Electron Technology – ELTE 2013

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ABSTRACT

The paper presents a digest of chosen research and technical work results shown by researchers from technical universities, governmental institutes and research firms during the XIth Scientific Conference on Electron Technology ELTE 2013. ELTE Conference has been held every three years since more than three decades. The ELTE 2013 conference was held in Ryn Castle (Poland) on 16-20 April 2013 and gathered around 270 scientists, theoreticians, technologists and engineers from such areas as material engineering, chemistry, sensors, integrated circuits, electronics engineering, laser industry, photonics, etc. The conference featured the following major four topical sessions – Micro and Nano, Photonics, Materials and Technologies, and Microsystems; two dedicated sessions – a keynote plenary session on hot topics in electron technology, as well as a session on large research projects and grants realized by the relevant community. Oral topical sessions were accompanied by poster sessions. The paper is a succinct topical introduction to the volume of ELTE 2013 proceedings. Over 100 papers, gathered in the volume, present a very relevant cross section and state-of-the-art of this branch of science and technology in Poland with involved international co-operation.

Keywords: electron technology, electronic materials, photonic materials, electronic components, integrated circuits, advanced electronic systems, optical fibers, optoelectronics, photonics, spectroscopy, electronic and photonic metrology, measurement methods, measurement systems, Moore's Law, More Moore, More than Moore, VLSI, MEMS, MOEMS, microsystems, photonic integrated circuits, QCL, quantum cascade lasers, nano-materials, graphene, FinFET, VeSFET, VeSTIC, 3D design of electronics,

1. INTRODUCTION

The first conference ELTE'1980 on Electron Technology was held in Wrocław and Karpacz on 24-27 September 1980. This first event has started a very successful series of materials engineering and technology meetings. Since then, eleven conferences have been organized, by the research and technical communities of electronic and photonic technologies, summarizing the developments every three years. Picturesque Ryn Castle of the Knights of Cross was a venue for the XI-th ELTE'2013 Conference. The conference has gathered around 270 researchers, engineers, physicists, chemists and technologists from a few tens of institutions across this country, including representatives from academia, industry, innovative businesses and government. Since a few last meetings, the ELTE conference features four topical sessions: Micro and Nano, Photonics, Materials and Technologies, and Microsystems. Each day of the conference starts traditionally with a common plenary session and is continued in sections with contributed papers presented orally and then is supplemented with topical poster sessions. The presentations by young researchers were subject to additional evaluation for ELTE'2013 Award and SPIE Award. Below, the authors of this paper and this volume editors, present only a number of arbitrarily chosen subjects moved during the plenary sessions and in key oral presentations, which were representative introduction to broader fields debated during the conference. The aim of the paper is to present to a reader a very concise, yet no full, but fast overview of the ELTE'2013.

2. HOT TOPICS AND TOPICAL TRACKS IN ELECTRON TECHNOLOGY

Two presentations, strictly combined and finely supplementing, under a common title – More Moore or More Than Moore? Both! opened the ELTE2013. They were presented by prof.A.Strójwąs of Carnegie Mellon University and prof.T.Skotnicki of STMicroelectronics France. Both papers looked into the nearest and more distant future of electronics integration. Clear tendencies are observed like: reduce cost, reduce power consumption, maximize volumes, design for performance and flexibility, continuous shrink in dimensions, 3D FinFET on SOI, below 10 nm dimensions, system on chip, heterogeneous integration and finally full 3D design. Due to elimination of channel doping, FinFET on SOI technology allows for reduction in VDDmin, increased VDDmax and significantly lower leakage and hence IDDQ.

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The Authors bravely acknowledged that "the very competitive markets of today are no longer satisfied with the Moore's Law alone. They still do require "Moore" and even "More Moore" but the biggest revolution starting today is thanks to "More then Moore". If "Moore" technologies can be associated with processing and storage of information, then "More than Moore" can be seen as technologies enabling exchange of information with the environment." The applications of More than Moore technologies are countless embracing intelligent environment – smart city, intelligent house, wireless sensor networks, and bio-electronics.

A presentation on Photonic Integrated Circuits – future technology? was delivered by dr R.Piramidowicz, with co-authors. Photonic Integrated Circuits, or PICs, consist of a number of passive and active optical and optoelectronic functional components, which are integrated together on a common substrate, and are connected by optical signal paths. In a sense, they are analogous to classical VLSI circuits, but their development is not yet as advanced. Now, the most advanced PICs are used for optical fiber trunk DWDM systems, and for PMEMS or MOEMS. The first ones contain tens of laser transmitters and photonic receivers, each working with a rate of over 10Gbps. The latter solution adds integrated photonics to enrich classical MEMS. One of the aims of the current PICs technologies is to standardize the design, manufacturing and testing methods to lower costs, increase the yield, and through these procedures make them much more applicable.

