HL 69: GHz Dielectrics - Materials for mobile communication I (DF with HL/MM)

The world wide amount of wireless data exchange doubles roughly every year. In addition the individual data rates increase and the efficiency of the data exchange needs improvements. Antenna and filter elements are key components for such a development and are subject to intense research efforts. Impulses for innovation also originate from materials while new antenna and filter concepts influence material development. Two Focused Sessions are addressing the subject.

Organizer: Martin Letz (Schott AG Mainz)

Time: Thursday 9:30–13:00 Location: EB 407

Topical Talk HL 69.1 Thu 9:30 EB 407

New application scenarios for dielectric materials in mobile communication systems of the 5th generation — •Roland Gabriel — Kathrein-Werke KG, Anton-Kathrein-Straße 1-3, D-83004 Rosenheim / Germany

The worldwide data volume in mobile communication systems double nearly every year. To address this challenge, higher frequency bands will be used and broadband and multiband equipment are required. The new standard LTE-A and the standardization process for the 5th generation of the mobile communication systems enforces changes in the technology of antennas and filters. Beside the usage of new and higher frequency bands up to 60 GHz the broadband and multiband approach increase the requirements for the linearity of the components. For the use in FDD (frequency division duplexing) - systems this means an extreme low level of the active and passive intermodulation. In this contribution the extendend requirements for passive intermodulation are discussed. Different available solutions for the filter technology will be compared regarding the usage for different system solutions of the 4th and 5th generation. In addition the use of dielectric radiators in antennas will be reconsidered with respect to the multiband approach and the required inter- and intra-band isolation.

HL 69.2 Thu 10:00 EB 407

Impedance matching for high power transistors based on printed ceramics — •Alex Wiens, Daniel Kienemund, and Rolf Jakoby — Technische Universität Darmstadt, Institut für Mikrowellentechnik und Photonik

The multitude of standards in modern tele-communication systems, such as GSM, UMTS, LTE and WiFi make the hardware of a radio front end face a variety of frequencies and bands. Generally, each element of the front end is optimized to perform best at a certain frequency band and signal type. Power amplifiers can be considered as the most critical components of RF/microwave communication systems, as they dominate the power consumption and hence the efficiency of the whole system. They are therefore consequently the focus of intense research to achieve improved linearity and increased power efficiency. Barium-Strontium-Titanate (BST) varactors offer an alternative to semiconductor and MEMS technologies in the design of tunable matching networks for reconfigurable multi-band RF-power amplifiers, and for load modulation applications, where the varactor tuning is used to maintain high efficiency over a large dynamic range of the input signal. Recent advances in fabrication of high power tunable RF varactors based on BST are presented and discussed. Measurement results of a BST-based tunable matching network, implemented inside a GaN HEM Transistor show promissing performance for telecommuncation frequency range.

HL 69.3 Thu 10:20 EB 407

Enhanced magnetooptic Kerr effect and magnetic properties of Ce:YIG thin films — •Andreas Kehlberger[1], Kornel Richter[1], Gerhard Jakob[1], Mehmet C. Onbasli[2], Gerald F. Dionne[2], Dong Hun Kim[2], Taichi Goto[2], Gerhard Götz[3], Günter Reiss[3], Timo Kuschel[3], Caroline A. Ross[2], and Mathias Kläui[1] — [1]Universität Mainz, Mainz, Germany — [2]Massachusetts Institute of Technology, Cambridge, USA — [3]CSMD, Physics Department, Bielefeld University, Germany

