Microwave Laboratory

The **Microwave Laboratory** of the Christian Albrechts University of Kiel (CAU) has continued research in the areas of **ultra-wideband technology (UWB)**, **power amplifiers for communication systems**, and **high frequency materials and components**. The working area of **microwave sensors**, where highly recognized research has been carried out during the last few decades, has been further extended to field based sensors, which include for example eddy current sensors, low frequency capacitive sensors and magnetoelectric sensors. Another working area is **molecular spectroscopy**, where work on spectrometer construction continues.

UWB-technology concentrates on sensors for the characterization of condition, composition and history of natural materials. At present the research is focused on non-contacting determination of the properties of dielectric objects, which may be much smaller than the footprint of the interrogating antenna. Over the years the laboratory has acquired considerable expertise in the application of dielectric spectroscopy and in the use of multivariate statistics to analyse the response of UWB signals.

Industrial microwave sensors is an area, where the microwave laboratory has a long established experience. A wide range of sensors has been created in the past. Present work concentrates on millimetre wave doppler radar sensors for the characterization of, for example aerosols, on other radar sensors and on sensors for medical applications. In addition, a novel density independent measurement method was enhanced, which is suited for moisture measurements up to very high moisture levels. Significant effort has been devoted to investigations concerning the characterisation of thin film magnetoelectric sensors in collaboration with the materials research at Kiel and to low noise electronic circuits for interrogating such devices.

The working area **Materials and high frequency components** is focused on various characterization methods for the determination of the permeability of magnetic nanocomposites at frequencies up to several GHz. The materials are then applied in components such as inductors or balun transformers at microwave frequencies. Close cooperation exists in this area with the materials research at CAU Kiel.

Molecular spectroscopy is focused not only on spectroscopy itself, but also on the development of new spectrometers in the millimetre and sub-millimetre wave region.

Results

Non-Contacting Characterization of the Dielectric Properties of Objects of Irregular Shape

The aim of the DFG-project ISOPerm (irregular shaped objects permittivity) is to develop an UWB method for the measurement of the dielectric properties of irregularly shaped bodies by using a non-contacting approach. Industrial processes often require the determination of e.g. the water content of bulk materials and other process parameters. There is a strong correlation between many of those quantities and the dielectric properties. Therefore, dielectric measurements are well-suited for material characterization. Existing methods for such measurements require that the samples are regular in shape. They also require that the entire used cross section of the electromagnetic field which is filled with the material under test. The method under development does not require this restriction. Contrary to existing methods and as a novel approach an attempt was made using multivariate analysis, to separate those effects due to the geometry of the object from those due to its dielectric properties. It was successfully proved with simulations and measurements of dielectric objects and the use of multivariate analysis methods that the determination of the dielectric properties is independently possible of shape, size and orientation. It was also shown that related properties like e.g. the water content of water-ethanol mixtures, the carbon content of carbon loaded silicones or the moisture content of moist clay granules can be determined directly from the time domain data. Dedicated hardware was built in order to reveal the system performance and accuracy under practical conditions. The use of a special-tailored miniaturized sampling oscilloscope capable of transmitting and receiving UWB-signals with several gigahertz of bandwidth leads to very promising results. Further investigations are focused on

the improvement of the whole measurement set-up and individual components in order to achieve better accuracy. Signal processing and multivariate calibration procedures are also subject to further studies.

UWB Through-Wall-Radar

An application of UWB radar system with a breath simulator for remote measurement of the position and respiration of hidden persons in varying positions and angles had been finished. The result is that only certain angles can get the imitated breath frequency for each point. The angles extend beyond both sides of the transmitting and reflecting angle (TRA) area. The higher the distance, the less angles are available to get breath frequency and the TRA gets smaller. The best results are obtained with angles where the object person is facing the line connecting the transmitting and receiving antenna. In every row, the highest relative amplitude is in its middle (TRA) area. The peak amplitude becomes smaller with larger distances.