Today, no material research and technology conference can go without a session, or a keynote presentation, on graphene. Graphene in electronics – properties, technologies and applications was a presentation delivered by dr. W.STrupiński of ITME Warsaw. ITME runs a technological group specializing in manufacturing of graphene samples of high quality. The group manufactures and characterizes graphene and prepares the samples for pilot applications.

A presentation on nanometrology in microsystems and nanotechnologies was presented by prof.T.Gotszalk of Wrocław University of Technology. The author did a concise digest of current challenges, confinements and achievements in the nano metrology of functional microstructures and nanostructures. He illustrated the presentation with living examples of own work carried out at WrUT.

By means of MOEMS technology it is possible to miniaturize optical measurement apparatus. This was a subject of a presentation by a group of Authors, represented by prof.Ch.Gorecki of FEMTO-ST Institute of Besancon. Several micro devices were designed and manufactured in MOEMS technology, like: scanning confocal microscope, and low-coherence matrix interferometer. Technology of several micro-mechanical components were shown, like: micro-actuators, scanners, as well as micro-optical like glass micro-lenses. Micro-mechanical and micro-optical integration issues were debated.

Prof.A.Kisiel of WUT pictured a portrait of silicon as viewed differently from the perspective of applications as a detecting material of elementary particles in the LHC experiment in CERN. Silicon matrix and/or strip detectors are used as vertex detectors and trackers, allowing for reconstruction of transverse particle paths. They are subject to technical compromise by intense ionizing radiation, and, thus, radiation damage and untimely aging.

Evolution of MOS transistors was presented by prof. A.Jakubowski of WUT. Now, the most complicated constructions and architectures of integrated circuits are represented by SoC chips. The author presented a historical path for the discrete MOS transistor leading to such complicated systems. He emhasized awaiting difficulties with further miniaturization of the systems. New material and construction solutions in advanced integrated circuits allowed to keep the fast pace of development.

Functional nanomaterials are used in gas sensing and in renewable energy sources (based on hydrogen modules). A presentation on various nanomaterials based on TiO_2 was delivered by prof.K.Zakrzewska of AGH University. The usable design parameters for new functional nano-materials are relations between electron structure and micro-structure, manufacturing method, as well as physical and chemical properties.

3. MICROELECTRONICS AND NANOELECTRONICS

The field of microelectronics and nanoelectronics is still intensely developing, against the fears to approach to the technological boundaries, and reach soon the technical saturation. An innovative idea was presented for Vertical Slit

Field Effect Transistor, or VeSFET, proposed by prof.W.Mały of Carnegie Mellon University. This construction is expected, what has been confirmed experimentally in test components, to be very energy efficient, and to open new technical possibilities to overcome many barriers in technology scalability. VeSTICs are integrated circuits based on this innovative transistor. The characteristics of drain current on material and construction parameters of VeSFET, which are different from classical FET transistors, promise large integration scalability. Diminishing the diameter of a single transistor is, fortunately, not accompanied by lowering of critical thickness of the oxide layer in the gate.

The development of CMOS technology went till now along the path of lowering the transistor dimensions. Lowering dimensions has still some potential, below 10 nm, but keeping the pace of development is also due to a few additional factors. High-k transistors with metal gate defined a new standard around 2007. The newest generation of MOS transistors are FinFETs of characteristic dimension as low as 22nm. The current forecasts by ITRS (International Technology Roadmap for Semiconductors) concerning the well-being of silicon technologies today reach 2026. This date, however, is expected to be shifted further into the future. The research work on high level of integration of MOS circuits is carried out at IMiO PW.

High power semiconductor components have their own specificity, and go along different development paths. A fundamental requirement is high voltage resistance and low leakage current, when polarized reversibly, as well as low voltage drop when polarized for the conduction state. A common feature of these components is broad N^- basis whcich is responsible for voltage resistance. The IGBT punch-through transistors are subject to analysis. Application a buffering N^+ layer allows in these components for the increase of the breakdown voltage, only when the resistance in the conduction direction does not increase. These components are modeled at Łódź University of Technology, in a team of prof.A.Napieralski.

The photovoltaic industry is an extremely strong driver, and standards setter of technology development in the area of thin-film electronics nanostructures. The prevailing nanostructures applied now are lithographic single layer, which are far from optimal. They are especially impractical in large area applications and local 3D ones. An alternative fabrication method is large-area thin-film technology. The new thin-film technologies apply self-created and self-organized nano-structural modified materials and make use effectively of size-confined quantum effects. These materials are used for transparent electrodes in PVCs, MOSFETS with floating gate - FGMOS for FLASH memories, and TFT transistors in LCD matrices. These technologies are expected to be compatible with industrial CMOS processes. The work on thin-film nanostructures. Mainly for PV applications, are carried out at IMiO PW.

