INFOTEHNOLOOGIA TEADUSKOND
THOMAS JOHANN SEEBECKI ELEKTROONIKAINSTITUUT
TEADUS- JA ARENDUSTEGEVUSE AASTAARUANNE 2013

1. Instituudi struktuur

Thomas Johann Seebecki elektroonikainstituut;
Thomas Johann Seebeck Department of Electronics
Hea of the Department/Instituudi direktor: Toomas Rang

- Siduselektroonika õppetool, Chair of Communicative Electronics, Prof. Toomas Rang
- Siduselektroonika teaduslabor, Communicative Electronics Research Laboratory (Baselab SIE), Dr. Paul Annus.
- Pooljuhtelektroonika teaduslabor, Semiconductor Electronics Research Laboratory (BaseLab MINAKO), Prof. Toomas Rang

2. Instituudi teadus- ja arendustegevuse (edaspidi T&A) iseloomustus

2.1. Description of the research activities:

Communicative Electronics Research Laboratory (Baselab SIE)

Investigation into spectrally sparse signals and sequences, with main emphasis on improved algorithms for synthesis and optimization continued. Possibility for optimisation of the methods for synchronous real time processing of the spectrally sparse response from objects was investigated. Wide range of possible usability scenarios and application areas were under investigation, including those required for medical diagnosis; for analysing of micro-droplets; materials and structures like smart composites; precise measurement of the properties of alloys; properties of algae; improvement of pulse oximetry with joint usage of electrical and optical impedance; investigation of the activity of neural cells (together with Chalmers Technical University in Gothenburg) and most importantly for effective differentiation between normal and cancerous tissue. New impedance measurement solutions for improvement of energy consumption estimation and energy efficiency in portable devices were targeted.

Solutions for usage in the field of medicine range for creation of an algorithm for generating vascular networks in small tissue scale for later usage during modelling of blood flow dynamics to investigation of transfer characteristics of vascular system. Work was carried out in cooperation with East Tallinn Central Hospital, North Estoanian Regional Hospital, Sahlgrenska Hospitalet in Gothernburg and TAK ELIKO.

In the field of simulations an electric impedance measurement with 2 electrodes on the dynamic 3D vascular 1 layer network was investigated. The results of the simulation were impedance signals that show changing impedance signal due to pulsatile blood-flow in the small tissue patch.

Research was carried out on conversion and processing algorithms of adaptively oversampled and modulated signals with applications mainly in the impedance spectroscopy and image processing. End-applications range from determineing properties of the materials and alloys to smart composites. Topics under investigation include embedded sensors, short range communication issues, signal processing and energy harvesting solutions in connection with composite materials. Solutions for precise measurement of the properties of alloys and (Euro-)coins have been developed based on the methods of the impedance spectroscopy.

Investigation of the possibilities of developing of novel solutions and algorithms for the fast and precise profiling of the roads, by using of the laser projection and smart image processing started.

Most important results:

- Novel algorithms for synthesis and optimization of the spectrally sparse signals for system identification;
- Novel methods for generation and processing of signals used for identification of objects (biological and physiological, chemical and electrochemical, electrically conducting and semi-conducting etc. materials, structures, organs, devices and systems) with the aim to enable task specific optimisation of the measurement solutions towards speed, precision, size or efficiency;
- Novel algorithms for estimation of the central blood pressure in the aorta non-invasively, based on electrical bioimpedance information measured on radials.
- Results of the research projects were published on conferences, discussed in workshops and meetings, and patented when deemed feasible. Chapter was written into Springer Encyclopaedia of Microfluidics and Nanofluidics in international cooperation.
- Developed technologies have been licenced to two European companies: Carometec (DK), and Injeq (FI).

Selected publications.

