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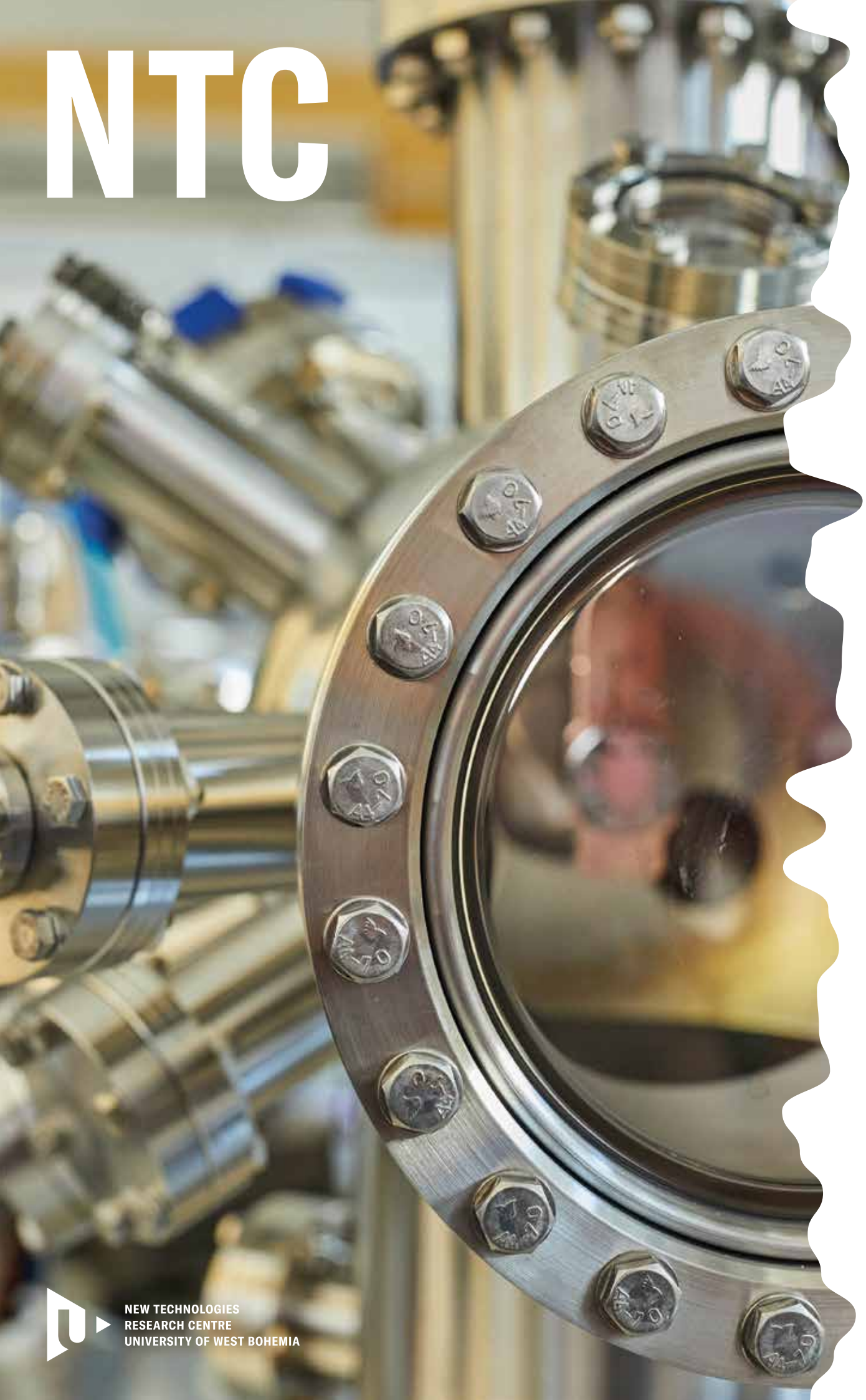


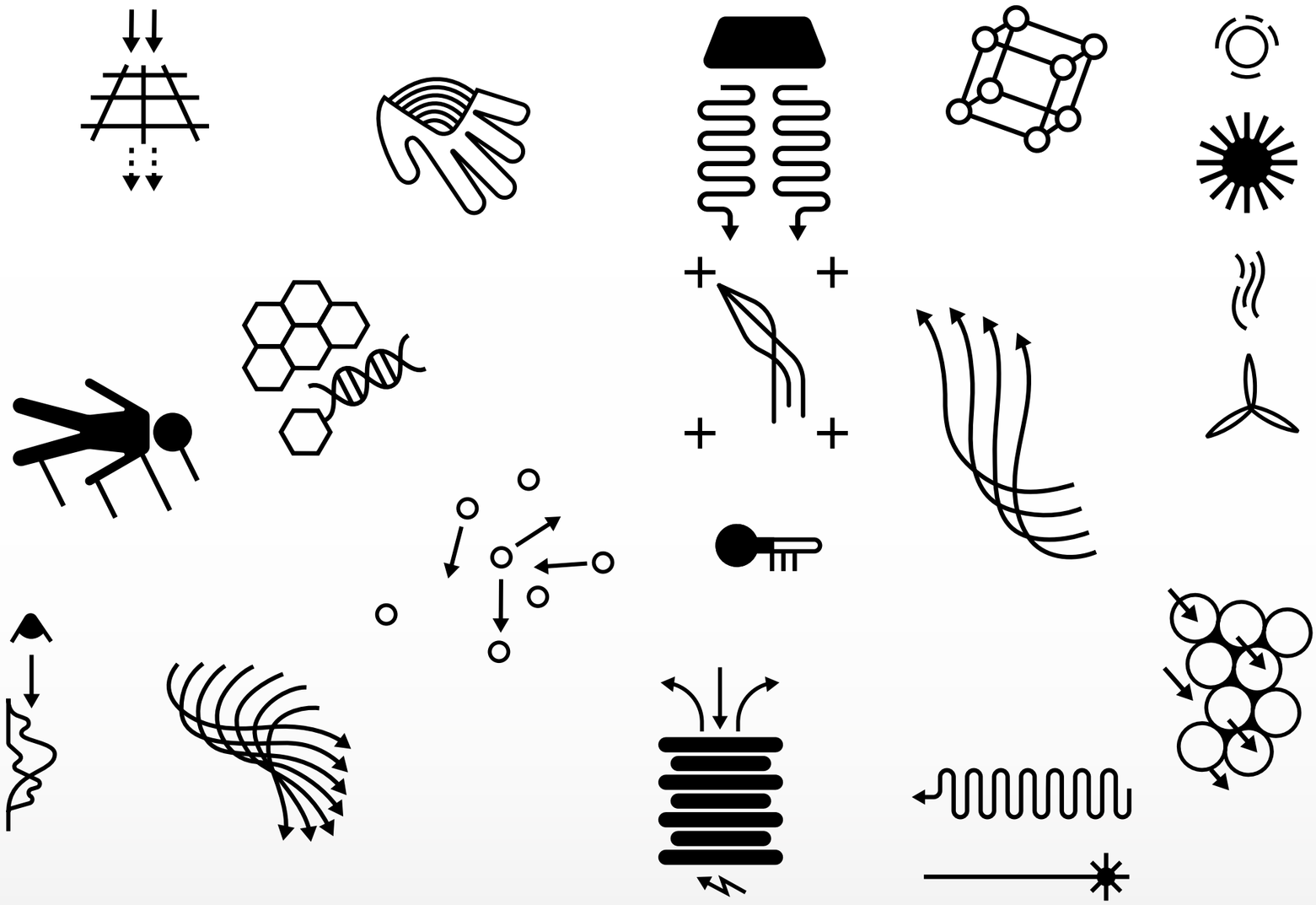
NEW TECHNOLOGIES
RESEARCH CENTRE
UNIVERSITY OF WEST BOHEMIA

ANNUAL REPORT NTC

2019

ANNUAL REPORT NTC 2018

2019 Annual Report New Technologies – Research Centre University of West Bohemia



NTC

OBSAH

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DEAR READERS,

Last year, NTC achieved many successes, which are described in the annual report. We have solved many research projects from providers from the Czech Republic and abroad and have successfully completed dozens of research contracts with companies.

I am personally pleased that we continue to strengthen the international cooperation and involve foreign experts from all around the world in our research teams. In 2019, 17 foreign national researchers from 11 different countries were employed at NTC. As usual, trainees from Brazil worked at NTC. Four foreign experts were part of the NTC Scientific Council. Our employees went on more than 190 international business trips, where they have developed cooperation with our partners. Stronger connection with foreign research institutions represents the way to the further development of NTC. Thanks to these activities, we have also succeeded in obtaining the first H2020 project entitled "Affordable High-Performance Green Redox Flow Batteries", whose main goal is the development, demonstration and validation of sustainable, economical and safe advanced redox battery technology.

In accordance with our values, we place high demands on the professional level of submitted publication results focusing on scientific journals included in the WoS and Scopus databases in the Q1 and Q2 quartiles. The publications of our researchers are highly cited. In terms of excellent publication results, I have to point out the acceptance of Jan Minar's and Saleem Khan's article in the prestigious Nature magazine.

Investment in state-of-the-art equipment is a prerequisite for further successful development of the centre. Last year we opened a new laboratory for spin and angular resolution photoemission. A laboratory equipped with SARPES is a great asset for NTC in the future. Its versatility and equipment will be invaluable in explaining and justifying basic physical phenomena, and in addition to its application into the basic research, this unique equipment can be used for chemical analysis of materials.

Since December 2018, we have been awarded the prestigious HR Excellence in Research Award, awarded by the European Commission. In 2019, we continued to fulfill the obligations arising from this award, which guarantees that we are creating favorable conditions at European level for researchers and other employees in all respects.

Over the past twelve months, the NTC has confirmed its position of a flourishing research center that is ready for the next challenges of a rapidly changing world. For this I would like to express my sincere thanks to all those involved in; to our employees, partners and all our supporters.