Microwave Moisture Measurement

The effective measurement of high moisture content solid matter (up to 50%) is performed by exploiting multiple (at least double) resonances of stray field resonators. Due to the fact that in this method the resonant frequencies should be widely separated, suitable resonators have to be conceived and designed. Our investigations show that implementing appropriate methods for the excitation of dielectric stray field ring resonators results in resonances which are sufficiently separated. Appropriate coupling positions for this kind of resonators were adjusted to realize wide-band operation. On the other hand, dielectric ring resonators were analyzed theoretically and experimentally. The theoretically determined resonator parameters (resonance frequency and quality factor) agree well with simulations and measurements. The applied method allows fast estimation of the resonance frequency and quality factor for different dimensions of the resonator. A lumped element(RLC) model for multiple resonances was developed additionally. This model facilitates the estimation of the complex permittivity of various materials.

Multiple-Utilized Microwave Resonators for Materials Characterization

In industrial processes it is important to know the composition and state of raw materials. Especially in food industry the water and salt content are important quality parameters. In general the water content of natural materials can be measured precisely with microwave resonators because they are very sensitive against small changes of the permittivity; water dominates the complex permittivity of food stuffs. With increasing water content of the material under test (MUT) the resonator is increasingly loaded by dielectric loss of the water. Furthermore the resonance frequency is detuned by permittivity changes. Finally the electrical field of the microwave resonator interacts with the permittivity of the MUT. The magnetic field can be used equally well for measuring the conductivity of the MUT. Due to ions in solution the conductivity is directly correlated to the salt content of a MUT. When penetrating a conducting MUT the magnetic field generates eddy currents which depend on the conductivity. The eddy currents in turn generate magnetic fields opposing the original fields of the resonator. Thus the resonator is increasingly loaded with increasing conductivity of the MUT. In order to separate the influence of the two constituents, namely water and salt, on the resonance, the electrical and/or the magnetic field of the resonator have to sufficiently penetrate the MUT. Various structures are conceivable to fulfil this requirement. As an example, a ring resonator is shown in figure 1: An aperture is placed between the ring resonator and the MUT in order to separate the field components, which can be altered by switching the excitation. When the localization of the feed port is altered to another position, the fringe field at the aperture changes from predominantly electric to magnetic. Using these two operation modes, the same sensor can separate permittivity changes caused by water and conductivity changes caused by salt content rapidly and non destructive.

PITAS

The Pitas-project is a common activity of the maritime cluster in Kiel and the chairs of ''Circuit- and System Theory, (Prof. Heute)'', ''Information and Coding theory, (Prof. Höher)'', and ''Microwave group, (Prof. Knöchel)'' from the Institute of Electrical Engineering and Information Theory, and the chair of ''Information Systems Engineering, (Prof. Klein)'' from the

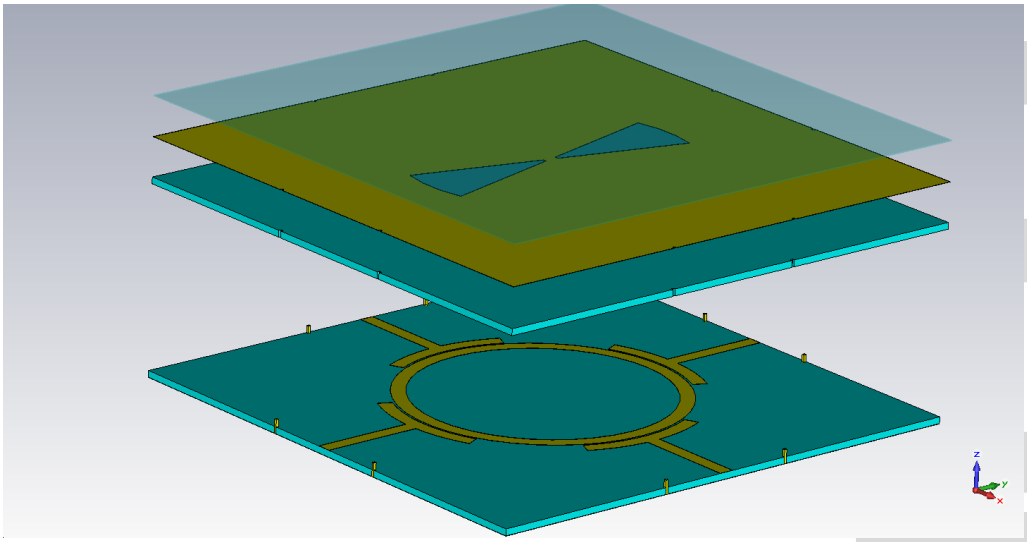

Fig. 1: Ringresonator for dual mode operation. Via the feeding port and an aperture the field penetrateing the material under test is selected.