1. Ojarand, J.; Annus, P.; Min, M. (2013).Optimisation of multisine waveform for bio-impedance spectroscopy. Journal of Physics: Conference Series , 434, 13 – 17.
2. Annus, P.; Land, R.; Reidla, M.; Ojarand, J.; Mughal, Y.; Min, M. (2013). Simplified signal processing for impedance spectroscopy with spectrally sparse sequences. Journal of Physics: Conference Series , 434, 9 - 12.
3. Min, M.; Paavle, T.(2013). Improved extraction of information in bioimpedance measurements. Journal of Physics: Conference Series, 434, 1 - 4.
4. Giannoukos G. and Min, M. (2013). Mathematical and physical modelling of the dynamic fluidic impedance of arteries using electrical impedance equivalents. Mathematical Methods in the Applied Sciences. ISSN (Print) 0170-4214 - ISSN (Online) 1099-1476. John Wiley and Sons, New Jersey). PubDate: 2013-06-05T03:01:59.094463-05, DOI: 10.1002/mma.2829, 7 pp.
5. Krivoshei, A.; Lamp, J.; Min, M.; Uuetoa, T.; Uuetoa, H.; Annus, P. (2013). Wearable System for Non-Invasive and Continuous Monitoring Central Aortic Pressure Curve and Augmentation Index. Studies in health technology and informatics (IOS Press, Amsterdam), vol. 189, June 2013, 101 - 106.
6. Mart Min, Toomas Parve, Uwe Pliquett (2013). Chapter: Impedance detection. In: Encyclopedia of Microfluidics and Nanofluidics, 2nd edition, (Ed.) Prof. Dongqing Li, SpringerReference (online), 25 pp.

<u>Semiconductor Electronics Research Laboratory (BaseLab MINAKO)</u>

Experimental and numerical study of wide and semi-wide bandgap materials based semiconductor devices; design and fabrication of improved semiconductor components using non-traditional technologies (e.g. DWT); Specific investigations (DLTS spectroscopy, numerical experiments) of electro-physical parameters (deep levels and their influence on electrical characteristics) in semiconductor structures.

The DLTS spectra obtained from the analyzed *p+-pin-n+* structures demonstrate the presence of electron and hole type deep levels in all investigated samples. Within each group, the configuration of the spectra is identical. This indicates that the sources of defects are stable, reproducible and depend on the variations in technology for epitaxial growth. The width of the space charge calculated from the C-V characteristic exceeds the width of the *i* layer and spreads into the *p* and *n* depletion regions. The permanent change in the capacitance over all the temperature range and the very weak dependence of the capacitance on the reverse voltage indicate that the thickness of the overcompensated layer practically coincides with the thickness of the space charge, as well as indicating evidence of a homogeneous spatial distribution of defects across the width of the space charge.
Participation in joint research experiments with the research group from the Department of Electrical Engineering the conclusion was made that both Si and SiC MOSFETs seems to be suitable for implementation in the qZS-derived push-pull DC/DC converters. Despite more strict requirements to the driving signal, the SiC MOSFET is considered more preferable due to totally reduced power losses compared to the Si device. Despite of higher price, especially in the case of SiC diodes, the implementation of these devices could be considered as practical efficient solution in DC/DC converters.

Most important results:

- The general spectra for all three groups, the permanent presence of hole traps, such as the center of H2, can be identified as significant. This means that from the special studies on the "proper" test samples made from the *p+-pin-n+* structures, for example, the Schottky diode, or a sharp *pn*-junction, first the exact parameters of the key defects (centers A and B) can be set; and then, the correction factors for the peaks of interest in the general background spectra of *p+-pin-n+* structures can be determined. This in turn will provide an opportunity for express DLTS control of the finished product and thus can be realized in on-line monitoring of the LPE process in order to optimize the dynamic characteristics of the devices.
- Detection of the new phenomena in SiC semiconductor structures using Kelvin probe surface investigations linking the surface potential with the distribution of dislocations on the surface of the diode chip. We stated that the location of threading dislocations is clearly visible in spite of the fact that the resolution of the method itself looses it's detection capability already eralier.
- The numerical experiment showed clear deep level influence on electrical charactersitics due to the decrease of the capture centres cross section in the trap cluster, which is supported by positively charged donor traps influence on the hole current through the potential barrier.