Petr Kavalíř, NTC Director

1 → DIRECTOR'S FOREWORD

In 2019, NTC developed its activities according to the Strategic Plan for 2016-2020, which is fully in line with the Strategic Plan of UWB.
The key activity was the final phase of the CENTEM+ sustainability project, which followed the CENTEM project from the OP RDI programme. The CENTEM+ project was supported by the National Sustainability Programme (NPU I). In addition to CENTEM+, NTC has also dealt with a number of other projects from domestic providers, such as the Ministry of Education, Youth and Sports (MEYS), the Technology Agency of the Czech Republic (TACR) and the Grant Agency of the Czech Republic (GACR).
An important group of projects that have been and are being addressed by NTC are projects from the cross-border cooperation programme Czech Republic- Bavaria Free State ETC Goal 2014-2020, which is provided by the Ministry for Regional Development of the Czech Republic. NTC continued to implement two major OP RDE projects in 2019, which will be developed until 2022. In 2019, NTC also started the implementation of two sub-projects within the “Mechanical Engineering” consortium in the National Competence Centre 1 (NCK1) programme. At the end of 2019, a third sub-project was applied for and this proposal was approved. The project is scheduled to start in 2020.
Another NTC milestone reached at the end of 2019 was the acquisition of a project from Horizon 2020 under the name “AFFORDABLE HIGH-PERFORMANCE GREEN REDOX FLOW BATTERIES” with the acronym "HIGREEW", in the Call LC-BAT-4-2019: Advanced Redox Flow Batteries for Stationary Energy Storage. The main goal of HIGREEW is the development, demonstration and validation of sustainable, economical and safe advanced redox battery technology.
In addition to the planned applied results successfully transmitted to industrial partners, the research also achieved many high-quality publication outputs relevant for the evaluation of NTC in terms of research excellence. In addition to grant projects, an integral part of NTC is strong and long-term cooperation with industrial partners in the area of contractual problem-oriented research.
NTC continues to strengthen international cooperation and involves foreign experts in its research teams. In 2019, 17 foreign researchers from 11 different countries were employed at NTC. As usual, trainees from Brazil were accepted. Four foreign experts were part of the NTC Scientific Board.
Thanks to the education of young researchers and a targeted strategy of attracting talent from abroad, NTC has managed to be an attractive employer. Of the total number of 136 employees (96 men, 40 women) in 2019, more than half were younger than 40 years, which represents a very promising human resource for further development. The research institute supports not only professional growth, but also regular further education and development of managerial and other necessary skills. Emphasis is placed on transparent human resource management processes.
Since December 2018, NTC has been awarded the prestigious HR Excellence in Research, abbreviated HR Award, awarded by the European Commission. In 2019, the Institute continued to fulfil its obligations under this award, which guarantees that it creates favourable conditions for researchers and other employees in all respects.

NTC personnel structure in terms of qualification is shown in Table 1.

EMPLOYEES CAPACITY	PERSONS
Total	136
Professors	8
Associate Professors	11
Ph.D.	62
Other University graduates	39
Secondary school graduates and others	16

TAB 1 Employees Capacity of NTC.

NTC’s organizational structure in 2019 was based on research topics, with a substantial part of professional activities integrated into CENTEM+. The organizational structure of NTC in 2019 is graphically shown in Figure 1.

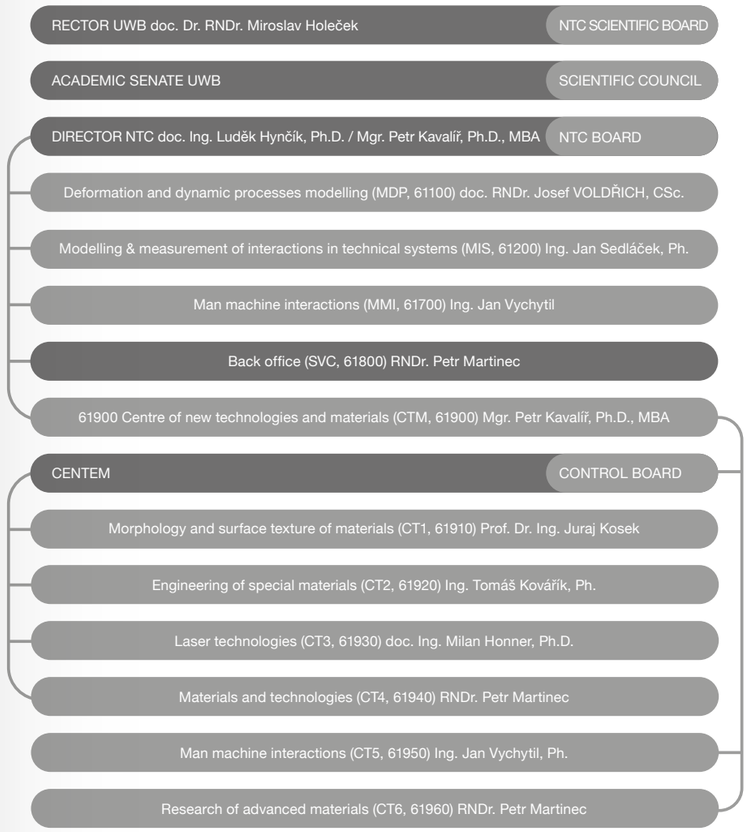


FIG 1 Organization structure of NTC in 2019

CONTRACTUAL RESEARCH

As in previous years, also in 2019, New Technologies – Research Centre was involved in dealing with problems and participating in activities together with commercial partners. Research and service activities were predominantly provided to them. These were research institutions and, above all, industrial enterprises from home and abroad. In 2019, 63 contracts for contractual research and 89 contracts for additional activities totalling 12.2 million CZK were dealt with. The key partners were mainly the following companies: ŠKODA AUTO, a.s.; NET4GAS, s.r.o., Wikow Gear, s.r.o., ZF Engineering Plzeň, s.r.o.; MAHLE Behr Holýšov, s.r.o.; Howden ČKD Compressors, s.r.o.; ZVVZ-Enven Engineering, a.s.; Škoda JS, a.s.; VALEO VÝMĚNÍKY TEPLA, s.r.o.; Mercedes-Benz (Great Britain); University of Bayreuth (Germany); ČEZ Energoservis, s.r.o.; COMTES FHT, a.s.; Pilsen TOOLS, s.r.o.; COMDES CZ, s.r.o.; Pilsen Prazdroj, a.s.; TESLA Electrontubes, s.r.o.; Red Bull Advanced Technologies in Milton Keynes (Great Britain); SCG Chemicals (Thailand); Diamorph hob certec; VŠB – Technical University Ostrava; Brisk Tábor a.s.; Sécheron Tchequie, s.r.o.; Thai Oil PCL (Thailand); NILAN, s.r.o., Kingspan, a.s; Thermal Focus BVBA (Belgium); Energotrans, a.s.; Institute of Plasma Physics AS CR; ÚJP Praha, a.s.; JABLOTRON ALARMS, a.s.; Eurometalgroup, s.r.o., NIMETAL, s.r.o.; UK Medical Faculty; Frentech Aerospace, s.r.o.; GTW TECHNIK, s.r.o.; University of Chemistry and Technology, Prague; MEDICEM Institute, s.r.o.; Ably Medical (Norway); MemBrain, s.r.o. and other. All the above-mentioned contracts were always completed within the agreed deadlines and in accordance with the ideas of the contracting authorities.

THE CENTEM AND THE CENTEM+ SUSTAINABILITY PROJECTS

In 2019, the CENTEM+ Sustainability project was successfully completed, which followed the CENTEM project from the OP RDI programme. The CENTEM+ project was supported by the National Sustainability Programme NPU I for the period 2015 to 2019. The volume of eligible costs in this project is 60 million CZK per year, of which approximately 27 million CZK is subsidies from the Ministry of Education, Youth and Sports. In 2019, attention was focused on completing all the research objectives and activities promised in the project application. Attention was also paid to the completion of all applied results. These results have been properly completed so that they can be used in subsequent projects or in activities related to the commercialization of individual results. In the coming years, attention and emphasis will be focused on the activities related to the commercialization of results generated in NTC workplaces.

PROJECTS

Another NTC milestone reached at the end of 2019 was the acquisition of a project from the H2020 programme under the name “**AFFORDABLE HIGH-PERFORMANCE GREEN REDOX FLOW BATTERIES**”, abbreviated “**HIGREEW**”, in Call LC-BAT-4-2019: Advanced Redox Flow Batteries for Stationary Energy Storage. The main goal of the HIGREEW project is the development, demonstration and validation of sustainable, economical and safe advanced redox battery technology. This project involves partners from Spain from the Institute “Centro de Investigación Cooperativa de Energías Alternativas Fundación”, from France from the institute “CNRS – Centre National de la Recherche Scientifique” and industrial partners “Gamesa Electric Sociedad Anónima”, “Pinflow Energy Storage, s.r.o.”, “Heights UK Limited”, “C-TECH Innovation Limited” and others.
In 2019, NTC participated in the three projects financed from the Grant Agency of the Czech Republic (GACR). These were the projects “**Electronic structure of Lanthanides-doped materials for phosphor-converted white light emitting diodes**”, “**Strength of materials and mechanical components based on iron: Multi-scale approach**” and “**Fluid Acoustics in Periodic Micro-Architectures**”. The total financial subsidy from the GACR provider was 1.6 million CZK.
Another group is projects with application effect in cooperation with industrial partners. These projects are dealt with in close cooperation with industrial enterprises, which are usually the main beneficiaries of projects, and NTC acts as a research institution in supporting these industrial partners. The projects are funded by the Technology Agency of the Czech Republic (TACR) from the Competence Centre programme. The NTC Research Centre dealt with two projects with a total financial subsidy of 2.9 million CZK under the titles “**Centre of research and experimental development of reliable energy production**” and “**Advanced Technologies for Heat and Electricity Production**”, which were successfully completed at the end of 2019.
In 2019, NTC started the implementation of two sub-projects within the “**Mechanical Engineering**” consortium within the National Competence Centres 1 (NCK1) programme. The project involves another 26 participants, such as CTU in Prague, COMTES FHT, a.s., VUT Brno, Institute of Material Physics AS CR and industrial partners, e.g. Wikov Gear, s.r.o., TOSHULIN, a.s., Škoda Machine Tool, a.s., TOS Varnsdorf, a.s., and others.
Two sub-projects are being addressed within the project “**National Competence Centre for ENGINEERING**”. The first sub-project deals with the topic of “Gearbox Optimization Using Analytical and Numerical Methods with Experiment Support (e.g. operating conditions, acoustics, durability, strength calculations, etc.)” in cooperation with Wikov Gear, s.r.o.
As part of the implementation of this sub-project, theoretical analyses are planned, including analytical and numerical calculations, experimental research including validation of computational models and activities related to the design and optimization of gearbox parts. The second sub-project is called “Application of Transition Metal Oxides and Heusler Alloys with Unique Physical Properties in Sensors and Actuators”. The activities in the sub-project focus on theoretical predictions of new materials, characterization of transition metal oxides and Heusler alloys, and the manufacturing process of sensors and actuators. In 2019, these sub-projects were financed in the total amount of about 1.75 million CZK. At the end of 2019, a third sub-project was applied for and this proposal has been approved. The project is planned to start in 2020.
In the second half of 2019, another two projects with application effect were launched in cooperation with industrial partners in the THÉTA programme on the topic “**Experimental and Computational Critical Heat Flux Identification of Small Power Output Reactor (SMR) Fuel Rods**” in cooperation with Škoda JS, a.s. The main objective is to develop sophisticated methodologies; based on such sophisticated procedures, local effects associated with critical heat flux that can occur during the operation of fuel rods can also be described. This knowledge has a huge impact on the acquisition of know-how in the area of reactor safety, not only in the Czech Republic.
The second project in the THÉTA programme focuses on the topic “**Research and development of advanced flow energy storage technologies**”. The aim of the project is research and development of energy

storage technologies, as there is a growing demand for simple and safe ways to store electricity. Furthermore, the project deals with the development of flow-through electrochemical energy storage, which seems to be an ideal technology for storing surplus electricity generated on windy and sunny days. The project partners are ICT Prague and EnergyCloud, a.s. These projects are financed in the total amount of approximately 1.5 million CZK.