Institute of Computer Science. The goal of the subproject ''Radar and Tracking'' is detection of small targets like rubber boats one mile around ships for identifying of possible threats like pirates. Several concepts habe been investigated. Close analysis of possible radar signals was taken. On the basis of the obtained results a coherent pulsradar system was designed. The new designed system has advantages in detecting small targets on rough sea in relation to the at present used radar systems. The radar system is now under test in the laboratory of the ''Microwave group''.

Rotary Joint for the Near-Range Radar (PITAS)

A rotary joint facilitates scanning of an antenna beam in the horizontal plane at constant radiated power in the whole range of scanning angles. Such a wave-guide component has been designed using propagation mode conversion from the rectangular wave-guide H01 mode to the circular wave-guide H11 mode. A polarization rotation section is formed by an elliptical waveguide. Such a configuration of the rotary joint provides high power transmission, which is limited by the properties of the rectangular waveguide. The insertion loss of the developed device does not exceed 0.3 dB at a voltage standing wave ratio (VSWR) of less than 1.2 in a bandwidth of 4%.

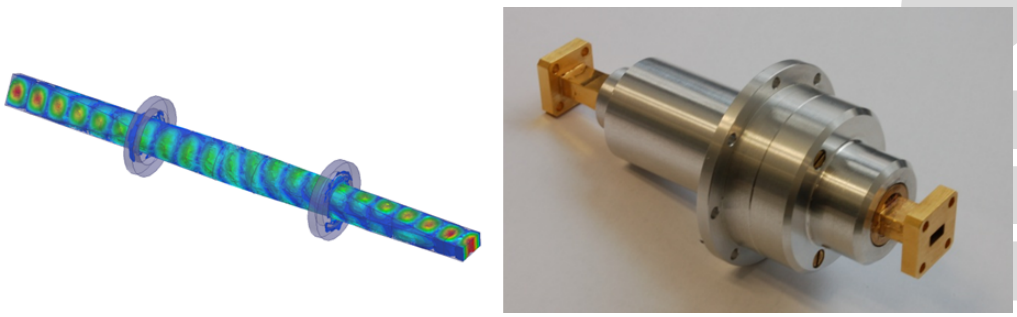

Fig. 2: Rotary Joint

Collaborative Research Centre SFB 855 ''Magnetoelectric Composite Materials - Biomagnetic Interfaces of the Future''
Subproject C3: Sensor Modelling and Electronic Signal Processing

Aim of the collaborative research centre SFB 855 is the development of a high sensitive magnetoelectric (ME) detection unit that is able to measure biomagnetic signals in the picotesla range. For this reason the ME modulation technique was

further developed. Thus it was possible to improve the sensor sensitivity for a 1 Hz magnetic input signal by a factor of 1000. This technique also allows broadband measurements, which are necessary for biomagnetic measurements. Currently additional Barkhausen noise impairs the achievement of the same sensitivity as in resonance. Work is in progress to reduce the influence of this noise source. Together with the Multicomponent Materials group of the Institute for Materials Science a frequency modulation approach for cantilever based magnetic field sensors was developed and investigated. Furthermore noise calculations and measurements have been carried out for MEMS based ME sensors from the Fraunhofer Institute for Silicon Technology (ISIT). Results show that despite of their small size of below 1 mm^2 these sensors achieve a sensitivity level of 100 $pT/\sqrt{Hz}$. Finally an optically based test setup (picture) for ME cantilevers was developed to achieve the full characterization of the sensors equivalent circuit.