Selected publications.

1. Korolkov, Oleg; Toompuu, Jana; Rang, Toomas (2013). Analysis of Deep Level Centres in GaAs pin-Diode Structures. Electronics and Electrical Engineering, 19(10), 95 - 98.
2. Mizsei, János; Korolkov, Oleg; Toompuu, Jana; Mikli, Valdek; Rang, Toomas (2013). Study of surface defects in 4H-SiC Schottky diodes using a scanning Kelvin probe. Materials Science Forum , 740-742, 677 - 680.
3. Blinov, A.; Chub, A.; Vinnikov, D.; Rang, T. (2013). Feasibility Study of Si and SiC MOSFETs in High-Gain DC/DC Converter for Renewable Energy Applications. *In: Proceedings of : IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society, 11-14 November 2013, Vienna, Austria.* , 2013, 5973 - 5976.
4. Beldjajev, V.; Rang, T.; Zakis, J. (2013). Steady State Analysis of the Commutating LC Filter Based Dual Active Bridge for the Isolation Stage of Power Electronic Transformer. 8th International Conference-Workshop Compatibility and Power Electronics (CPE2013), Ljubljana, Slovenia, June 05-07, 2013. IEEE, 2013, 138 - 143.

2.3. Loetelu struktuuriüksuse töötajate rahvusvahelistest tunnustustustest.

None

2.4. Loetelu struktuuriüksuse töötajatest, kes on välisakadeemiate või muude oluliste T&A-ga seotud välisorganisatsioonide liikmed.

Prof. Toomas Rang:

- Journal "Electronics and Electrical Engineering" (Kaunas, Lithuania), member of the editorial board
- External scientific expert for Georgian Academy of Sciences
- External expert for British Engineering and Physical Sciences Research Council
- Chairman of the International Program Commitee of Baltic Electronics Conference BEC (Estonia)
- IEEE (USA) member
- Memeber of the Board of the Estoninan Association of Engineers

Prof. Mart Min:

- Section editor of the Journal of Electrical Bioimpedance
- International Society of Electrical Bioimpedance, member
- International Society of Electrocardiology, member
- IEEE International Instrumentation and Measurement Society conferences I2MTC, member of the programme committee
- "Proceedings of Riga Technical University - Electronics and Telecommunications" (Riga, Latvia), member of the editorial board
- International Committee for Promotion of Research in Bio-Impedance (ICPRBI, member

Dr. Olev Märtens:

- IEEE IM/EMB/ED chapter chair, Estonian section

2.5. Aruandeaasta tähtsamad T&A finantseerimise allikad.

Sihtfinantseeritav teema T061; Energiasäästlikud elektroonikasüsteemid; TAR8077IE, Integreeritud elektroonikasüsteemide ja biomeditsiinitehnika tippkeskus CEBE; 3 ETF granti ja 3 lepingut välisriikidega (EL raamprogramm ja ettevõtlus), 2 Eesti riiklikku programmi (energiatehnoloogiad ja materjalitehnoloogia).

2.6 Soovi korral lisada aruandeaastal saadud T&A-ga seotud tunnustusi (va punktis 2.3 toodud tunnustused), ülevaate teaduskorralduslikust tegevusest, teadlasmobiilsusest ning anda hinnang oma teadustulemustele.