The last project in the area of applied research is the project **"Therapeutic Care for Convicted"** from the TACR ÉTA programme. The benefit of this project, focused on post-incarceration care, will be mapping out concrete barriers that impede the application of therapeutic care in prison and evaluating existing therapeutic approaches applied to persons participating in research regarding the care of prisoners. In 2019, this project was financed in the amount of approximately 0.8 million CZK.

This year, the project **"Computational and Experimental Design of Advanced Materials with New Functionalities"** continued in the OP RDE in Call 02_15_003 Support of Excellent Research Teams, in priority axis 1. The aim of this project is to support research and development in the areas of material structures, and electrical and optical properties of new materials, under the leadership of an internationally recognized foreign expert, Associate Professor Doc. Ján Minár. This year, the implementation was focused primarily on the completion of the SARPES laboratory, where, during the month of April, the SARPES (Spin and Angle Resolution Photoelectron Emission Spectrometer) was delivered and installed; it is an exceptional piece of equipment in the Czech Republic, worth over 44 million CZK. In September 2019, the opening ceremony of the laboratory was attended by invited guests from the Pilsen Region and the City of Pilsen, as well as representatives of the University of West Bohemia and technical Faculties. This purchased device helps to understand the properties of certain materials by light striking them with sufficient energy and releasing electrons and particles that provide unique properties. SARPES will allow scientists to study not only the energy and momentum of an electron, but also its exceptional quantum property, the so-called spin. The opening ceremony was preceded by a visit of Karel Havlíček, Minister of Industry and Trade and Deputy Prime Minister of the Czech Republic, who visited the University of West Bohemia in Pilsen on 19 July and was shown the materials laboratory with the SARPES device.

Another project in the call "Pre-Application Research for ITI" is a project called **"LabIR-PAV/Pre-Application Research of Infrared Technologies"**. The LabIR-PAV project deals with interdisciplinary pre-application research on measuring methods based on the use of infrared radiation for contactless analysis of thermomechanical processes in laser material processing technologies, for determination of optical, thermal and mechanical properties of materials and for non-destructive testing of materials and products.

In 2019, the implementation of the project **"Application of Modern Technologies in Medicine and Industry (AMTMI)"** continued within the Call "Pre-application Research for ITI" in the RDE OP. The research project is carried out in cooperation of the University of West Bohemia (UWB) and Charles University, the Faculty of Medicine in Pilsen (LFP). For the University of West Bohemia, two University Parts are involved in the project: FAS, with the NTIS Research Centre, and the NTC Research Centre. In the part dealt with by NTC, this project is focused on creating methodologies and algorithms for further refining of mathematical and experimental modelling of selected tissue types and biological fluids. This project targets virtual, personalized and translational medicine. The project will also enable the development of biomechanical models of the human body with respect to anthropometry and biomechanical properties.

For 2019, the total grant amount for the above three projects is approximately 25.1 million CZK.

An important group of projects that were addressed by NTC in 2019 are projects from the Operational Programme ETC Objective Czech Republic – Free State of Bavaria 2014-2020, which are provided by the Ministry for Regional Development of the Czech Republic. These projects are primarily focused on the cooperation of cross-border partners from the Czech Republic and the Free State of Bavaria in priority axis 1 "Research, Technological Development and Innovation". In 2019, three projects under this

programme were successfully completed, and three projects are continuing their implementation phase in 2020.

The aim of the first project, **"Virtual Model for Prevention, Therapy, and Rehabilitation of Shoulder Complex Pathologies"**, was a close cooperation with German partners OTH and FN Regensburg. In the framework of the cooperation, a new muscular-skeletal model of the shoulder joint is being developed in the program AnyBody Modelling System, including its subsequent implementation in clinical practice. This project was successfully completed in August 2019.

Another project under the designation **"TheCoS – Thermoplastic Composite Structures"** is designed to provide a reliable production chain for fibre composite supporting structures with a thermoplastic matrix consisting of a component manufacturing process and laser beam welding as a bonding technology. This project was also successfully completed in August 2019.

The third project, **"Cross Border R & I Network for Energy Efficiency and Combined Cold Heat and Power"**, is carried out in cooperation with the Faculty of Mechanical Engineering (FME), including the cooperating entities FST/KKE, VVRC (formerly SUSEN) and RTI. The project aims to increase the competitiveness of small and medium-sized enterprises (SMEs) in the subsidy area. This project was successfully completed in September 2019.

The fourth project from the ETC Objective 2014–2020 programme is the creation of a common research platform between NTC at UWB and the Technology Centre for Energy (TZE) at the University of Applied Sciences in Landshut focusing on energy storage research and storage integration with other technologies. This research and cooperation are carried out under the project **"FSTORE: Cross-border Platform for Research of Future Power Storage Possibilities and their Integration"**.

Another project is **"Obstetrics 2.0 – Virtual Models for Injury Prevention during Childbirth"**, which aims to find the optimal position and locomotion of an obstetrician during manual perineal protection to achieve maximum efficiency depending on the anthropometric data of the mother and the obstetrician. In order to achieve these goals, a computational musculoskeletal model of a human with a detailed sub-model of the upper limb will be used.

The last project in this group is **"MATEGRA – Advanced Porous Biomaterials Functionalised with Stem Cells for Better Osseointegration of Implants"**. The MATEGRA project is focused on the development, optimization and testing of new types of biocompatible surfaces in titanium implants to improve osseointegration and adhesion of bone tissue. Another main goal of the project is the creation of interconnection of research institutions, expert groups and knowledge transfer in the area of development and testing of new porous biomaterials.

For 2019, the total subsidy amount for these six projects amounts to approximately 13.3 million CZK.

COOPERATION WITHIN UWB

Regularly, as in previous years, NTC, in 2019, participated in cooperating with other UWB Faculties in the framework of the Student Grant Competition (SGS). In 2019, five projects totalling almost 4.1 million CZK were supported; these projects were obtained from targeted support for specific University research from the Ministry of Education, Youth and Sports. These projects primarily included students of the Faculty of Mechanical Engineering (FME), the Faculty of Applied Sciences (FAS) and the Faculty of Education (FE).

PROFESSIONAL OUTCOMES

In 2019, NTC again placed high demands on the professional level of submitted publication results, especially in the area of journals included in the WOS and Scopus databases in the Q1 and Q2 quartiles. Also, in 2019, NTC dealt with contractual research contracts from commercial partners. The volume of publication activity and the number of applied results listed in the National Register of Results (RIV) are presented in Tables 2 and 3.

PUBLICATION RESULTS	NUMBER
Journal Article	46
Conference Paper	52
Book Chapter	2
Technical Reports	47

TAB 2 Publication results.

APPLIED RESULTS	NUMBER
Functional Sample	6
Authorized Software	1
Verified Technology	5
Prototype	4
Patent – awarded in CZ	1
Patent application – submitted in the national phase in the UK	1

TAB 3 Applied results.

EXCELLENT ACHIEVEMENT IN PUBLICATION IN 2019

The article "Large magnetic gap at the Dirac point in Bi2Te3/MnBi2Te4 heterostructures" was accepted for future publication in the prestigious magazine Nature.

Authors of the article:
Rienks, E. D. L.; Wimmer, S.; Sanchez-Barriga, J.; Caha, O.; Mandal, P. S.; Ruzicka, J.; Ney, A.; Steiner, H.; Volobuev, V. V.; Groiss, H.; Albu, M.; Kothleitner, G.; Michalicka, J.; Khan, S. A.; Minar, J.; Ebert, H.; Bauer, G.; Freyse, F.; Varykhalov, A.; Rader, O.; Springholz, G.

Another article "Direct observation of half-metallicity in the Heusler compound Co2MnSi", published previously in Nature Communications, achieved the status of "Highly cited paper" in the "Web of Science" database in the field of PHYSICS during September / October 2019.

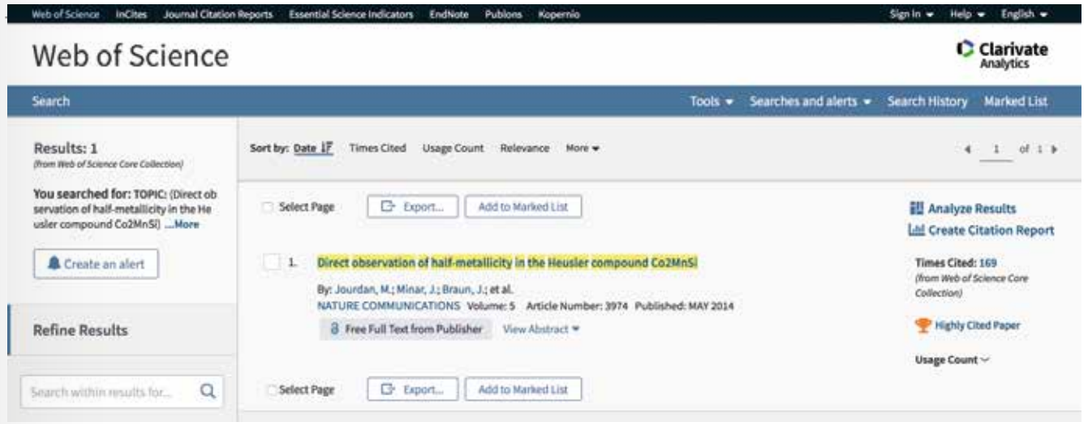


FIG 2 Screenshot in the Web of Science database.