One of the directions in the CMOS technology development, trying to avoid the size confinement, are multi-gate transistors. Generally, the MOS devices work better: at a bigger charge density at the same gate current; improved charge transport conditions by increased charge mobility, charge velocity, saturation velocity or via ballistic transport; and with shorter channels; reduced parasitic capacity and resistance. Some of these issued are solved by multi-gate architecture of transistors fabricated by SOI technology. The gate acts, in a multi-gate transistor, from several sides on the active region, as opposed to a single side action in classical structures. FinFETs have two gates, while the surrounding gate transistors GAA have circular gate. The gate control on the channel area is better in multi-gate structures. Short channel effects are weaker and active region may not be doped – eliminating harmful fluctuation of dopant concentration effects. Research is carried on junctionless transistors, what leads to miniaturization of the structures even up to 5nm. New effects in these structures are modeled in IMiO PW.

4. PHOTONICS

Quantum Cascade Lasers, or QCL are ideal source for molecular spectroscopy. They are developed at the Institute of Electron Technology – ITE Warsaw, in a team lead by prof.M.Bugajski. The team provides ready packaged laser chips for application devices, for example for molecular and gas spectrometry at the level of ppb. Such sensor systems with gas trapped in a cavity and multiple optical path are tested at Military University of Technology, WAT Warsaw. Photon energies of concern in QCL are in the 10 – 300 meV region. Leading to generation of THz waves, or MIR and FIR. ITE manufactures QCLs from AlGaAs/GaAs with several quantum wells. Optical power in the pulse reaches from 6W to 13W. Beam divergence FWHM is around 13^o. Generated wavelength is 885nm. Aging measurements were done up to 3kH. Different aging effects were observed depending on the induced stresses in the laser structures.

Mounting and thermal stresses have a considerable impact on the defects revealed during aging tests in laser diodes for 808 and 880nm. A research work on laser diodes technology is carried out in the technological center ITME Warsaw, in a team directed by prof. A.Maląg. A continuous degradation in laser diodes with large initial embedded mounting stress is caused by defect increase at the back mirror. Low mounting stress diodes have different degradation mechanisms, and the characteristics may shift thermally in different direction as compared with large stress chips. The defects are mainly caused by inhomogeneous distribution of temperature along the active region in the chip. The mounting stresses may be minimized nd thus their influence is made negligible. Resonator lengths in the measured laser dodes were from 1 to 3 mm. They were mounted directly on Cu and/or CuC radiators.

A key component of hybrid pixel detectors are multichannel integrated circuits for massive parallel readout. The used fabrication technologies are 3D and nanometric. The detectors consists of a combination of semiconductor pixel detector made of Si, GaAs or CZT and a multichannel ASIC. The detectors count photons in the energy range of keV. These detectors are very attractive, in many applications like medicine, material research and safety, against the integration type detectors, due to bigger dynamic range, better optical contrast, and a possibility to differentiate, with high resolution, the photons of different energies. Each pixel in these circuits has its own, fast, nondependent readout channel. Pixel dimensions are $100x100\mu m^2$. Power consumption is several tens of µW, and noises are below 100 electrons rms. Work frequency is up to several MHz. Each pixel counts independently their own photons. High pixel density forces 3D solutions. 3D architecture provides better functionality and electronics parameters, but also allows for implementation of intelligent algorithms increasing the quality of detected images. The work is done at AGH in a team lead by prof.P.Gryboś.

ITE Warsaw specializes in manufacturing of high quality silicon detectors for charged particles. These detectors in large series are manufactured for high energy physics, particle detectors, accelerator laboratories ion and nuclear physics. Mainly for GSI Research Center in Darmstadt. The research is carried out on them to optimize their performance, lower costs, increase yield and reliability. The work is directed in a team run by dr M.Węgrzecki. There are constructed epiplanar detectors of the following kinds: 64 element chromatographic matrices for COMPACT detection system (Cryo On-line Multidetector for Physics and Chemistry of Transactinides – Hs, Cn, Fl, and 119, 120 elements); two-element detectors for COLD system (Cryo On;line Detector) used in PSI institute in WIllingen; detectors for dose meter of radon used in IfS/HZM institute, and neutron sensors for dose meters also researched in this institute.