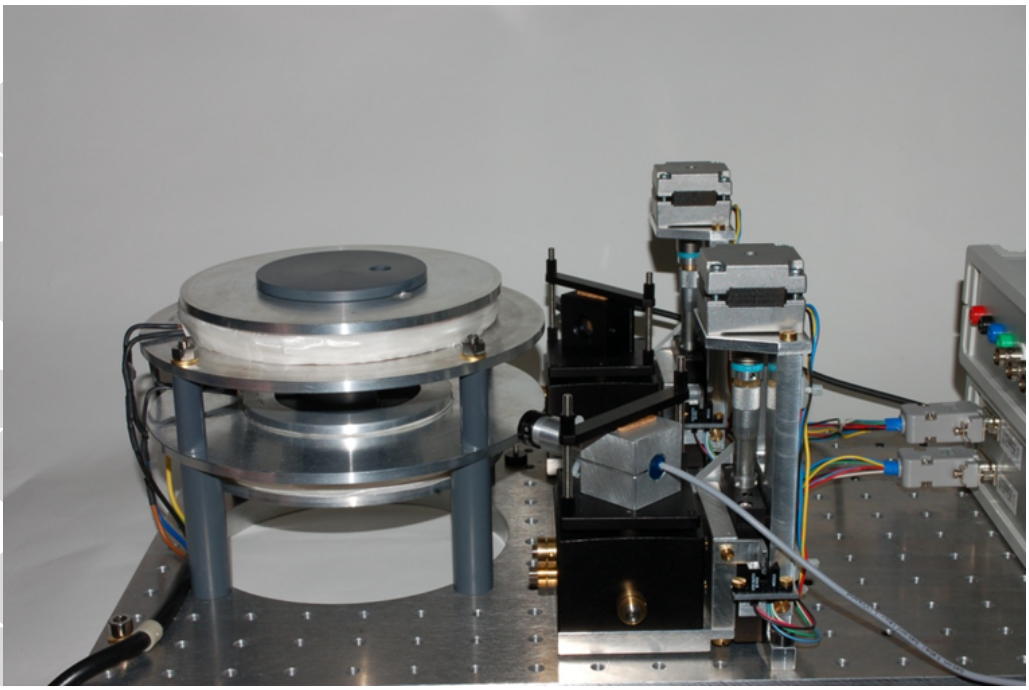

Fig. 3: Optical based test setup for ME sensor characterization

Application of metamaterials in microwave resonators and slow wave structures

The aim of the project is the consideration of metamterials applications in microwave resonators and slow wave structures. In this regard, and based on rigorous analytical formulations the ability of different metamaterial layers in realizing miniaturized metamaterial loaded resonators, filters and sensors has been investigated and examples of miniaturized resonators and filters has been designed, simulated and realized. On the other hand, analytical investigations show the ability of metamaterials in realizing optimized slow wave structures for spatial harmonic magnetrons which are currently suffering from low efficiency and output power. Due to the fact that the operation of these magnetrons has not been fully investigated, we have developed a fully realistic model using CST-PIC simulator and we have considered very particular conditions governing the operation of these magnetrons. The simulation results based on this model, show very good agreement with the measured ones. This agreement confirms the accuracy of the model. In the following this model operation was applied to several optimized anode structures. The geometrical characteristics of these optimized structures are determined by formulating a criterion for increasing output power.

Microstrip Filter Design with Fuzzy Logic

The main goal of this research plan is focused on the development of a fuzzy based approach which enables a designer to relate physical parameters of the filter to the required electrical characteristics. In order to provide such a useful design

tool, which accelerates the filter design process, we completed the following steps in the last year. In order to complete the modeling process in a wider variation range of independent variables, the number of membership functions was increased. In order to increase the accuracy of the model, the conventional IDS pattern, was modified. This modification improves the accuracy when there is not enough initial data. In the next step, we developed our fuzzy model in order to support, simultaneously, three modeling parameters. The completed model was applied to model coupling and external quality factor in the case of square open loop resonators and triangular open loop resonators. Results were compared with the ones extracted by full wave calculations. They were in a good agreement. Based on the extracted fuzzy-based surfaces, three different filters were designed, fabricated and tested. By the proposed approach coupling and external quality factors were modeled for other kinds of resonators, such as spiral resonators and split ring resonators. For the case of split ring resonators, four different independent parameters were modeled simultaneously. Accuracy of the extracted surfaces was confirmed by the full wave approach. Two different filters were designed, fabricated and tested based on the extracted surfaces. A good accuracy between the measurement and simulation results confirms the accuracy of the proposed fuzzy-based filter design approach. The validity of the approach was also confirmed for a novel proposed metamaterial filter. Measured and simulated results were also in good agreement. The method has been applied to different kinds of resonators with different modeling parameters with the same simplicity and unique approach. It should be mentioned that it is completely fast and accurate in comparison with the common full wave-based approach. In the last year 3 conference papers and 2 journal papers were published and one journal paper was accepted for publication.