DEFORMATION AND DYNAMIC PROCESSES MODELLING (MDP)

In 2019, the research team of this department continued to participate in the project of the Centre of Research and Experimental Development of Reliable Energy TE01020068, the CENTEM+ project and EVT 615019/1536. At the same time, this team was involved in a new major project, National Centre of Competence MECHANICAL ENGINEERING TN01000015, within its research theme RT3 – Research of Mathematical Modelling of Machines, Technologies and Physical Processes Important for Machine Units. A specific contribution of this team was the cooperation with Wikov Gear, s.r.o. in the sub-project Gearbox Optimizing while Using Analytical and Numerical Methods with the Experiments Support.

More extensive cooperation in the form of contractual research took place with Sécheron Tchequie, s.r.o.; it concerned the development of specialized software.

Preparations for the merger of two departments Deformation and dynamic processes modelling and Modelling and measurement of interactions in technical systems were done in the given year.

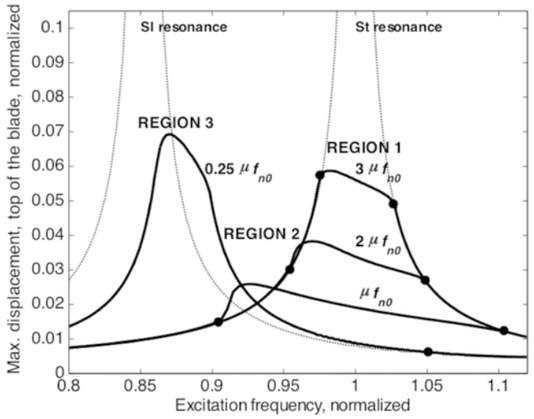
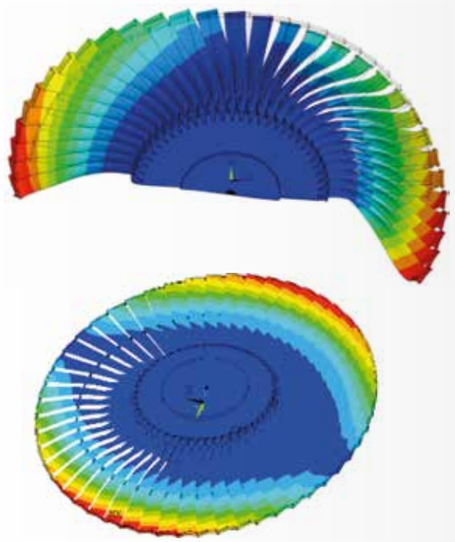


FIG 3 Frequency of excitation.



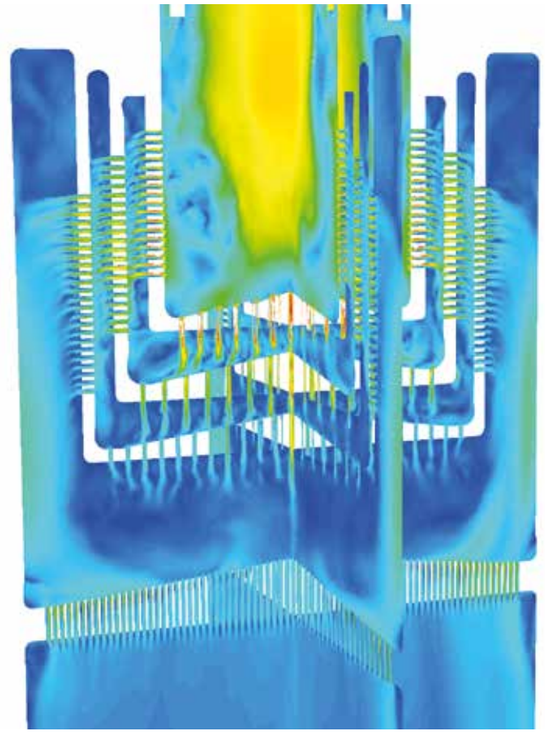
MODELLING AND MEASUREMENT OF INTERACTIONS IN TECHNICAL SYSTEMS (MIS)

In 2019, the department participated in several grant research projects and, at the same time, further developed direct cooperation with traditional and new industrial partners.

In September 2019, the cross-border collaboration project Interreg V-A – Germany/Bavaria-Czech Republic under the name “Cross-border Network for Research and Innovation in Energy Efficiency and Co-generation of Heat and Electricity” was successfully completed. Because of the excellent cooperation with the German colleagues in Amberg, joint meetings are planned for 2020 and topics for future joint projects will be identified. At the end of the year, the project of the TACR Competence Centre entitled “Advanced technologies for heat and electricity production” was successfully completed. On the other hand, two new research projects of TACR were launched in 2019, namely the NCK Engineering project, where the main partner of the Division is Wikov Gear, s.r.o. The second project launched was the Theta project entitled “Experimental and computational critical heat flux identification of small power output reactor (SMR) fuel rods” where the main beneficiary is ŠKODA JS, a.s. The project focuses on both experimental and computational analyses of the boiling crisis.

Direct cooperation with industrial partners has traditionally been aimed mainly at the energy and automotive industries. Unfortunately, cooperation with our long-time partner Howden ČKD Compressors, s.r.o., who ended their development activities, did not continue in 2019. On the other hand, cooperation with, e.g., ZF Engineering Plzeň, s.r.o. was extended, and new cooperation relations were established.

During 2019 the department closely cooperated with other parts of the university: NTC employees participated in teaching in all study degrees (at FME and FEE). Students of bachelor and master study programmes are involved in the activities of the department and Ph.D. students of FME are trained by employees of the department.



MAN-MACHINE INTERACTION (MMI)

The main activity of the team in 2019 was addressing existing research projects in cooperation with Czech and foreign partners. In the Czech-Bavarian cooperation project entitled “Obstetrics 2.0 – Virtual Models for Injury Prevention during Childbirth”, the MMI department was the leading partner. This project was carried out in cooperation with the Faculty of Medicine in Pilsen (LF UK) and the Ostbayerische Technische Hochschule Regensburg (OTH).
As part of the Czech-Bavarian cooperation project “Virtual model of the human body for prevention, treatment and rehabilitation of shoulder disorders”, the MMI team organized a project workshop in June 2019. The MMI research team, together with experts from the OTH partner University, presented their results regarding the use of computer modelling tools in clinical practice. The project was completed in September 2019. The main results include an improved virtual model of the shoulder complex and scientific articles that were submitted for review in prestigious journals.
In December 2019, the GA 17-12925S project: “Strength of materials and mechanical components based on iron: Multi-scale approach” was completed. The MMI department participated as a co-researcher. The project was aimed at the issue of crack propagation in iron on multiple scales ab-initio calculations of electronic structure, molecular dynamics and finite element methods. The main results of the project were professional publications in prestigious impact journals. The MMI Division participated in four of these results. The success of the project will be evaluated by the provider during 2020.
In January 2019, project TL02000205: “Therapeutic Care for Convicted” began; the only researcher is the MMI team. The benefit of this project, focusing mainly on post-incarceration care, will be to map out concrete barriers that make it difficult to apply therapeutic care in prison.
As usual, the MMI department was involved in the “Science Week” event. Within the event the team organized a lecture on “Computer Modelling for Transportation Safety” in November 2019. For the Institute for the Care of Mother and Child, the MMI team carried out contractual research in the area of obstetrics.
In 2019, the MMI department participated in a research concerning the death of Jan Masaryk. There was considerable media interest in the results, whether it was on Czech Television, on the radio or in Internet and printed dailies. Some of the interviews with an MMI employee have been published, e.g.: *https://www.irozhlas.cz/zpravy-domov/jan-masaryk-vrazda-sebevrazda-smrt-pad-vysetrovani-policie_2002080600_kno*

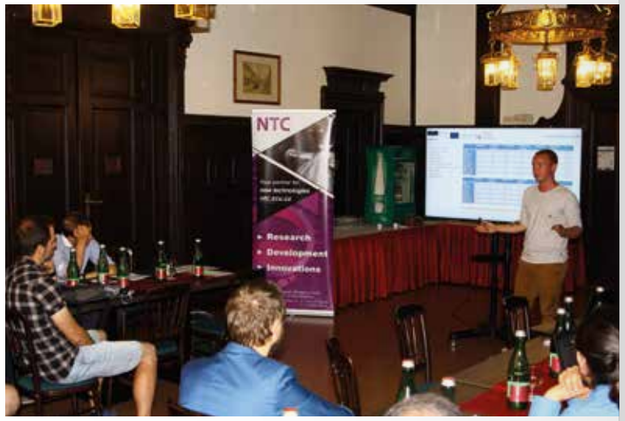


FIG 4 A researcher from the partner University OTH, M.Sc. Maximilian Aurbach, acquaints the workshop participants with the results of the project.

MODELLING AND MONITORING OF THE HUMAN BODY (MLT)

The main activity of the department in 2019 was addressing the ITI research project: “Application of Modern Technologies in Medicine and Industry”. Within this project, the MLT team was involved in the development of virtual models of the human body, both based on the finite element method and the so-called multi-body structure. An integral part of this development was also an experimental measurement of the properties of living tissues. The main outputs of the project in 2019 were publications in scientific journals.
Since February 2019, the MLT Division hosted a foreign expert, Dr. Abbas Talimian, as part of the Mobility 3.0 project. Dr. Talimian participated in the research of the department, in the area of future mobility safety. Important visits to the department were the arrival of Prof. Jean Claude Jolly of the Université d’Angers (France) and Prof. Bernard Korzeniewski of Jagiellonian University (Poland) in 2019. Both experts discussed the possibilities and perspective of the inclusion of an oxidative phosphorylation model in a multi-scale model of optimizing muscle contraction as a source of energy at the cellular level. Traditionally, the team also hosted Brazilian students.
In 2019, MLT expanded its instrumentation with two forceplates These allow the determination of the reaction forces involved in walking and sporting activities, which is essential in developing realistic virtual models of the human body. Thanks to these plates, it was possible to establish contacts for possible cooperation in the area of development of lower limb prostheses (Protetika Plzeň) and in the area of self-defence and combat sports (FHCS of UWB).
In October 2019, MLT participated in the organization of the “2nd International Symposium on Future Mobility Safety Science and Technology”, which took place in Pilsen. The symposium is organized annually in cooperation with two Chinese universities: Tianjin University of Science and Technology and South China University of Science and Technology. A great success was the participation of leading international experts in the fields of the automotive industry, safety and biomechanics of the human body, such as Dr. Saeed Barbat (Ford Motor Company), Dr. Rémy Willinger (University of Strasbourg), Prof. Jac Wismans (SAFETEQ) and many others. During the symposium, experts were sharing their knowledge, giving lectures and participating in panel discussions.
In April 2019, the MLT Division also organized the Czech version of the National Day of Biomechanics, which took place in Techmania in Pilsen. A representative of MLT team gave a lecture on the biomechanics of the human body. In September, MLT participated in the Days of Science and Technology organized by the ASCR.