Yttrium iron garnet (YIG) is a ferrimagnetic and electrically insulating garnet oxide that has low intrinsic magnetic damping. These properties make YIG a functional layer for spin-wave generation and filtering for telecommunication devices operating at microwave bands. The substitution of Y by Ce allows for an enhancement of the magnetooptic properties and to further influence the magnetic material properties. Our work presents an extensive study of high quality epitaxial Ce:YIG thin films and reveals that not only the magnetooptic properties but also the magnetic anisotropy can be tailored by the Ce substitution. For the first time we show that beside the Faraday rotation also the magnetooptic Kerr effect is enhanced compared to pure YIG, making a broader range of wavelength, including the fibreoptics band, accessible. We present growth methods for polycrystalline Ce:YIG films, which allow the development of integrated on-ship devices.[1,2] Our results show the suitability of Ce:YIG thin film for future magnetooptic and spintronic applications. [1] Lei Bi et al., Nature Photon. 5, 758-762 (2011) [2] Taichi Goto et al., J. Appl. Phys. 113, 17A939 (2013)

HL 69.4 Thu 10:40 EB 407

Design of miniaturized antennas for GNSS applications using a high DK dielectric material — •Stefano Caizzone — Institute of Communications and Navigation, German Aerospace Center (DLR), Wessling, Germany

The use of high dielectric constant (high DK) materials is particularly appealing for a vast number of Radio Frequency (RF) applications, including antenna design. In this field, in fact, high DK low-loss dielectric materials could enable consistent improvements in antenna miniaturization. To the present day, however, common high-DK materials suffer from relatively large manufacturing tolerances, implying remarkable frequency shifts in the antenna radiation and need for retuning. This work, on the other hand, shows the use of a new dielectric material with diminished tolerances for antenna design purposes, both through preliminary tests with a simple antenna structure and through the enhanced design of a miniaturized antenna for GNSS applications. The initial tests were performed in order to validate the usability of the material in the RF area: it was used as a substrate for a microstrip patch antenna. The results show a good behavior of the high DK material and its aptitude for RF antenna design. As a consequence, a Dielectric Resonator Antenna (DRA), fully exploiting the dielectric properties of the material, was designed for use in the lower L-Band of the Global Navigation Systems, allowing for good performance over a wide bandwidth, covering E5, L2 and E6 bands.

Topical Talk HL 69.5 Thu 11:00 EB 407

Dielectric-loaded antennas for circular polarisation: their contribution to the information capacity of wireless terminals — •Oliver Leisten — Maruwa Europe Ltd, UK

Dielectric-loaded multi-filar helix antennas offer solutions as miniature circular polarised antennas in small devices with the advantage that body-loading can suppress reflections from the device: improving circular polarisation discrimination. This is an example of materials-science enabling the design of antennas providing relatively predictable performance in a cluttered and changing near environment. Modern wireless systems typically operate with complex scattering from objects in the indoor environment which can be scaled in frequency to be compared to the Rayleigh scattering of light from the particles of dense smoke. Indeed modern MIMO devices exploit the low spatial autocorrelation of such fields invoking the principle of spatial multiplexing to multiply the information capacity per unit of spectral bandwidth. Such systems use multiple receiving antennas to receive scattered signals summing by superposition, at those discrete antenna locations, of information streams transmitted from multiple transmitting antennas. The small resonance volume dielectric-loaded antennas, together with platform independent polarisation, enhances statistical independence of signals, improving system data-capacity by reducing interference between datastreams. The use of right and left hand circular polarised antennas to invoke polarisation diversity is interesting as Rayleigh scattering develops spin-turbulent fields.

20 min Coffee Break

HL 69.6 Thu 11:50 EB 407

$Ba_4Al_2Ti_{10}O_{27}$ glass-ceramics as dielectric materials for antenna elements in wireless communications — •Martun Hovhannisyan[1], Hubertus Brauna[1], Yuliang Zheng[2], Arshad Mehmood[2], Martin Letz[1], and Rolf Jakoby[2] — [1]Material & Technology Development, SCHOTT AG, Hattenbergstrasse 10, Mainz, 55122, Germany — [2]Technical University of Darmstadt, Darmstadt, D-64283 Darmstadt, Germany