Photonic sensors and measurement systems are used increasingly frequently in biological, veterinary and medical applications. A team from IMiO WUT, in cooperation with a veterinary team from Life Sciences University in Warsaw, applied disposable sub-miniature optical fiber capillaries to detect early mastitis changes in cows. The probes of milk and whey were processed in minute quantities by means of optical transmission and fluorescent spectroscopy. The mastitis was detected using subtle phase transition in the sample fluids. The dynamic range of measurements using photonic capillary is much bigger than un the classical methods.

Optical coherent tomography (OCT) is a method of 2D and 3D imaging of internal structures of semi-transparent objects, with analysis of optical radiation dissipated in backward direction. The radiation is analyzed in a low-coherence interferometer. OCT is characterized by big longitudinal and transverse resolutions, of the order of single µm. This is a noninvasive, non contact and not harmful method. It is used particularly frequently in ophthalmology. At Technical University in Gdańsk, a team lead by prof.B.Kosmowski i applying OCT for scanning industrial objects. for the purpose of defectoscopy or defect detection. Also PS-OCT techniques are used (Polarization Sensitive OCT). There are investigated corrosion processes with this method. In pharmaceutical industry, OCT measures the quality and continuity of pills cladding. The research goes into the direction of searching new applications but also signal processing algorithms, an system optimization for industrial applications.

5. MICROSYSTEMS

Micro-chips are used frequently for fluoro-metric detection of chemical signals. Most frequently, a single parametric detection is realized. i.e. for a single wavelength, excitation and detection for a single fluoro-chrome and single measurement chamber. Multi-parameter detection, what is required for example in analysis of food pathogens, requires the usage of a few independent measurement channels with several fluoro-chromes, in a single sample. Miniature laser modules were used for construction of a multi-parameter fluorimetric measurement system. CCD imager, and image analysis was used for the detection of the system response. There were measured 9 and 37 parameters in the full version of the system. The development work on multiparameter chip-based fluorimetry is done at the WrUT in Wrocław, in a tem lead by prof.J.Dziuban.

The signal converters in bio-chemical sensors are frequently made of AlGaN/GaN heterostructures. Generally, there is observed a big interest in application of nitrides from the third group of periodic table in bio-chemical sensors. Such a sensor has two basic components: a converter and a receptor. The receptor is subject to specific physical and/or chemical reactions, which cause, in turn, changes in the properties of the converter. Chemical information is changed to electrical, optical, acoustic, etc. Semiconductor sensors use field effects, like in MISFET. MOSFET, MESFET and HEMT transistors. A metallic gate in these transistors is replaced by a receptor, like in ISFETs. In some sensor solutions, the issue to be solved is the bio-non-compatibility of the gate surfaces, especially in HEMT transistors. Some of these surfaces are bio-toxic. The work on ISFET and HEMT based bio-chemical sensors is conducted at Wrocław University of Technology, in a team run by prof.M.Tłaczała and prof.R.Paszkiewicz.

A semiautomatic, micro-fluidic 3D micro-system, imitating the physiology of a tumor in-vivo was constructed at the Faculty of Chemistry WUT, in a team lead by prof.Z.Brzózka. Spheroids of human cells ore grown and analyzed in the microfluidic 3D system. The system is made of bio-compatible PDMSX. This elastomeric material of hydrophobic surface is permeable for gases. 3D tissue models are much closer to the reality, than single cell layers used in classical HTS (high throughput) screening methods. That is why spheroids are used, which are ball like aggregates of adherent cells. These cells show many common features with some tumors. The micro-system architecture was designed flexibly enough to allow cell growing, interaction with drugs and tissue healing.

A microchip was designed, at the Faculty of Chemistry WUT, for detection or rare genetic diseases. The aim is a research on lysosomal storage disorders LSDs. A deficit of activities is observed for some enzymes. Early diagnosis is important for the efficieny of patient's therapy. The most efficient diagnosis method is genetic investigation. One of the complications is a large number of genetic mutation coding the observed enzyme. There are searched alternative methods, cheeper, more time, space and cost effective. Analytic microsystems are considered to be the optimal solutions. In such a system the activity of an observed enzyme is done in flow conditions, by microphoresis. The microsystem which can measure samples on-line uses optical fibers for illumination and optical signal detection.