FIG 5 Prof. Bernard Korzeniewski is lecturing at NTC during his stay at MLT.

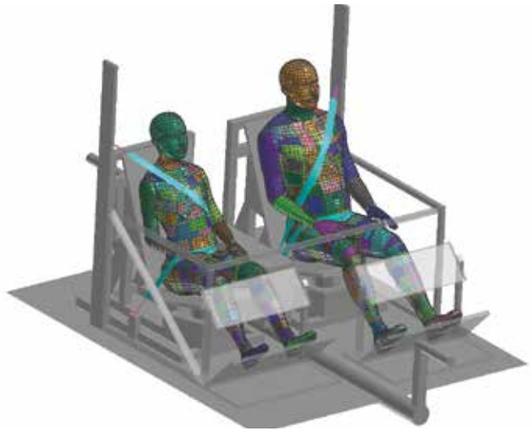
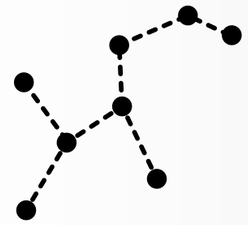


FIG 6 An accident scenario simulation with rolling over the roof of a vehicle

RESEARCH OF ADVANCED MATERIALS (RAM)



This workplace deals with theoretical and experimental research on the electronic structure of solids and low-dimensional systems, with emphasis on electron spectroscopy. In 2019, the workplace continued to address the OP RDE project calls for support of excellent research teams “CEDAMNF: Computational and Experimental Design of Advanced Materials with New Functionalities”; close interconnection of theoretical and experimental methods is the central part of this project.

The department also dealt with the GACR project “Electronic Structure of Lanthanides-doped Materials for Phosphor-converted White Light Emitting Diodes”. This project was successfully completed in 2019. Both the above projects resulted in a number of articles in prestigious impact journals.

RAM participated in the organization of two international workshops in Prague: “Theory Meets Experiment in Low-Dimensional Structures with Correlated Electrons” 1–4 July 2019, and “Current Successes in Photoemission III” as part of the APCOM 2019 conference, which was held on 19-21 June 2018 in the High Tatras.

An important milestone is the opening of a new laboratory for spin and angularly-resolved photoemission (SARPES). Scientists from the group of Doc. Dr. Ján Minár participated in designing SARPES, a device worth 44 million CZK. Photoemission is a method that helps to understand the properties of certain materials by light striking them with enough energy and releasing electrons and particles that are responsible for their unique properties. SARPES makes it possible to study not only the energy and momentum of an electron but also its exceptional quantum property – so-called spin. This laboratory, equipped with SARPES, is a great NTC asset for the future. Its versatility and functionality will be priceless for explaining and justifying basic physical phenomena; in addition to being used in basic research, this method can currently also be used in industry for chemical analyses of materials. The device will increase the scope of cooperation of UWB with institutions in the Pilsen Region, the Czech-Bavarian Region and throughout Europe.

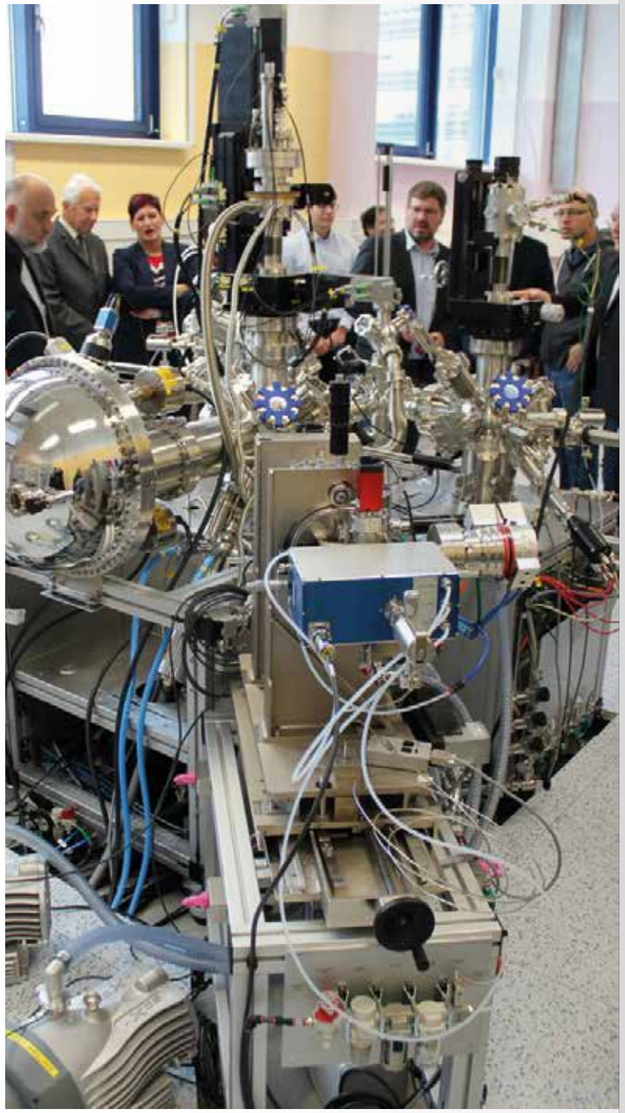


FIG 7 The opening ceremony of the SARPES laboratory in the presence of representatives of the Education, Youth and Sports Division of the Pilsen Regional Authority and colleagues from UWB.

As part of international cooperation with experts from Germany, Austria and the Czech Republic, the RAM team has been able to describe a yet unknown phenomenon regarding signal transmission. As their experiments with magnetically-doped topological insulators have shown, a surprising phenomenon, self-organization, helps lossless signal transmission. The RAM team, specifically Saleem Khan and Jan Minár, sent their findings for publication in the prestigious Nature magazine, which was accepted. Extensive experiments involving the preparation of materials, testing of their properties and their description began as early as 2012 and lasted about five years. This is a thorough verification of their functionality, especially the so-called surface states of materials, which means the electron states in the boundary atoms of solids that otherwise do not occur in materials. This discovery has significant implications for both basic research and the latest technologies.

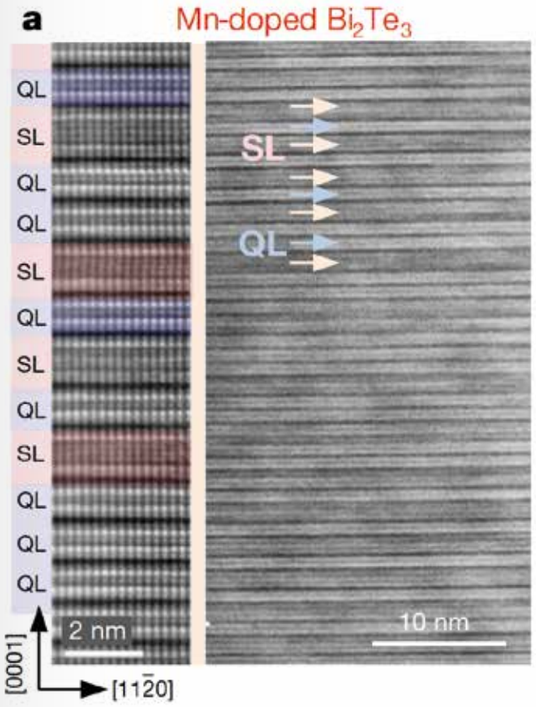


FIG 8 Structure of manganese-doped Bi2Te3 as measured with an electron scanning microscope showing self-organization of layers where, from the original 5-atom layers (QL), 7-atom layers (SL) were formed. Manganese forms the central monatomic layer in SL. (Rienks et al., Nature 576, 423 (2019).

Within this work, the properties of bismuth telluride with manganese admixture were verified. It was manganese that, thanks to its magnetism, changed the structure of the substance, which is otherwise very resistant to external influences, and whose activity can be regulated.

These materials are characterized by their multi-layer structure. As can be seen from Figure 8, they are arranged in layers of five or seven atoms, i.e. about one nanometre. Seven-atom layers are formed by adding manganese, which is preferably incorporated into the structure at the centre of the seven-atom layers. This improves the desired material properties. A specific feature of the research was the close interconnection of experimental and theoretical methods. Using quantum mechanical calculations, we have been able to describe the magnetic properties of this system. In the future, these calculations will allow for predicting other new materials.

It is also evident from the published articles that key collaboration has been established and developed with Professor Hubert Ebert (LMU, Munich), Professor Karol Hricovini (Uni Cergy-Pontoise), Professor Simon Mun (Gwangju Institute of Science and Technology), Professor Hugo Dil (EPFL Laussane) and Professor Christina Scheu (MPI Düsseldorf).