Molecular Spectroscopy

Molecular spectroscopy in the range of millimetre- and sub-millimetre wavelengths (carried out by Prof. Guarnieri) allows the investigation of free molecules in the gas phase. In this state the molecules are in continuous motion proportional to their thermal energy. A part of this energy is stored as rotational energy. The activity of the lab was concentrated on the improvement of the resolution of the millimetre- and sub-millimetre wave spectrometer to allow very precise measurements of transition frequencies between rotational energy states. Astronomical observations in millimetre- and sub-millimetre wavelengths have led to the discovery of many different molecules in the interstellar clouds. Laboratory spectra of such molecules in the millimetre- and sub-millimetre range measured with a precision $\leq$ 1 kHz are therefore needed for modern astrophysical investigations. To this purpose this laboratory's spectrometer has been supplemented with devices that have allowed the observation of absorption lines with lamb-dip (a result of a saturated absorption process) accuracy. This method allows the measurement of the absorption lines with a precision $\leq$ 1 kHz. A corresponding paper was published in 2007 in Astrophysics Letters. Further to increase the sensitivity of the InSb-Detector-chip in the frequency range near 1 THz (0,1 m/m wavelength) a suitable cryostat provided with a neodyn permanent magnet, delivering a magnetic field of 1,4 Tesla around the InSb-chip, is under construction in the local workshop of the faculty. Within the scope of the DFG-cooperation project with the Institute of Applied Physics of the Russian Academy of Science (Nizhnii Novgorod) spectra of the HCCCN (propene cyanide), NH3 (ammonia) and various isotopologues of water have been investigated with the goal of obtaining precise transition frequencies in the millimetre- and sub-millimetre range with accuracies $\leq$ 1 kHz for investigation of the dynamics of interstellar clouds.

Personnel

Head of the group: Prof. Dr.-Ing. R. Knöchel; Secretary: M. Bork
Technical Staff: H. Runkowske, Dipl.-Ing. (FH) W. Taute

Scientific Staff:

M.Sc. C.-C. Chao	01.01.-31.12.2010	externally funded
Through wall radar		
Dr.-Ing. F. Daschner	01.01.-31.12.2011	CAU
Resonant stents / Microwave sensors / Heterotopic bone induction		

Dipl.-Ing. R. El Korch	01.04.-31.12.2011		BMWi / CAU
High level moisture measurement with microwave resonators			
Dipl.-Ing. F. Hettstedt	01.01.-30.04.2011		DFG
Magnetic nanocomposites for RF-applications			
Dipl.-Ing. R. Jahns	01.01.-31.12.2011		DFG
Magnetoelectric sensors			
Dr.-Ing. T. Lehmann	01.01.-31.12.2011		Guest researcher
Lüttlng			
Dipl.-Ing. H. Mextorf	01.01.-31.12.2011		DFG
Non-contacting characterisation of irregular shaped objects			
M.Sc. N. Nasresfahani	01.01.-31.12.2011		DAAD
Metamaterials in microwave structures			
M.Sc. P. Rezaee	01.01.-31.12.2011		DAAD
Microwave filter design with fuzzy logic			
Dipl.-Ing. W. Stellmach	01.03.-31.12.2011	(50%)	BMWi
M.Sc. O. Teplyuk	01.01.-31.12.2011		CAU
Radar-sensor			

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Leitungstheorie, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ R. Jahns)

Nichtlineare Schaltungen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Radar, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Hochfrequenz-Messtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ F. Daschner)

Praktikum Hochfrequenztechnik, 4 hrs Practical/Week,
R. Knöchel (+ F. Daschner, F. Hettstedt, H. Mextorf, O. Teplyuk)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

Summer 2011

Radar, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Daschner)

