor Evaluation									
			kEUR		1	2	3	4	5	6	7	8	9	10
IT support	**J. Kļaviņš**		**900**											
Renovation (5 floors)														
Doors		U	900	**2.76**	3.04	2.48							2.77	
Floors		U	240	**2.85**	3.16	3.08							2.31	
Ceilings		U	250	**2.82**	3.20	3.00							2.27	
Replaning lab sizes		U	230	**2.85**	3.00	3.12							2.42	
Electrical instalation		U	350	**2.90**	3.24	3.04							2.42	
Fume cupboards, other special ventilation		U	150	**3.31**	3.76	3.32							2.85	
Fire security, access control and network		U	110	**3.17**	3.24	3.28							3.00	
Watersuply		U	50	**3.27**	3.28	3.48							3.04	
Dismantling		U	90	**3.02**		3.28							2.75	
Thermo insulation		U	5	**3.34**		3.56							3.13	
Supporting acctions		U	20	**3.24**		3.23							3.25	
Design and supervision of construction		U	100	**3.38**		3.17							3.59	
Refurnishing		U	200	**3.52**	3.58	3.48							3.50	