4 → ON DEPARTMENTS AND SECTIONS

MORPHOLOGY AND SURFACE TEXTURE OF MATERIALS (CT1)

2019 was the last year of working on the CENTEM+ project. Both publication and applied research results were being completed.
In August, the team, in cooperation with partners (ICT Prague, EnergyCloud a.s.), started to address the TACR project THÉTA (TK02030001): “Development of Advanced Flow-through Electrochemical Energy Storage”. UWB is the main researcher of this project focused on the development of electrical energy storage using high-capacity oxygen-based cathodes. Two groups of systems are being studied: metal-air and organics-air. Both technologies can be used as both stationary and mobile economical electric power storage. The project duration is 53 months.
During 2019, the team was invited to participate in the consortium for Project H2020 in the programme LC-BAT-4-2019: “Advanced Redox Flow Batteries for Stationary Energy Storage”. The project HIGREEW (“Affordable High-Performance Green Redox Flow Batteries”) was supported at its beginning in November 2019. The overall goal of the HIGREEW project is to design, develop and validate an advanced redox battery based on new, water-soluble, economical organic electrolytes compatible with an optimized membrane. This project is focused on research, development and optimization of flow batteries based on an aqueous solution of organic electrolytes with an optimized membrane with low resistance and fast electrode kinetics for high energy density and long life. The project duration is 40 months.

https://www.higreew-project.eu

HIGREEW

In cooperation with other research groups, the CT1 Department published a total of six (6) impact articles in 2019. Of these, three (3) publications were accepted by prestigious journals with impact factor 7+ (Journal of Membrane Science, Journal of Power Sources). The amount of contractual cooperation with companies in 2019 was 1.68 million CZK.
The Department also regularly participates in activities aimed at bringing scientific topics closer to the general public.

ENGINEERING OF SPECIAL MATERIALS (CT2)

In 2019, the researchers of the department dealt with tasks in the area *Fuel Cell Development and Testing* and in the area *Materials Chemistry and Biomaterials*. The research activity was focused on the assembly and testing of a fuel cell (FC) in the testing stand Greenlight G20.
Functionality was verified and regulation of flow, pressure, humidity and other parameters related to FC performance was dealt with (Fig. 9 a, b). In addition to assembling necessary hardware into a controllable circuit, the software was being developed simultaneously to control the circuit and allow users to enter the volume control. The fuel cell was debugged, and the system control was completed to remotely connect the FC to an FC user through a software application.
The group joined a consortium with Unipetrol, ČEZ, ÚJV Řež, and ICT Prague and submitted a project application in the TACR Théta Call on the topic: “Pilot Project of Production and Distribution of Hydrogen for Sustainable Mobility Using Renewable Electricity”. In the area of FC research, successful cooperation was established with Dr. Schechter (Ariel University, Israel). This cooperation is focused on joint measurements of performance characteristics of new polymer membranes, computational modelling of electrochemical states in an FC and on publishing. For the period 2020–2022, several professional internships of our staff are planned at this workplace.
The project MATEGRA (“Advanced Porous Biomaterials Functionalised with Stem Cells for Better Osseointegration of Implants”), which is being developed in collaboration with UKR Regensburg, is successfully underway. At this stage, various surface treatment parameters were investigated by laser texturing, followed by chemical surface activation and bioactive coating (Fig. 9 c). Cell activity was tested on the surface of textured titanium surfaces with a degree of purity of 1, 2, 5 and the preparation of porous silica-titanium glasses as suitable substrates for bioactive particles (Fig. 9 d, e). The research results will be published in scientific impact journals.
The materials chemistry group further developed the topic of preparation and characterization of nanocomposite hydrogels. The research was focused on the dimensional stability and temperature resistance of double-crosslinked hydrogels modified with bioactive semiconducting nanoparticles. Research activities were also focused on the preparation and description of porous carriers for photocatalytic nanoparticles and the study of their dimensional and thermal stability (Fig. 9 f). The group presented its results at a joint seminar with OTH Regensburg and participated in the successful defence of the project.

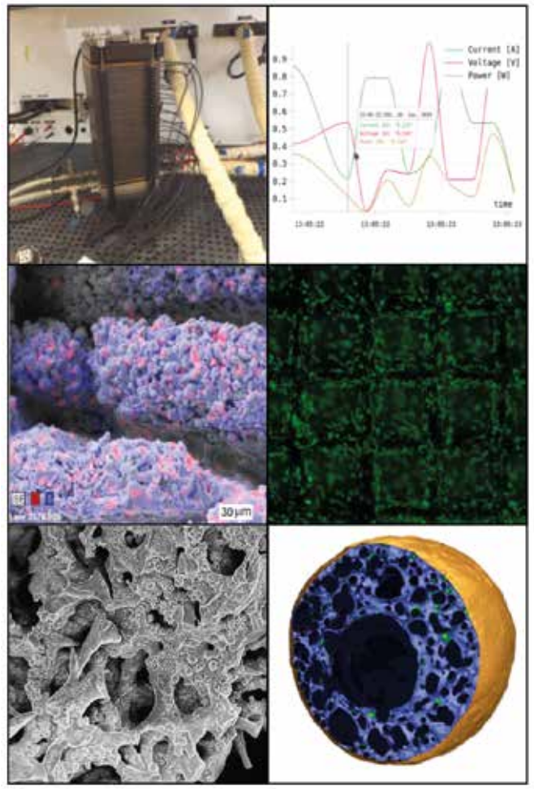


FIG 9 FC wiring and testing (a), Performance characteristics displayed through control software user interface (b), Laser-textured titanium surface - EDX mapping (c), Cell activity on the surface of textured titanium: Grade 2 (d), Porous silica-titanium filler prepared by sol-gel method (e), Floating carrier for photocatalytic nanoparticles with hierarchically-structured porosity (f).

4 → ON DEPARTMENTS AND SECTIONS

LASER AND INFRARED TECHNOLOGIES (CT3)

In 2019, the CT3 Department, with the support of the ITI project "LABIR-PAV – Pre-Application Research of Infrared Technology", focused on a new laboratory layout and instrument purchase. The acquisition of new infrastructure required thorough market research based on technical specifications and subsequent tenders. The purchase of new devices is the first step towards the project goals, which include implementation of new ideas, acquisition of international patents, application in the application sphere, commercialization and participation in international projects with a society-wide reach.

Many team members have achieved significant success. First, Ing. Jiří Martana, Ph.D., who successfully defended his Associate Professorship at the Faculty of Mechanical Engineering of the University of West Bohemia and lectured at the International Summer School of Trends and New Development in Laser Technology organized by the Technische Universität Dresden and the Fraunhofer IWS Institute. The topic presented and the results aroused a response and opened cooperation with several workplaces in the area of rapid temperature measurement in laser texturing of surfaces.

Significant international contacts were also established in 2019, among other things also due to the LabIR® brand under which paints for thermal imaging and thermal imaging software is being developed and distributed. LabIR® thermographic paints obtained an excellent Category 2 result according to the M17+ methodology. They enable accurate thermographic measurement and thus eliminate one of the obstacles to applying accurate thermographic measurement in many fields. Thanks to its uniqueness, the product has successfully established itself in foreign markets and is used in the areas of automotive, aviation and space applications, solar energy, electronics, construction, engineering and healthcare. Thermographic paints are ordered by universities, research organizations, companies or corporate development centres from around the world. Major customers include, e.g.: Fraunhoffer ISE, Max-Planck Institut, Onera, German Aerospace Centre (DLR), Dyson Ltd, HP, Cognatec, Valeo Siemens and others.

In addition to research and development activities, the CT3 Department is also involved in popularizing science. The Association of Technical Diagnosticians in the Czech Republic, z.s. (ATD CR, z.s.) awarded the research institute NTC a certificate as an approved training centre for Thermal Imaging Technician. The department will train and educate those interested in preparing for certification and re-certification in the field of thermography technical diagnostics; the department will offer independent and professional assistance to graduates and participation in joint research and development projects.

Thermography education kits for schools is a project that wants to take advantage of the IR cameras as a modern school tool that will improve and refresh the teaching of technical subjects and inspire both students and teachers. It should expand students' awareness of thermography measurement and its application. The aim is to inspire students to study modern technologies and technical fields. The CT3 Department has been dealing with thermography for twenty years and wants to pass on its experience to a new generation of researchers and industry employees. It participates in the project together with the UWB Faculty of Education, the Faculty of Education of the University of South Bohemia in České Budějovice and the UWB Division Lifelong Learning and Distance Learning. The project does not only include education using IR cameras. Students could visit NTC and learn more about thermal imaging technologies and the practical use of infrared technologies. The Department offers its facilities and consultations for the purposes of student projects; courses for teachers are also planned. The project has the ambition to facilitate access to the created aids for a wide range of schools and teachers and to extend its scope to other regions.

FIG 10 Thermography inspection of plastic welding.

ASOCIACE TECHNICKÝCH DIAGNOSTIKŮ
ČESKÉ REPUBLIKY, z.s.
VŠB - TU Ostrava, 17. listopadu 2172/15, 708 00 Ostrava - Poruba

Číslo : ATD-722-017/2019

vydává toto osvědčení na

schválené školící pracoviště

pro oblast

technik diagnostik termografie

organizaci

Západočeská univerzita v Plzni, NTC

Adresa : **Univerzitní 2732 / 8, 301 00 Plzeň**

IČO : **49777513**

Zastoupena : **doc. Ing. Milanem Honnerem, Ph.D.**

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V Ostravě dne : 25.09.2019

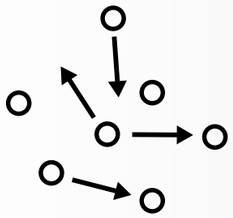
Ing. František Vdolečék, CSc.
prezident ATD ČR, z.s.

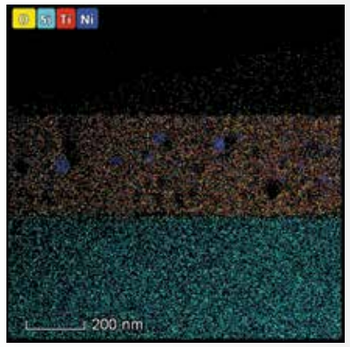
FIG 11 Certificate of approved training centre for Thermal Imaging Technician

FIG 12 The IR camera as a modern teaching aid.

MATERIALS AND TECHNOLOGIES (CT4)

In 2019, research in the field of silicon-based thin films focused primarily on the preparation of multi-dimensional photonic structures and the preparation of thin-film tandem silicon solar cells. In the area of photonics, proven technology for the preparation of a multidimensional photonic structure has been developed. In the area of thin-film silicon photovoltaics, research has continued to optimize the deposition parameters of silicon layers for single-transient and tandem solar cells prepared in a five-chamber apparatus. Furthermore, the technology for preparation of a multi-transient (tandem) silicon-based solar cell was created: the tandem solar cell showed an efficiency of over 11%, a no-load voltage (Voc) of 1.3 V, a short-circuit current (Jsc) of 12 mA/cm2 and an FF (fill factor) of 71 % (Fig. 13).
In the next step, processes were designed to improve the usability of transparent ZnO-based conductive layers and the possibility of greater replacement of layers containing rare and expensive Indium. In cooperation with the Department of Physics, an experiment was conducted to prepare transparent conductive layers by the HiPIMS (high-power impulse magnetron sputtering) method, which is of industrial interest, especially due to the high deposition rate. The first results have already been published and the layers have been used for further research of piezo generators in collaboration with the QMUL University workplace in London.
Subsequently, the development and optimization of the system of silicon multilayers and nanocrystals and the development of semiconducting amorphous oxides InGaZnO and ZnSnO (Fig. 14) continued under the ongoing bilateral cooperation agreement with the “Solid-State Electronics Laboratory, the Ångström Laboratory at Uppsala University”.
The study of perovskite materials based on SrTiO3 and the influence of nickel doping on physical properties of the layers prepared and their electron structure also continued, see Fig. 15.