Ei soovi

2.7 Instituudi teadus- ja arendustegevuse teemade ja projektide nimetused *(Eesti Teadusinfosüsteemi, edaspidi ETIS, andmetel)*

- Haridus- ja Teadusministeerium

– sihtfinantseeritavad teemad:
T061, Energiasäästlikud elektroonikasüsteemid, Min Mart (2012 – 2014)

– baasfinantseerimise toetusfondist rahastatud projektid (sh TTÜ tippkeskused):
B04, HTM, Metrology for competitive competence (01.05.11 - 31.12.13)
Involved researcher: Olev Märtens

– riiklikud programmid:
- Teiste ministeeriumide poolt rahastatavad riiklikud programmid:

AR12139, Smart composites: design and manufacturing, National R&D program „Materials technology“. RP Materjalitehnoloogia teadus- ja arendustegevuse toel (01.07.12 - 31.12.14)
Involved researchers: Olev Märtens, Raul Land, Rauno Gordon, Mart Min, Ago Mõlder

Uurija-professori rahastamine:

- Eesti Teadusagentuur

– grandid:
ETF9394, Elektriliste kudede diagnostikameetodite arendamine veresoonkonna dünaamilisi mõjutusi arvestades, Gordon Rauno (2012 – 2014)

ETF8905, Adaptiivselt ülevõendatud ja moduleeritud signaalide muundamise ja töötlemise algoritmide uurimine, Märtens Olev (2011 – 2013)

ETF8592, Laia keelutsooniga materjalidel baseeruvad integreeritud Schottky ja heterosiirded: tehnoloogiad ja modelleerimine, Rang Toomas (2011 – 2014)

– ühisgrandid välisriigiga:

– järeldoktorite grandid (SA ETF ja Mobilitas):

– tippteadlase grandid (Mobilitas):

- Ettevõtluse Arendamise SA

– eeluuringud:
– arendustoetused:

- SA Archimedesega sõlmitud lepingud

– infrastruktuur (nn „mini-infra“, „asutuse infra“):

AP061, Energiasäästlikud elektroonikasüsteemid, Min Mart (1.01.2012 - 31.12.2013)

ÜLTAP29-1, Energiasäästlikud mikro- ja nanostruktuursed sardsüsteemid ja komponendid (SARS4), Eva Keerov (1.06.2012 - 18.01.2014)

ÜLATP15-3, Mikro- ja nanostruktuursed sardsüsteemid ja komponendid (SARS3), Toomas Rang (1.06.2011 - 7.07.2013)

– Eesti tippkeskused:

TAR8077IE, Integreeritud elektroonikasüsteemide ja biomeditsiinitehnika tippkeskus, Mart Min (7.07.2008 - 31.08.2015)

– riiklikud programmid:

AR10126, Energiatehnoloogia,ENERGIASÜSTEEMI TALITLUSE OPTIMEERIMINE MUUTUVKOORMUSTE TASAKAALUSTAMISEKS, Alvar Kurrel (1.11.2010 - 31.10.2013)

AR12118, materjalitehnoloogia, Efficient plasmonic absorbers for solar cells, Alvar Kurrel (1.07.2012 - 31.12.2014)

– muud T&A lepingud:

- SA Keskkonnainvesteeringute Keskusega sõlmitud lepingud:
- Siseriiklikud lepingud:
- EL Raamprogrammi projektid:

VFP567, FP7-SME, Innovative, Highly Efficient Road Surface Measurement and Control System, Olev Märtens (01.08.12 - 31.07.14)

- Välisriiklikud lepingud:

2.8 Struktuuriüksuse töötajate poolt avaldatud eelretsenseeritavad teaduspublikatsioonid *(ETIS klassifikaatori alusel 1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1 ja 5.1).*