Dielectric glass-ceramics with $Ba_4Al_2Ti_{10}O_{27}$ as the main crystalline phase are obtained by controlled heat-treatment of a non-porous bulk-glass phase. Such a non-porous material has advantages over ceramics with residual porosity wherever metallization steps are applied to the material. Depending on the details of heat-treatment profile the $Ba_4Al_2Ti_{10}O_{27}$ is formed as a main phase with secondary phases $BaTi_4O_9$ or $BaAl_2Si_2O_8$. Microstructural observation using scanning electron microscopy (SEM) shows nanometer-sized crystals (40nm) grown in a true glass phase. The microwave dielectric characterization using Hakki-Coleman setup shows a Qf from 2000 GHz to 10.000 GHz, dielectric constant from 19 to 33 and |tf| of <20 ppm/K. Balancing between different crystalline phases allows to adjust |tf| to zero. To our knowledge the present work is the first one emphasizing the attractiveness of the microwave dielectric properties of the phase $Ba_4Ti_{10}Al_2O_{27}$. Such glass-ceramics are well suited for antenna and filter applications in microwave electronics.

HL 69.7 Thu 12:10 EB 407

Highly conducting $SrMoO_3$ thin films for microwave applications — •Aldin Radetinac[1], Arzhang Mani[1], Sergiy Melnyk[2], Mohammad Nikfalazar[2], Jürgen Ziegler[1], Yuliang Zheng[2], Rolf Jakoby[2], Lambert Alff[1], and Philipp Komissinskiy[1] — [1]Institute for Materials Science, TU Darmstadt, Germany — [2]Institute for Microwave Engineering and Photonics, TU Darmstadt, Germany

We have measured the microwave resistance of highly conducting perovskite oxide $SrMoO_3$ thin film coplanar waveguides. The epitaxial $SrMoO_3$ thin films were grown by pulsed laser deposition and showed low mosaicity and smooth surfaces with a root mean square roughness below 0.3 nm. Layer-by-layer growth could be achieved for film thicknesses up to 400 nm as monitored by reflection high-energy electron diffraction and confirmed by X-ray diffraction. We obtained a constant microwave resistivity of 29 $\mu\Omega$cm between 0.1 and 20 GHz by refining the frequency dependence of the transmission coefficients. Our result shows that $SrMoO_3$ is a viable candidate as a highly conducting electrode material for all-oxide microwave electronic devices. This work was supported by the DFG project KO 4093/1-1.

[1] A. Radetinac, A. Mani, S. Melnyk, M. Nikfalazar, J. Ziegler, Y. Zheng, R. Jakoby, L. Alff, and P. Komissinskiy, Appl. Phys. Lett. **105**, 114108 (2014)

Topical Talk HL 69.8 Thu 12:30 EB 407

Tunable GHz-components with ferroelectric and liquid crystal technologies for mobile terrestrial and satellite-based systems — •Rolf Jakoby — Institute of Microwave Engineering and Photonics, Technische Universität Darmstadt, Merckstr. 25, 64283 Darmstadt, Germany

Recent progress in Liquid Crystal (LC) technology made in Darmstadt is very promising for next-generation reconfigurable/tunable microwave and millimeter wave devices because they exhibit excellent properties at high frequencies above 15 GHz, since LC losses generally decrease with increasing frequency. This opens up new low-cost LC applications beyond optics. In contrast, ferroelectric material, particularly Barium Strontium Titanate (BST), is well suited at frequencies below 15 GHz, using screen and inkjet printing of BST layers. Hence, with these two material classes, we can cover a frequency range from 1 GHz up to 1 THz for tunable components such as varactors, tunable delay and loaded lines, phase shifters, tunable filters, adaptive matching networks, tunable frequency selective surfaces, tunable multiband antennas, polarization-agile antennas, phased-scanning reflect- and phased arrays. This contribution presents an overview of the both technologies, BST and LC, including basic principles, tuning mechanisms, processing technologies, device concepts and design, packaging and integration issues as well as functional tests with focus on frequency-agile multiband antennas and filters as well as electronically beam-steering antennas for mobile terrestrial and satellite-based applications.