The applications of microsystems are increasingly wide. Microsystems are used for concentration of gases in gas detection systems at ppb level and below. Standardized gas concentration, reaching several orders of magnitude, increases considerably the sensitivity of gas traces systems. The work is done at WAT. One of the most efficient methods of manufacturing of microsystems is ink-jet printing. Tiny RFID antennas for HF and UHF bands are done, using jet-printing, at ISE WUT. Micro-mechanical beams are used in micro sensing systems for chemical and biomedical applications. A cooperative team from WrUT, ITE and Institute of Immunology and Experimental Therapy of PAS designed, manufactured and is testing a sensing system containing a matrix of 8 micro-beams. The system measures concentration of substances in liquid and gaseous environments. The beam position detectors are sensitive to nanometric shifts and picograms of weight. Micromechanical measurements are combined with electrochemical methods and impedance spectroscopy.

6. ELECTRONIC AND PHOTONIC MATERIALS AND TECHNOLOGIES

Embedded passive components in LTCC (low temperature co-fired ceramics) and in PCB (printed circuit boards) are researched in Wrocław Uni. Technology. Such components are manufactured and characterized at Faculty of Electronics, Microsystems and Photonics. Their stabilities are observed in long and short term periods. The observed long term stabilities of embedded passive components are surprisingly better than for comparable surface components. Classical and new applications of embedded components are reviewed and researched taking into account their advantages and confinements. Embedded passive components enable manufacturing of new generation of hybrid integrated electronic systems of high reliability.

ALD and hydrothermal technologies of oxide nanostructures are researched by a team of physicists at the Institute of PAS in Warsaw. The ALD – atomic layer deposition method was applied for the first time over 40 years ago to manufacture electroluminescent displays using such materials as ZnS, SrS, and CaS. This method was then applied for manufacturing of integrated circuits. ALD is used for deposition of thin insulating films under the gates in FET transistors. ALD enables deposition of conformal layers at complex surfaces. ALD is also a technology of choice for manufacturing various nanostructures in electronic like 3D structures and core-shell structures. Both of these methods ALD and HT are also used for manufacturing of nanofibers, nanopoles and nanopowders. High quality nanopoles of ZnO were manufactured of high uniformity and repeatability. Combination of both technologies leads to manufacturing of complex heterostructures for sensing and photovoltaic applications.

Pastes and inks for printed electronics are increasingly frequently used with the development and applications of fine and extremely accurate printing technologies in manufacturing procedures. The key components there are pastes and inks. These substances are conductive, dielectric, resistive, semiconducting, etc. The parameters of the inks are: electrical - like surface resistance, thermal - like thermal coefficient of surface resistance, dielectric constant. Different inks and pastes are used for various printing technologies – like jet printing, flexography, graviure, offset printing, screen printing, roll-to-roll printing, etc. Rich inks of tailored electronic properties got available with the availability of nanomaterials and conducting polymers. The pastes and inks can have a form of suspension or solution, depending on the application need. Many conducting polymers and metaloorganic components create solutions of small viscosity, which is an advantage in jet printing. Conversely, nanometals and nanoforms of carbon (C nanotubes, nanopetals of graphene) create suspensions. Some of these suspensions are subject to fast sedimentation, thus, making it difficult to manufacture effective inks. The technological work on pastes and inks for printed electronics technologies are carried out at ITME Warsaw and Faculty of Mechatronics WUT.

Applications of wide-band semiconductors and components is increasing in such fields like telecom, vehicle electronics and renewable energy sources. Power components of such materials like SiC and GaN replace Si ones. The major advantage is the increase of efficiency, and ability to work in adverse environments, like elevated temperature. Other advantages are lower energy consumption combined with increased efficiency, no need for active cooling, lower dimensions and mass of components, lower level of noise (when applied in cars), lover level of electromagnetic interferences. High voltage components may require GaN/SiC heterostructures in future applications. The work on SiO_2/SiC interfaces, GaN and SiC materials as well as high power components made of these materials are carried out at ITME and IMiO Warsaw.

High temperature SiC components require special wiring technology withstanding the adverse working conditions. They may work long term with the junction temperature over 500^oC. At such temperatures any classical wiring and bonding techniques inside the package are irrelevant. Mounting of SiC components inside a metal package requires an additional ceramic insulation. Thus, the thermal resistance is increased. One of the solutions is application of an all ceramic package. Ceramic background substrate is directly attached to the radiator. The inside wiring is done by wire bonding or by flip-chip. There is used DBC- direct bond copper technology with the ceramic core. The core is made of Al_2O_3 or AlN materials. The DBC substrates are available with 200 μm thick layer of Cu deposited from both sides. The Cu layer is additionally covered with thin layers of Ag. The works on high temperature resistant package constructions of SiC power components are carried out at IMiO and ITE in Warsaw.