1.1

1. Korolkov, Oleg; Toompuu, Jana; Rang, Toomas (2013). Analysis of Deep Level Centres in GaAs pin-Diode Structures. Electronics and Electrical Engineering, 19(10), 95 - 98.
2. Mizsei, János; Korolkov, Oleg; Toompuu, Jana; Mikli, Valdek; Rang, Toomas (2013). Study of surface defects in 4H-SiC Schottky diodes using a scanning Kelvin probe. Materials Science Forum , 740-742, 677 - 680.
3. Ojarand, J.; Min, M. (2013). Simple and Efficient Excitation Signals for Fast Impedance Spectroscopy. Electronics and Electrical Engineering, 19(2), 49 - 52.
4. Ojarand, J.; Annus, P.; Min, M. (2013).Optimisation of multisine waveform for bio-impedance spectroscopy. Journal of Physics: Conference Series , 434, 13 – 17.
5. Annus, P.; Land, R.; Reidla, M.; Ojarand, J.; Mughal, Y.; Min, M. (2013). Simplified signal processing for impedance spectroscopy with spectrally sparse sequences. Journal of Physics: Conference Series , 434, 9 - 12.

6. Krivoshei, A.; Lamp, J.; Min, M.; Uuetoa, T.; Uuetoa, H.; Annus, P. (2013). Non-invasive method for the aortic blood pressure waveform estimation using the measured radial EBI. Journal of Physics: Conference Series , 434, 5 - 8.
7. Min, M.; Paavle, T.(2013). Improved extraction of information in bioimpedance measurements. Journal of Physics: Conference Series, 434, 1 - 4.
8. Giannoukos G. and Min, M. (2013). Mathematical and physical modelling of the dynamic fluidic impedance of arteries using electrical impedance equivalents. Mathematical Methods in the Applied Sciences. ISSN (Print) 0170-4214 - ISSN (Online) 1099-1476. John Wiley and Sons, New Jersey). PubDate: 2013-06-05T03:01:59.094463-05, DOI: 10.1002/mma.2829, 7 pp.

3.1

5. Blinov, A.; Chub, A.; Vinnikov, D.; Rang, T. (2013). Feasibility Study of Si and SiC MOSFETs in High-Gain DC/DC Converter for Renewable Energy Applications. *In: Proceedings of : IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society, 11-14 November 2013, Vienna, Austria.* , 2013, 5973 - 5976.
6. Beldjajev, V.; Rang, T.; Zakis, J. (2013). Steady State Analysis of the Commutating LC Filter Based Dual Active Bridge for the Isolation Stage of Power Electronic Transformer. 8th International Conference-Workshop Compatibility and Power Electronics (CPE2013), Ljubljana, Slovenia, June 05-07, 2013. IEEE, 2013, 138 - 143.
7. Giannoukos, G. and Min, M. (2013). Modelling of dynamic electrical bioimpedance and measurements safety. The 2nd AASRI Conference on Computational Intelligence and Bioinformatics (CIB2013), Jeju Island, South Korea, Dec.27-28, 2013. Procedia of American Applied Science Research Institute (AASRI) 2013, Elsevier B.V., Amsterdam, 6 pp.
8. Märtens, O.; Land, R.; Gordon, R.; Min, M; Rist, M.; Pokatilov, A. (2013). Precise eddy current measurements: Improving accuracy of determining of the electrical conductivity of metal plates. Olfa Kanoun (Ed). Lecture Notes on Impedance Spectroscopy: Measurement, Modeling and Applications, Vol 4, Nov.18, 2013. London: Taylor & Francis, pp. 109-115.
9. Pokatilov, A.; Parker, M.; Kübarsepp, T.; Märtens, O.; Kolyshkin, A. (2013). Grid-based computational algorithm for accurate AC conductivity measurements. 16th International Congress of Metrology, Paris, France, Oct. 7-10, 2013. EDP Sciences, 2013. DOI:10.1051/metrology/201311007, 4 pp.
10. Saar, T.; Reidla, M.; Märtens, O.; Land, R.; Min, M.; Herranen, H. (2013). Chirp-Based Piezo-Impedance Measurement. In: Proceedings of 8th IEEE International Symposium on Intelligent Signal Processing (WISP'2013), Funchal, Madeira, Sept. 16-18, 2013. (Ed.) A. Várkonyi - Kóczy. Funchal, Madeira. IEEE, 2013, pp. 83 - 86.
11. Mughal, Y. M.; Krivoshei, A.; Annus, P. (2013). Separation of cardiac and respiratory components from the electrical bio-impedance signal using PCA and fast ICA . IEEE International Conference on Control Engineering & Information Technology (CEIT'13). Sousse, Tunisia, June 04 - 07, 2013, 153 - 156.
12. Krivoshei, A.; Lamp, J.; Min, M.; Uuetoa, T.; Uuetoa, H.; Annus, P. (2013). Wearable System for Non-Invasive and Continuous Monitoring Central Aortic Pressure Curve and Augmentation Index. Studies in health technology and informatics (IOS Press, Amsterdam), vol. 189, June 2013, 101 - 106.
13. Annus, P.; Samieipour, A.; Rist, M.; Ruiso, I.; Krivoshei, A.; Land, R.; Parve, T.; Min, M. (2013). Wearable Data Acquisition System of Multimodal Physiological Signals for Personal Health Care. Studies in health technology and informatics (IOS Press, Amsterdam), vol. 189, June 2013, 107-112.
14. Kuusik, A., Sarna, K.; Reilent, E. (2013). Home Rehabilitation System Supported by the Safety Model. Studies in health technology and informatics (IOS Press, Amsterdam), vol. 189, June 2013, 145-151.