Hochfrequenzschaltungen für Mobil- und Satellitenfunk, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Hochfrequenz-Messtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,

F. Daschner (+ F. Daschner)

Hochfrequenzschaltungen und -systeme: Passive Systeme, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Bachelorpraktikum Hochfrequenztechnik, 4 hrs Practical/Week,
R. Knöchel (+ F. Daschner, R. Jahns, O. Teplyuk, H. Mextorf, R. El Korch)

Projekt, 3 hrs Practical/Week,
R. Knöchel

Seminar Hochfrequenztechnik, 1 hrs Seminar/Week,
R. Knöchel

Winter 2011/2012

Leitungstheorie, 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ R. El Korch)

Nichtlineare Schaltungen, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ R. Jahns)

Hochfrequenzschaltungen und -systeme: Aktive Schaltungen, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Rauschen in Kommunikations- und Messsystemen, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ W. Stellmach)

Projekt, 3 hrs Practical/Week,
R. Knöchel

Masterpraktikum Mikrowellen und EMV, 4 hrs Practical/Week,
F. Daschner (+ R. Jahns, A. Teplyuk, H. Mextorf)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

Third-Party Funds

Deutsche Forschungsgemeinschaft, *Magnetic nanocomposites for rf applications in mobile communication (Folgeprojekt)*, 01.10.2008-31.01.2011 (91400 EUR)

Deutsche Forschungsgemeinschaft, *Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte (ISOPerm)*, 01.10.2008-31.01.2011 (122300 EUR)

Deutsche Forschungsgemeinschaft, *Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte (ISOPerm) - Folgeprojekt*, 01.02.2011-31.01.2013 (126300)

Deutsche Forschungsgemeinschaft, *Aufbau und Optimierung von Spektrometern für den Submillimeterwellen-Bereich sowie Fortsetzung der rotationsspektroskopischen Messungen an interstellaren Spezies*, 01.10.2008-31.03.2012 (53995 EUR)

Deutsche Forschungsgemeinschaft, *Sonderforschungsbereich 855, Subproject C3: Sensor Modelling and Electronic Signal Processing*, 01.01.2010-31.12.2013 (579100 EUR)

Bundesministerium für Wirtschaft und Technologie, *Verbundprojekt: PITAS - Piraterie und Terrorabwehr auf Seeschiffen; Sensorik und Tracking*, 01.07.2010-30.06.2013 (1029711 EUR)

Innovationsstiftung Schleswig-Holstein, *''lüttIng.'' - Schüler-Technik- Akademie*, 25.05.2010-22.08.2012 (26140 EUR)

Deutscher Akademischer Austauschdienst, *Leonhard-Euler-Projekt, Zielland: Ukraine*, 01.09.2010-31.08.2011 (7280 EUR)

Deutscher Akademischer Austauschdienst, *Leonhard-Euler-Projekt, Zielland: Ukraine*, 01.09.2011-31.08.2012 (7380)

Further Cooperation, Consulting, and Technology Transfer

There is close cooperation concerning ''magnetic nano composites'' for rf applications with the departments of ''Multicomponent materials'' (Prof. Faupel) and ''Inorganic functional materials'' (Prof. Quandt) in the **Faculty of Engineering of CAU**.

With the ''Inorganic functional materials'' department (Prof. Quandt) there is also cooperation with regard to ''magnetoelectric sensors''.

There exists a cooperation concerning radiophysics and radioelectronics, radar technology and biological effects of electromagnetic waves and fields with the **Kharkov National University (KNU)**, Kharkov, Ukraine, in association with research institutes of the Ukrainian academy of science and the ''Institute of Radiophysics (IRE)'', (Prof. Khlopov) and the ''Institute of Radioastronomy (IRA)'', (Prof. Vavriv). There is also some cooperation within the framework of the Leonard Euler Program of the German Academic Exchange Service (DAAD).

With the **Technische Universität Hamburg Harburg**, (Prof. Dr. A. Jacob), we cooperate in the areas of ''microwave components'', ''microwave measurements'' and ''radar technology''.

With Prof. Dr. K. Schünemann, **Technische Universität Hamburg Harburg** and Prof. G. Khlopov, **Institute of Radiophysics**, Kharkov, Ukraine we cooperate in the area of industrial radar sensors.