A number of new and complex measurement methods in material technology has been used recently, including for example the scanning thermal microscopy. This method is developed at ITE Warsaw and WEMiF Wrocław University of Technology. Estimation of nanostrutures requires new metrological methods. Scanning thermal microscopy STM is a developed version of the AFM. It enables imaging of temperature distribution and thermal conductivity on the probe surface. The spatial resolution is better than 50 nm. The local damages of nanostructures may be localized. This method images efficiently micro through-silicon vias or TSVs, increased conductivity thermal micropaths, islands of low-k materials, etc. The STM with four contact thermoresistive probes was integrated with ATM using optical micro cantilever. The measurement system of high resolution features also precision voltage controlled current source, resistance meter, PID regulator to control the temperature of the nano-needle, and analog power and resistance meter for the probe.

Functional devices from epitaxial graphene are considered to be of great interest for future applications. Graphene layers ate manufactured at ITME Warsaw by a patented method which differs from standard method of pyrolitic dissociation of the surface of SiC. The technology relies on epitaxial growth on a smooth side of 4H-SiC monocrystal substrate of (0001) crystalic orientation. The graphene grown on SIC is not ideally flat and their parameters are worse than in the case of exfoliated graphene. The aim of research is to better the technology in order to obtain good quality graphene surfaces.

7. CEZAMAT

CEZAMAT is a large EU infrastructural project to build a research complex at Warsaw University of Technology for interdisciplinary investigations of new materials and technologies. The Center is expected to be equipped in advanced technological lines and platforms for design, simulation, diagnostics and characterization. CEZAMAT is a user laboratory, open not only for the participating institutions abut also for external users receiving technological grants to work with unique apparatus sets and technological lines. The participants of CEZAMAT are: Warsaw University of Technology (WUT), Institute of Physical Chemistry of Polish Academy of Sciences (IChF-PAS), Institute of Physics PAS (IF-PAS), Institute of High Pressures (IWC-PAN), Institute of Fundamental Technical Research of PAS (IPPT-PAN), Institute of Electronic Materials Technology in Warsaw (ITME), Warsaw University (UW) and Military University of Technology (WAT). The core laboratories of CEZAMAT are: Central Laboratory comprising of five equipment platforms: Platform for Modeling and Simulation; Technological Platform for structures, components and circuits; Material Technology and Manufacturing Platform; Diagnostics and Characterization Platform for materials, structures, components and circuits; and Biotechnology Platform. A number of associated laboratories are predicted, to be operated by the Institute of High Pressures of PAS (IWC-PAN), Institute of Experimental Physics of UW (IFD-UW), WAT and ITME.

The central research laboratory is the greatest CEZAMAT investment which will be completed in 2015. A complex of laboratories will be equipped with state-of-the-art technological and measurement devices and will provide rooms with optimum technical conditions to conduct high-technology research. Dependant on need, the laboratories will offer rooms with different classes of cleanliness, high resistance to vibrations or electromagnetic radiation. Clean-rooms will not only be characterized by a high class of air purity (10, 100 or 1000 according to US FED STD 209E norm), but will also be equipped with the necessary utilities (ultrapure gases, also liquid ones, deionised water etc.).

8. LOOK EVEN CLOSER – NANO/MICRO/OPTO LABS/WARSAW

The Nano/Micro/Oopto Labs infrastructural project, oriented on Photonics Technologies, has recently been realized at WUT jointly by two institutes – IMiO and ISE. Several combined photonics laboratories were modernized or organized, and equipped. Laboratory of Fiber-Optic Photonics is active in: characterization and design of new solutions for active and passive elements of the physical layer of fiber-optic communication systems; research and measurements of classic and specialty optical fibers (including microstructured optical fibers); characterization of active fiber optic components - amplifiers and coherent light sources; characterization of passive and active integrated optics elements for applications in telecommunication systems and sensing networks.

The laboratory of Microelectronic Integrated Circuit Design and Application deals with: designing of integrated circuits and systems for the high-tech nanoelectronics; development of methods of designing a new generation of integrated circuits; development of CAD software for integrated circuits design; research and testing of prototype integrated circuits and systems; characterization and testing of unpackaged ("on chip") and packaged circuits.

Laboratory of Microwave Photonics specializes in: development of microwave photonics techniques; characterization of electronic and optoelectronic components and systems in the microwave domain; modeling and characterization of properties of linear and nonlinear components and systems of microwave photonics; design and analysis of microwave and optical links for data transmission in measurement and control systems.

Laboratory of Microelectronic and Nanoelectronics Devices does research in: the area of advanced semiconductor devices technology; technology of dry chlorine plasma etching and fabrication of ultra-thin composite and metallic layers; non-standard quantum structures, silicon photonics and MEMS/MOEMS structures; complex diagnostics of micro and nano-electronic circuits, quantum devices and MEMS/MOEMS systems.