2.9 Struktuuriüksuses kaitstud doktoriväitekirjade loetelu *(NB! struktuuriüksus lisab struktuuriüksuse töötaja juhendamisel mujal kaitstud doktoriväitekirjade loetelu)*

Juri Mihhailov, Thomas Johann Seebecki elektroonikainstituut
Teema: Accurate Flexible Current Measurement Method and its Realization in Power and Battery management Integrated Circuits for Portable Applications.
Juhendaja: Prof. Toomas Rang
Kaitses: 13.06.2013
Omistatud kraad: filosoofiadoktor (elektroonika)

Tõnis Saar, Thomas Johann Seebecki elektroonikainstituut
Teema: The Piezo-Electric Impedance Spectroscopy: Solutions and Applications
Juhendaja: juhtivteadur Olev Märtens
Kaitses: 13.06.2013
Omistatud kraad: filosoofiadoktor (elektroonika)

2.10 Struktuuriüksuses järeldoktorina T&A-s osalenud isikute loetelu *(ETIS-e kaudu esitatud taotluste alusel)*

2.11 Struktuuriüksuses loodud tööstusomandi loetelu

1. Estonian Application:

U201300075 Utility Model - Modular measurement system (29.08.2013). Inventors: M. Rist, M. Min, P. Annus, R. Land, T. Parve, M. Reidla. Holders/owners: TTU and ELIKO.

2. USA Application

US 61/771,903, US Patent application - A method and device for personalized pulse oximetry (03.03.2013). Inventors: Erve Sõõru, Mart Min, Paul Annus, Raul Land. Holders/owners: ELIKO and RES-MEDICA

Patents

1. Patent of USA: US2011095747A1 alusel (Notice of Allowance 31.10.2013). Method and device for fast measurement of frequency response with scalable short chirp signals. Inventors: Mart Min, Toivo Paavle, Raul Land, Paul Annus, Toomas Parve. Owners: TTU and ELIKO.
2. European Patent EP2314217B1. Method and device for fast measurement of frequency response with scalable short chirp signals. (granted 13.03.2013). Inventors: Mart Min, Toivo Paavle, Raul Land, Paul Annus, Toomas Parve. Owners: Tallinn University of Technology, ELIKO Competence Centre.
3. Eesti patent EE05668B1 (avaldatud 15.08.2013). Meetod ja seade süsteemide ja substantside laiaribaliseks analüüsiks. Autorid: R. Land, P. Annus, M. Min, O. Märtens, J. Ojarand. Omanikud: Tallinn Tehnikaülikool ja TAK ELIKO.