Concerning sub-millimetre spectrometers and molecular spectroscopy we work in cooperation with the **Applied Physics Institute** of the **Russian Academy of Science** (Dr. Gera Golubjatnikov and Dr. Vladimir Markov) .

Cooperations with industry include; **AMS - Advanced Microwave Systems**, Hamburg, in the area of microwave sensors for density and moisture determination of materials,

Thales, Kiel, in the area of antennas,

Baker Hughes INTEQ GmbH, Celle in the area of high frequency sensors.

A cooperation concerning resonant stents and other stent solutions is carried out together with the **pediatric cardiology clinical centre of the Christian-Albrechts-University (PD Dr. Rickers)** and the measurements regarding heterotopic bone inductions are carried out together with the **Department of Oral and Maxillofacial Surgery of the Clinical Centre of the Christian-Albrechts-University (PD Dr. Dr. Becker)**.

As in previous years there is cooperation with **Dr M Kent**, a UK consultant, in the application of dielectric measurements and multivariate analysis.

Diploma, Bachelor and Master Theses

B. Stolze, *Aufbau und Untersuchung eines retrodirektiven Radarsystems*, 13.01.2011
S. Zhenyu, *Untersuchung von modulierten resonanten Stents*, 31.03.2011
M. Falb, *Entwicklung eines magnetoelektrischen Messverfahrens mit Effektmodulation*, 18.05.2011
L. Welsch, *Entwicklung einer digitalen Auswerteelektronik für magnetoelektrische Sensoren*, 06.06.2011
D. Reese, *Rekonfigurierbare Takterzeugung für ein Abtastoszilloskop*, 07.06.2011
J. M. Grimm, *Entwicklung eines Mikrowellenoszillators mit Streufeldresonator*, 19.08.2011
G. Davtjan, *Untersuchung eines Ringresonators zur Materialcharakterisierung mit multivariater Signalverarbeitung*, 23.09.2011
M. Grischan, *Zweimodiger Mikrowellen-Ringresonator zur Feuchtigkeits- und Leitfähigkeitsmessung*, 21.11.2011

Dissertations / Postdoctoral Lecture Qualifications

F. Hettstedt, *Weichmagnetische Nanokomposite und deren Anwendungen in der Hochfrequenztechnik*, 14.07.2011

Publications

Published in 2011

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *UWB free-space characterization and shape recognition of dielectric objects using statistical methods*, IEEE Trans. Instrum. Meas., **60**, 1389 - 1396 (2011)

H. Mextorf, T. Lehmann, R. Knöchel, *Compact cascaded directional couplers with continuously tuneable coupling ratios*, Proc. German Microwave Conference, 1 - 4 (2011)

F. Daschner, R. El Korch, R. Knöchel, *A Stray Field Ring Resonator for Quantitative Permittivity Determination*, Proceedings of the 9th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances, 119 - 126 (2011)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Free-spaced prediction of the water content of irregularly shaped bodies filled with water-ethanol mixtures*, Proceedings of the 9th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances, 162 - 169 (2011)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *New UWB Free-Space Method for the Classification and Characterization of Dielectric Objects*, Proc. ICUWB, 410 - 414 (2011)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Performance of Multivariate Calibration Methods for the UWB Characterization of Dielectric Objects*, Innovative Feuchtemessung in Forschung und Praxis, **6**, 105 - 112 (2011)

F. Daschner, S. Hoffmann, R. Knöchel, M. Jerosch-Herold, C. Rickers, *Resonant Stents for Non-Invasive Monitoring of Restenosis*, Proceedings of the 41st European Microwave Conference, 972 - 975 (2011)

R. Jahns, H. Greve, E. Woltermann, E. Lage, E. Quandt, R. Knöchel, *Magnetoelectric Sensors for Biomagnetic Measurements*, Medical Measurements and Application Proceedings (MeMeA), 107 - 110 (2011)

B. Gojdka, R. Jahns, K. Meurisch, H. Greve, R. Adelung, E. Quandt, R. Knöchel, F. Faupel, *Fully integrable magnetic field sensor based on delta-E effect*, Appl. Phys. Lett., **99**, 223502 (2011)