Theoretical and experimental results were published at international conferences. The output was three (3) proven technologies, two (2) functional samples and eight (8) articles in prestigious impact journals. Research on the effect of structural defects on the electron structure and properties of zinc oxides continues, see Fig. 16.

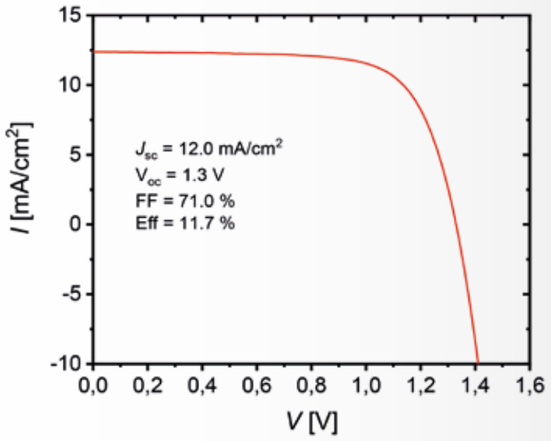
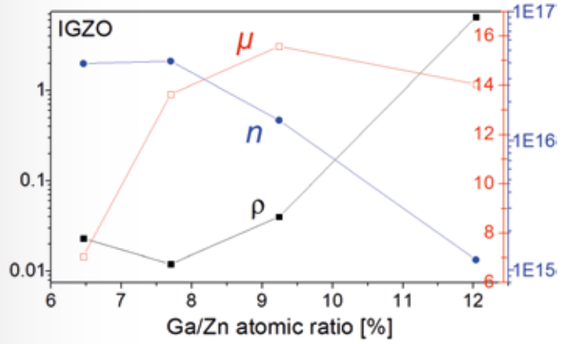


FIG 13 VA-characteristics of a tandem solar cell.



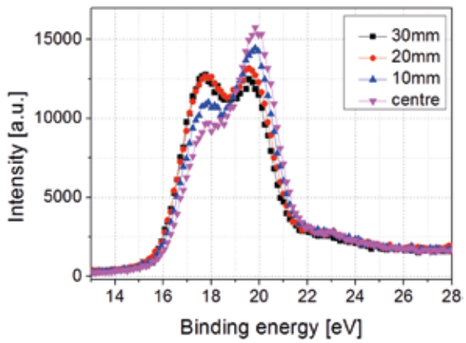
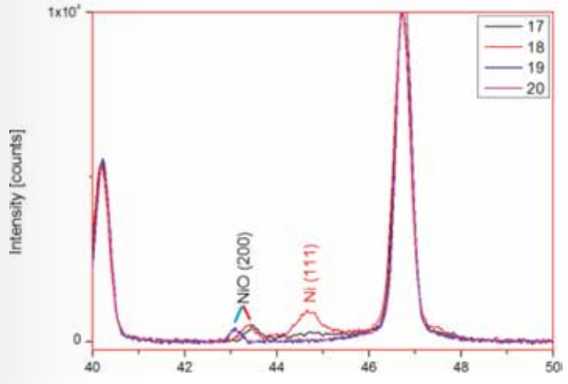


FIG 14



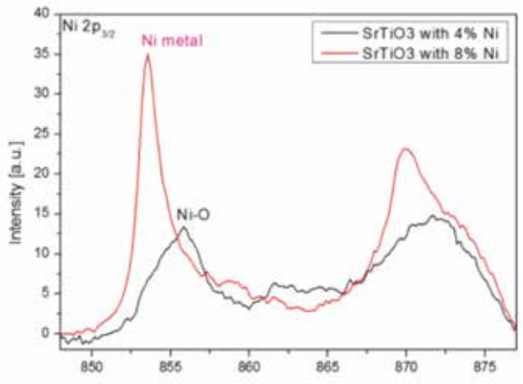
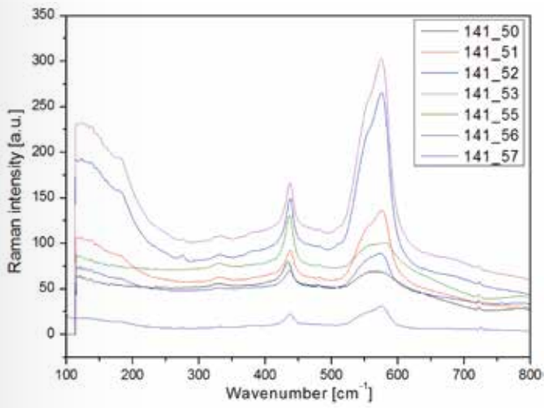


FIG 15



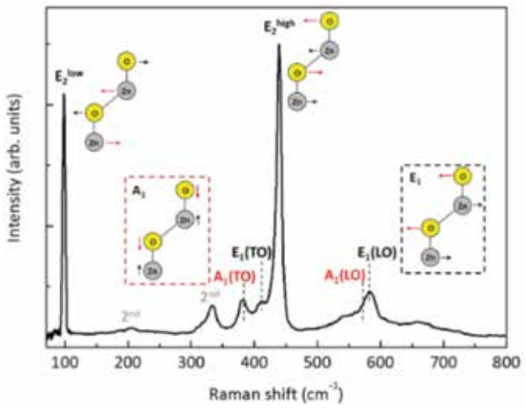


FIG 16

INTERNATIONAL COOPERATION, MAJOR AWARDS AND ACHIEVEMENTS

Within the framework of international cooperation and expansion of activities in the European and worldwide research sphere, Doc. Ing. Luděk Hynčík, Ph.D. was confirmed for his second term of office as Vice President for Education of the International Federation of Automotive Companies FISITA – *Féderation Internationale des Sociétés dÍngénieurs des Techniques de l'Automobile*. Dr. Hynčík was also appointed visiting professor at the Chinese *Tianjin University of Science and Technology* for the period 2019–2022. Ing. Jiří Martan, Ph.D. completed the Associate Professorship appointment procedure at the Faculty of Mechanical Engineering of UWB. Dr. Martan also represented the NTC Research Institute at the Summer School of Laser Technology organized by the *Technische Universität Dresden* and the institute *Fraunhofer IWS*. Ing. Michal Švantner, Ph.D. is a member of an international committee, an expert in the preparation of European standards within the working group European Committee for Standardization CEN/TC 138/WG 11 "*Infrared thermographic testing*". Mgr. Petr Kavalíř, Ph.D., MBA represents NTC in the expert team for innovation and technologies – The *Business and Industry Advisory Committee to the OECD*. The achievements of 2019 also included the award of the Ministry of Education for results in a doctoral study programme received by Ing. Jiří Vrána, Ph.D. from NTC, who graduated from the Institute of Chemical Technology in Prague. The scientist researched distributed electrochemical energy storage, within which he developed innovative solutions for vanadium flow batteries.

NTC has organized or participated in several international workshops, seminars and conferences. The seminar "**Advanced Porous Biomaterials Functionalized by Stem Cells to Improve Osseointegration of Implants (MATEGRA)**" was co-organized in cooperation with the University Clinic in Regensburg and brought together the topics of material engineering and biological testing of bone cell behaviour. The result of the Czech-Bavarian cooperation project was a workshop entitled "**Virtual Model of a Human for the Prevention, Treatment and Rehabilitation of Shoulder Diseases – Current Situation and Future Challenges**", where experts from NTC and OTH Regensburg presented their results. Two international conferences were organized within the project "Computational and Experimental Design

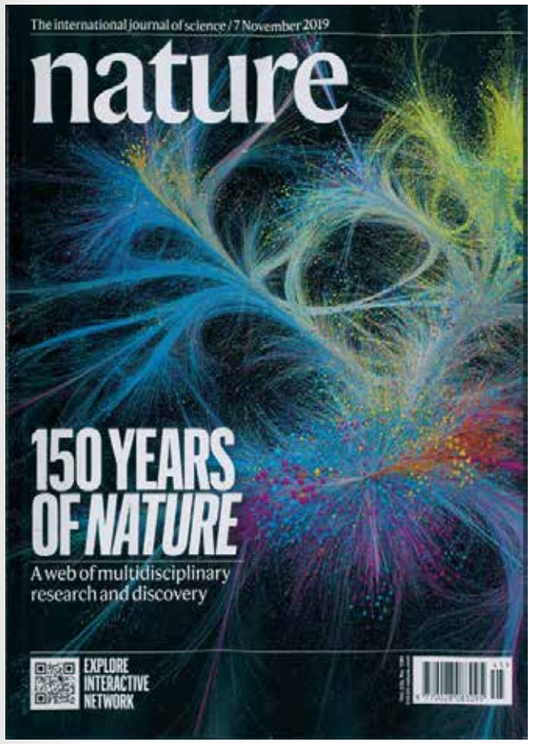


FIG 17 Cover page of the journal Nature, which published the article "Large magnetic gap at the Dirac point in Mn-induced Bi2Te3/MnBi2Te4 heterostructures".

of Advanced Materials with New Functionalities". The first "**CSPES 2019**" is part of the APCOM 2019 conference at Štrbské pleso in the High Tatras, Slovakia, aimed at photoemission with a focus on electron microscopy. Another co-organized conference was "**Theory Meets Experiment in Low-Dimensional Structures with Correlated Electrons**" held in Prague in cooperation with the Institute of Physics of AS CR in Prague. This conference was supported by the **Psi-k organization** with the amount of 5,600 EUR. The conferences aimed to strengthen the creation of international cooperation between researchers focused on theory and experimental measurement. Both events were attended by top scientists and researchers in the area of applied physics from all over Europe. NTC experts presented results of innovation in redox flow batteries at the prestigious conference "**The International Flow Battery Forum 2019**" in Lyon. In autumn, the Department of Engineering and Technologies of the Faculty of Natural Sciences of the Matej Bel University in Banská Bystrica organized the 35th International Scientific Conference "**Technické vzdelávanie ako súčasť všeobecného vzdelávania" (Technical Education as Part of General Education)**. Representatives of the NTC Research Centre presented the results of the first phase of the "**Thermography education kits for schools**" project. In October, the 2nd International Symposium on Transport Safety took place – "**Future Mobility Safety Science and Technology**". The symposium was attended by more than 70 participants from universities and industry representatives. In addition to the above-mentioned NTC international workshops, NTC was represented by Dr.Hynčík, who accepted an invitation to a debating evening of the Czech Liaison Office for Research, Development and Innovation called "**Science Café**" in Brussels.