Laboratory of 2D/3D Vision Systems specializes in: testing of prototype vision systems and advanced research in the field of methods and algorithms of acquisition, processing and analysis of time-variable image data in 2D & 3D regime; analysis of spectral properties of image processors and scene acquisition materials; research of vision systems quality (expertise analysis and optimization of existing solutions); elaboration of new technologies for acquisition, processing and displaying of 3D images; development of methods for processing and analysis of image for application in vision monitoring and security systems.

Laboratory of Microsystems Technology specializes in: designing, construction, technology and characterization of hybrid electronic and optoelectronic next generation Microsystems; fabrication and characterization of MEMS and MOEMS structures with state-of-the-art technologies and materials; fabrication of next generation optoelectronic and sensor components for applications in hybrid Microsystems; prototyping and fabrication of short series of novelty, thick film microelectronic and optoelectronic microsystems with the use of state-of-the-art technologies.

Laboratory in Digital Signal Processing is researching: application of radio, television, UMTS, GSM and GPS signals in passive localization of objects; digital compression of radar signals; radar imaging at high resolution of the terrain and marine objects from mobile platforms (e.g. airplane, UAV, satellite); application of continuous waves with different types of modulation (e.g. FMCW radars, noise radars) for low-probability-of-intercept radar; research on propagation properties of electromagnetic waves in multipath environment; development of new techniques of software and hardware real-time signal processing.

Laboratory of Internet-based Measurement Systems is doing research in: design and development of advanced hardware and software, including applications in industrial conditions; dedicated fiber networks for telemetry, specialized access networks, sensor networks and hybrid optoelectronic telemetric networks; design, development, testing and implementation of fast dedicated data processors and devices for processing of measurement data in telemetric networks; modeling and optimization of measurement systems.

9. FOTEH – PHOTONICS AND TERAHERTZ TECHNOLOGIES

FOTEH is a project of development of photonics and terahertz technology Research Center of the Faculty of Electronics and IT of WUT. It encompasses modernizing of infrastructure at thirteen laboratories – forming the Foteh Research Centre. The modernizing process shall enable advanced research work in the area of photonics and terahertz technologies, which require use of the latest in state-of-the-art of measurement and technological apparatus. The main result of the project is a considerable increase of research potential at Warsaw University of Technology, which would be involved in realization of scientific, as well as research and development projects, conducted in cooperation with business partners, and allowing for an enhancement of knowledge transfer from academia to industry. The project budget includes investment tasks worth in total 9 mln EUR, of which over 80% has been assigned to purchases of more than 400 high-end devices. Project is co-financed by the European Union from the European Regional Development Fund in scope of Operational Programme Innovative Economy.

Instrumental and Integrated Optics Laboratory covers: an assembly of complementary technological and measurement laboratories, specializing in fabrication and measurements of selected fibre-optic omponents, equipped with apparatus for inscription and characterization of periodic structures in optical fibres and fibre elements, as well as apparatus for photo-acoustic elements characterization and unique set-ups for designing and characterization of photonic integrated circuits (PICs).

Laser Spectroscopy of Photonic Materials covers: versatile optical characterization of new optically active materials for applications in new generation of photonic systems; research works conducted in the lab are often initiative to further studies done at Instrumental Photonics and Integrated Photonics Laboratory.

Image Photonics Laboratory covers: acquisition, processing and visualization of 3D image sequences; main areas of research include development of new technologies of image data analyser, acquisition systems operating in wide spectral range (from 300 nm to 1 mm), and three dimensional (3D) imaging solutions for non-destructive testing applications in THz range.

GHz an d THz Materials Research Laboratory covers: characterization of material properties in the millimetre and submillimetre wavelength range; acquired apparatus, equipped with unique, in-house designed and fabricated measurement heads, enables stoichiometric characterization of materials for identification of the relationship between internal structure of the material and its measurable parameters.

Design and Prototyping of Information Processing Circuits in Programmable Structures Laboratory concerns: providing support in research tasks of the Instrumental Photonics and Integrated Photonics Laboratory, through research work concentrated on photonics applications of large computing power digital circuits.

Biometrics and Machine Learning Laboratory covers: devices and systems for biometric verification of identity, with specific focus on security issues utilizing authored methods of identity recognition and biometric data authenticity testing, techniques of machine learning.

Photonic Telecommunication Network Test-bed Laboratory does research on new opto-telecommunication technologies - high-throughput and high-capacity transmission systems, reconfigurable optical networks, access networks and in-house systems.

Image Data Analysis and Data Visualization provides: support for analysis of information obtained in photonics research; providing access to environments adequate to conducting research work in automated methods for image data processing and recognition of objects.