R. Jahns, H. Greve, E. Woltermann, E. Quandt, R. Knöchel, *Noise Performance of Magnetometers with Resonant Thin Film Magnetoelectric Sensors*, IEEE Transactions on Instrumentation and Measurements, **60 (8)**, 2995 - 3001 (2011)

R. Knöchel, A. Teplyuk, G. Khlopov, K. Schünemann, *Millimeter wave range sensor for protection of outdoor areas*, Proceedings of the 6th Future Security Conference, 468 - 471 (2011)

N. Nasresfahani, P. Rezaee, K. Schünemann, R. Knöchel, M. Tayarani, *Miniaturized Coaxial Cylindrical Cavity Filters Based on Sub-Wavelength Metamaterial Loaded Resonator*, Proceedings of the International Conference on Electromagnetics in Advanced Applications, 1086 - 1089 (2011)

N. Nasresfahani, P. Rezaee, M. Tayarani, *Application of Metamaterials in Microwave Humidity Sensors*, Proceedings of the 25th International Symposium on Microwave and Optical Technology, 143 - 146 (2011)

N. Nasresfahani, K. Schünemann, *Modifying Humidity Sensors Through the Use of Metamaterial Structures*, Theoretical and Methodical Problems of Radio Engineering Systems Effective Functioning, 103 - 110 (2011)

P. Rezaee, N. Nasresfahani, R. Knöchel, M. Tayarani, *Active Learning Method for External Q Computation*, Proceedings of the 6th German Microwave Conference, 1 - 4 (2011)

P. Rezaee, N. Nasresfahani, R. Knöchel, M. Tayarani, *Using Active Learning Method for designing Miniaturized Microstrip Metamaterial Bandpass Filters*, Proceedings of the 25th International Symposium on Microwave and Optical Technology, 257 - 260 (2011)

P. Rezaee, N. Nasresfahani, R. Knöchel, M. Tayarani, *Active Learning Method for Designing Miniaturized Waveguide Filters Loaded by Broadside-Coupled Split Ring Resonator*, Proceedings of the 13th International Conference on Electromagnetics in Advanced Applications, 1074 - 1077 (2011)

P. Rezaee, M. Tayarani, R. Knöchel, *Active Learning Method for the Determination of Coupling Factor and External Q in*

Microstrip Filter Design, Progress in Electromagnetics Research, **120**, 459 - 479 (2011)
P. Rezaee, M. Tayarani, R. Knöchel, *Miniaturized Microstrip Filter Design Using Active Learning Method*, Radioengineering Journal, **20**, **4**, 857 - 865 (2011)

Presentations

H. Mextorf, R. Knöchel, *Kontaktlose Charakterisierung dielektrischer Objekte mittels multivariater Analysemethoden*, UKoLoS Berichtskolloquium, Karlsruhe, Germany, 28.02.-01.03.2011

Further Activities and Events

Prof. Knöchel served as a Vice-Dean until the beginning of July and thereafter as the Dean of the Faculty of Engineering (Technische Fakultät).

Prof. Knöchel is active in the IEEE-MTT (Microwave Theory and Techniques) Society. He was chairman of subcommittee-29 ''Broadband Microwave Systems'' within the programme committee of the ''International Microwave Symposium'', IMS, which is the biggest conference worldwide in that area. He is also Chairman of the technical committee MTT-16, ''Microwave Systems'', and since 2007, a member of the selection committee for the ''IEEE MTT Distinguished Microwave Lecturers''. He also represents the MTT in the executive committee of the ''International Conference on Ultra-Wideband, ICUWB''. He is a member of the ''editorial board'' of ''Frequenz'' and a reviewer for the journals ''IEEE Transactions on Microwave Theory and Techniques'', ''IEEE Microwave and Wireless Components Letters'' as well as journals of the UK ''Institute of Physics'' (IOP) others. He is also a member of VDE Expert Group 7.3, ''Mikrowellentechnik''. Apart from his membership of the IEEE he is also a member of the ''European Microwave Association, EuMA'' and of URSI, commission A.

Prof. A. Guarnieri, is working in the microwave laboratory and leading the ''molecular spectroscopy''.