An important achievement in 2019 was the opening of the **SARPES** laboratory, thanks to which NTC ranks among exceptional workplaces not only in the Czech Republic but also in Europe. Another success is that NTC was involved in the H2020 project consortium in the programme LC-BAT-4-2019: "**Advanced Redox Flow Batteries for Stationary Energy Storage**". The research team began working on the **HIGREEW** project (Affordable High-Performance Green Redox Flow Batteries) at the end of 2019.

A great matter was also the publication of the experimental work "**Large magnetic gap at the Dirac point in Mn-induced Bi2Te3/MnBi2Te4 heterostructures**". For New Technologies – Research Centre of UWB, this is the first publication in the prestigious journal Nature. NTC gained popularity in the media thanks to the scientific conclusions of Jan Špička and Martin Čermák, who e**xplained the circumstances of the death of former Czechoslovak Minister of Foreign Affairs Jan Masaryk**. The two men initiated the reopening of the investigation into the death.

EDUCATION AND POPULARIZATION OF SCIENCE

Although NTC does not have its students, it has long been involved in education and science popularization. In 2019, NTC employees guaranteed specialized courses in the framework of the Faculty (FAS, FEE and FME) study programmes, participated in teaching full-time and part-time courses, and supervised students participating in projects and preparing their bachelor, master and doctoral theses. This year, the Research Institute also accepted a few foreign students as part of their internships and tried to involve non-technical students through its interdisciplinary approach.

In support of elementary and secondary education, NTC sought opportunities to increase interest in technical studies. One such opportunity was to participate, together with Techmania in Pilsen, in the organization of the National Day of Biomechanics, which is part of a worldwide event. Biomechanics Day was attended by more than 200 elementary school pupils. Another interesting opportunity was the participation of NTC in Days of Science and Technology organized by the ASCR.

During the autumn holidays, NTC invited the Club of Gifted and Thoughtful People from Pilsen Techmania to its labs. The Club members could, among other things, see, thanks to the thermal camera, thermal radiation and technical possibilities of its perception, which would otherwise be impossible for the human eye. During the educational excursion, the public could see computer simulations of road accidents and see how strain gauge plates work.

The NTC CT3 team continued the implementation of the “Thermography education kits for schools” project, which broadens the students' awareness of thermographic measurement and its application. Training of employees of industrial companies in the area of Thermography and Technological Processes is also an important part of educational activities. NTC has been certified as an approved training centre in the area of thermography diagnostic techniques.

The most important financial sources of NTC were incomes from grant projects of basic and applied research from the providers: MEYS, the Ministry of Regional Development, GACR and TACR amounting 76,8 million CZK. Income from institutional funds was just over 43 million CZK.

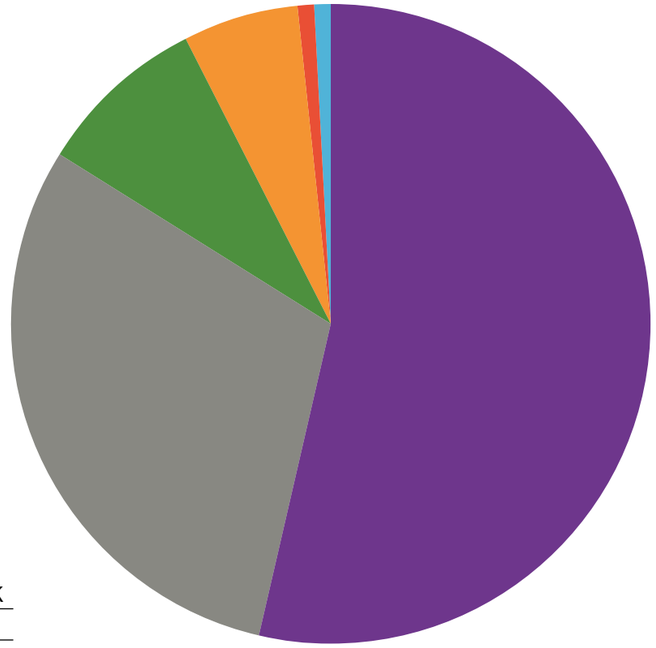
In 2019, NTC also received part of the Ministry of Education’s grant for creative and educational activities in the amount of 8.6 million CZK. In the area of contractual research and knowledge transfer, NTC managed to obtain contracts worth nearly 12.3 million CZK.

NTC received financial donations totalling almost 900,000 CZK.

The research institute NTC transferred 8 million CZK to the Investment Property Reproduction Fund and the Operating Fund increased by 7.7 million CZK during the year.

At the end of the year, more than 1.1 million CZK was transferred to the Targeted Support Fund.

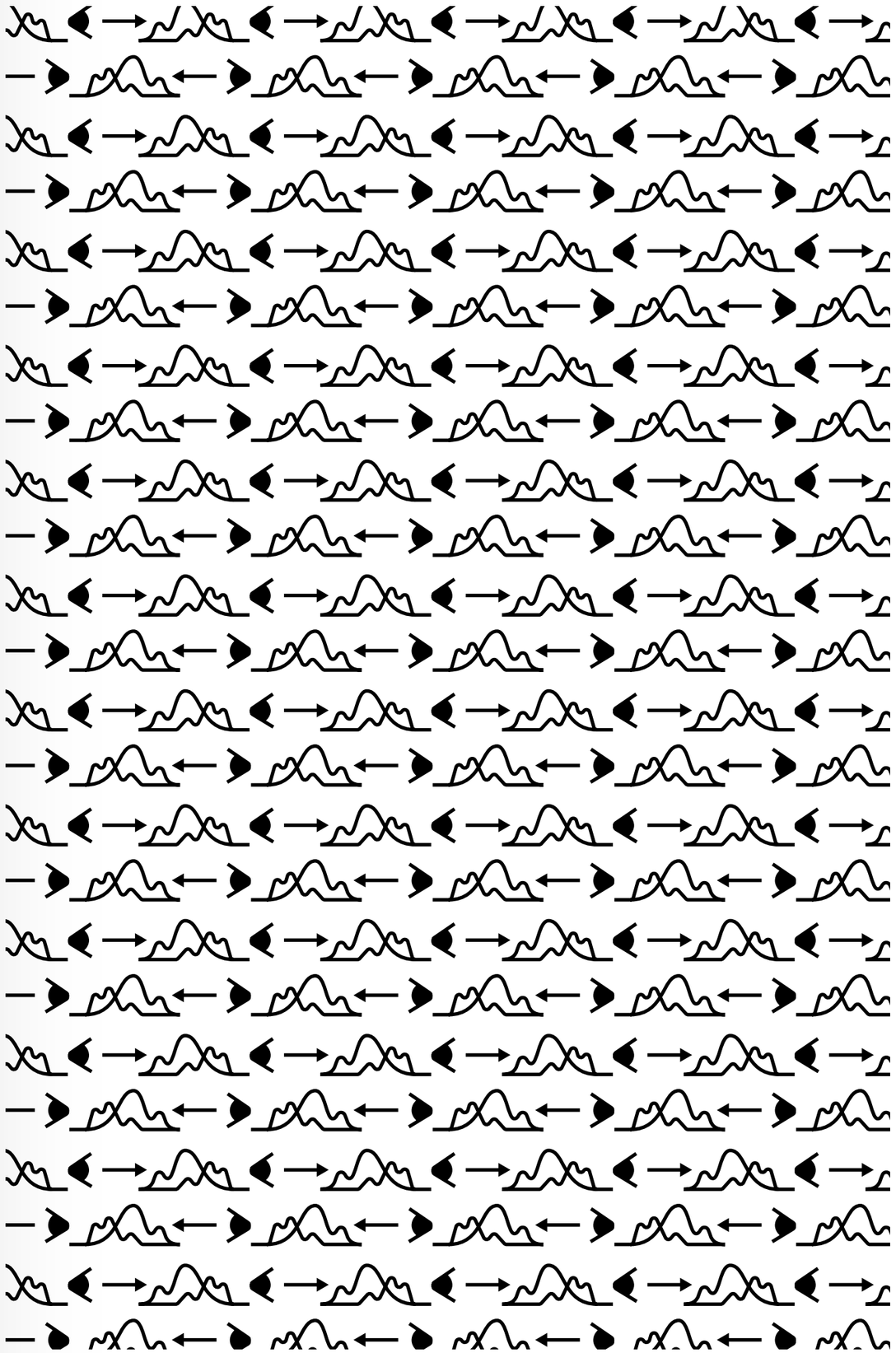
FIG 18 NTC budget in thousands CZK.



GRAPH OF INCOME	THOUSANDS CZK
Grant programs	76800
Institutional funds	43246
Contract research	12276
Creative and educational activities	8609
Targeted Support Fund	1120
Other income	887

7 → CONCLUSION

NTC teams successfully completed several projects and contracts in 2019. They will work on newly acquired projects and contracts as planned.
In 2020, it will be necessary to further strengthen the competitiveness of our teams because of the change in the evaluation of research organizations at the national level and the change in the Internal Methodology of Assessment of UWB Parts and the termination of the Centem+ project.
For this reason, NTC analyses and prepares for future research trends and seeks new partnerships and resources for its activities.
New multi-disciplinary research projects and new ways of commercializing existing NTC results (e.g. spin-offs, start-ups) are under preparation. To maintain the competitiveness of NTC, foreign experts must be involved in NTC research and, of course, cooperation with relevant international entities is essential. Finally, the HR Award project is intensively developing human resources. Employees increase their language skills and strengthen managerial and psychosocial skills. The changed structure of NTC should also contribute to the more efficient functioning of the organization.
As in previous years, meeting key monitoring indicators, raising funds to finance all projects and further developing NTC will be crucial in 2020.



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