IT Support for Photonics Research Laboratory provides: analytical and IT tools streamlining photonics research; the laboratory consists of two work areas: one focused on software coding, and one for data mining.

Photonic Measurement and Control Systems Laboratory provides: integration of photonic technology with reconfigurable, fast and multi-channel measurement and control systems with terabit throughputs; research in photonic technology and integration of data transmission in photonic systems with FPGA technology and PCB technology.

Terahertz Techniques Laboratory covers: design, prototyping and measurements of high-frequency circuits and systems covering 10 MHz to 0,5 THz band, with the use of highly stable signal sources, receivers, analyzers and multi-channel non-linear network analyzer.

Antenna Laboratory does research on spatial distributions of the electromagnetic field in the millimetre-wave and sub-terahertz range to develop and study of antennas, characterize parameter of materials and designing of the communication, imaging and radar systems.

10. GENERIC INTEGRATION TECHNOLOGIES FOR PHOTONICS - PARADIGM

PARADIGM is a large research project realized by IMiO WUT (Institute of Microelectronics and Optoelectronics, Warsaw University of Technology). It stands for Photonic Advanced Research And Development for Integrated Generic Manufacturing. The aim is to create the Eastern Europe Design Hub in Photonics Integration technologies. The research backbone of the project are ASPICs – Application Specific Photonic Integrated Circuits. The photonics research design hub is aimed to offer and provide three fundamental research functionalities:

- state-of-the-art expertise and support in designing , development and characterization of ASPICs,
- access to the cutting edge photonics technologies,
- unique opportunity of preparing and delivering prototypes of ASPICs to Polish and Eastern Europe companies, enterprises, research institutions and universities.

More information on the PARADIGM project is available on the web page of the IMiO WUT Institute.

11. ELTE'2013 AND SPIE AWADS FOR THE BEST YOUNG RESEARCHER AND STUDENT PAPER PRESENTATION

The Scientific Committee of the Conference has chosen a number of the best student and young researcher presentations for the Awards of ELTE'2013 and Awards funded by SPIE. SPIE provided the winners with monetary award, complimentary annual membership and free subscription to 50 paper downloads. The winners and their presentations were, in these two award categories, as follows:

ELTE'2013 Scientific Committee Young Scientist Awards:

- In Photonics: Krzysztof Anders (IMiO WUT), Conversion of excitation in low phonon energy glasses doped with Er^{3+} ions at excitation with pressure-tuned laser diodes
- In Materials: Jakub Kaczmarski ITE Warsaw), Amorphous In-Ga-Zn-O thin-films for applications in transparent electronics
- In Microsystems: Tomasz Grzebyk PWr Wrocław), A conception of MEMS mikrosystem integration with a miniature vacuum pump
- In Microelectronics and Nanoelectronics: Marcin Myśliwiec (ITE Warsaw), Mounting conditions of SiC diodes using silver technology

SPIE Best Presentation Award for Students:

- Anna Jusza (IMiO WUT), Composite polymer materials for active optical fibers of next generation (Photonics - poster presentation) – first prize
- Karina Kwapiszewska (Faculty of Chemistry WUT), Semi-automatic micro-fluidic system imitating a tumor in vivo (Microsystems - oral presentation) – ex aequo first prize
- Stanisław Stopiński (IMiO WUT), TX-RX WDM system manufactured in integrated photonics technology (Photonics - poster presentation) – second prize
- Grzegorz Wielgoszewski (PWr Wrocław), Thermal scanning microscopy as a tool for quantitative characterization of thermal properties of nanostructures (Materials - oral presentation) – ex aequo second prize
- Konrad Nieradka (PWr Wrocław), Micromechanical beams as a sensing platform for chemical and biomedical diagnostics (Microsystems - oral presentation) – ex aequo second prize

12. CONCLUSIONS AND XIITH ELTE'2016

The ELTE'2013 meeting was a fruitful event gathering the key researchers and engineers from the fields of electron technology and electronic components and systems in this country. The conference was richly participated not only be leading researchers but also by Ph.D. students and young researchers. The conference has shown tight connections of the national research electronic materials and technologies communities with the relevant leading international laboratories, as well as with electronics and photonics industries. A considerable whole figure of participants in the ELTE'2013 attests the strength of this field of research and technology in this country and this geographical region, as well as of European and global cooperation in electron technology.

The XIIth ELTE'2016 Conference on Electron Technology, next one in series, will be held in September 2016 and the organizer is AGH University of Science and Technology in Kraków. The organizers warmly invite, as usual, the researchers active in the fields of electron technology to present their work during this challenging meeting.

13. ACKNOWLEDGMENTS

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