1. EVENT DETAILS

TITLE: Advanced Manufacturing and Design Techniques for Emerging 3D Microwave and Millimeterwave RF Filters"

ABSTRACT (500 words limit):

This workshop will focus on recent advances in emerging manufacturing and integration processes for 3D microwave and millimeter-wave RF filters for the next generation of wireless and satellite communication systems. In particular, the workshop will present new RF design and electromagnetic modeling techniques for new classes of RF filtering components (bandpass/bandstop filters, multi-band filters and multiplexers) based on well-established manufacturing processes such as CNC machining and Si-based microfabrication that enables the realization of RF filters from mmWaves to frequencies in the sub-THz region (E.g, 700 GHz). Furthermore, the workshop will provide an overview of emerging digital additive manufacturing processes such as stereolithography, selective laser sintering for new types of materials such as ceramics, plastics and metals and their application to advanced RF filtering architectures. The potential of these processes for complex geometries as well as for RF filters with advanced RF performance, high-frequency of operation, small form factor and low weight will be discussed in detail. Lastly, the workshop will present new RF design methodologies and novel RF filtering architectures that are uniquely enabled by the manufacturing flexibility of 3D printing that facilitates the realization of unconventional shapes.

Workshop type: Full-Day Workshop

Conference association: Associated with IMS

JUSTIFICATION: The unprecedented growth of wireless and satellite communication applications is increasingly calling for advanced RF filtering components with small form factor, low weight and advanced capabilities. In particular, the recently released NR2 frequency bands in the 24.25 GHz to 52.6 GHz range as well as frequencies in the sub-THz regime are expected to enable a plethora of high-data rate, imaging and spectrum sensing applications. However, the current RF design, integration and manufacturing techniques have been limiting the proliferation of communication systems at these frequencies due to their high loss, manufacturing deficiencies and lack of precision. Additive manufacturing (AM) and Si-micromachining have been increasingly explored for the realization of the next generation of microwave and millimeter wave components. However, their capabilities haven't yet been explored to their maximum potential mainly due to being used as a replacement of conventional CNC or PCB manufacturing. This workshop provides new insights in the use of emerging digital additive manufacturing techniques, PCB and microfabrication techniques for the realization of advanced and high-frequency RF components. For the first time, the workshop will discuss the potential for monolithically-integrated RF filters with complex geometries to microwave as well as to mmWave frequencies. To the best of the organizers' knowledge the proposed design and integration concepts haven't been presented to any other IMS or EuMW workshops before and as such there is a great need for such a workshop in IMS 2022. Researchers and practitioners working in the field of advanced manufacturing techniques and process for 3-D filters and, more generally, passive devices for emerging applications are expected to attend our workshop. Audience will come both from the academia and the industry, due to the growing interest of new fabrication techniques of microwave passive devices, such as additive manufacturing. It is expected that this workshop can be one of the more-highly attended for IMS2022 if accepted, being considered as strategic by TC-5 during the annual summer meeting.

Has This Topic Been The Subject of an IMS/RFIC/ARFTG Workshop Previously? No

Additional comments (Are all speakers currently conformed and if not-what fraction are confirmed? Any other comments

All of the proposed speakers are confirmed and are planning to attend IMS and present at this workshop. The proposed workshop proposal includes two merged proposals (one from Prof. Hoft et al. and another from Prof. Psychogiou and Prof. R. Gomez-Garcia) as suggested by the workshop organization committee during the first review round.

PARTICIPATION PLAN:

The workshop organizers will encourage the audience to ask questions during or after the end of each talk as it is typically done in all IMS workshops. Each talk will allow sufficient time for Q & As at the end of each talk and we also plan to have a 20 min long panel discussion at the end of the workshop.

End-of-workshop panel discussion covering questions such as:

1. What are the loss, scaling, and frequency limitations of the demonstrated additive manufacturing techniques or Si-micromachined techniques?

2. What are the prospects of AM in being used for commercialized RF products?

3. What interesting manufacturing and design capabilities are "unlocked" with the proposed manufacturing techniques, e.g, SLA, SLS, DMLS?

4. Is Si-micromachining the pathforward for THz based RF components and what are the applications that will benefit the most?

Estimated number of attendees: 100

ENDORSEMENTS:

1. MTT TC-5 (Xun Gong, Xun.Gong@ucf.edu)
2. MTT TC-13 (Dimitra Psychogiou, DPsychogiou@ucc.ie)

2. EVENT CONTRIBUTORS

1. Dimitra Psychogiou, University College Cork and Tyndall National Institute, Ireland, University of Colorado at Boulder, USA, DPsychogiou@ucc.ie
2. Roberto Gomez-Garcia, University of Alcala, Spain, roberto.gomezg@uah.es
3. Michael Höft, Kiel University, Germany, Michael.Hoeft@tf.uni-kiel.de

3. PRESENTATION, SPEAKER, CO-AUTHOR DETAILS

1. Prof. Michael Hoft, Kiel University, Germany (Michael.Hoeft@tf.uni-kiel.de, +49 431 8806150)

Title: Advanced and adaptive waveguide filter configurations for W-band and beyond

Abstract: By pushing forward the design aspects and manufacturability of microwave components in the higher frequency ranges, namely W-band (75 – 110 GHz) and beyond, new frequency-band allocations can be designated for up-coming mobile and satellite communication systems (providing world-wide

internet over satellite, remote sensing applications, 5G support infrastructure and radio-navigation services). This presentation focusses on providing an overview of the recent research on advanced W-band waveguide filters, where on one hand, small dimensional require the use of high precision-manufacturing technologies, while on the other hand, low geometrical complexity must be adapted to meet the design-rules of the intended technology to be used. Advanced configurations for the realization of multiple transmission zeros and the utilization of higher order modes for advanced performance will be discussed. Results of filters manufactured with high-precision CNC milling as well as 3D-printing will be presented.

Biography: Michael Höft (IEEE M'04-SM'08) received the Dipl.-Ing. degree in electrical engineering and the Dr.-Ing. degree from the Hamburg University of Technology, Hamburg, Germany, in 1997 and 2002, respectively. From 2002 to 2013, he was with the Communications Laboratory, European Technology Center, Panasonic Industrial Devices Europe GmbH, Lüneburg, Germany. He was a Research Engineer and then a Team Leader, where he was involved in the research and development of microwave circuitry and components, particularly filters for cellular radio communications. From 2010 to 2013, he was also a Group Leader for the research and development of sensor and network devices. Since 2013, he has been a Full Professor with Kiel University, Kiel, Germany, in the Faculty of Engineering, where he is currently the Head of the Chair for Microwave Engineering of the Institute of Electrical and Information Engineering. His research interests include active and passive microwave components, (sub-)millimeter-wave quasi-optical techniques and circuitry, microwave and field measurement techniques, microwave filters, microwave sensors, and magnetic field sensors as well as related applications. He is a member of the European Microwave Association, the Association of German Engineers, and a member of the German Institute of Electrical Engineers.

2. Prof. Anthony Ghiotto, University of Bordeaux, France (anthony.ghiotto@ims-bordeaux.fr / +336 30 43 64 47)

Title: Recent Development in AFSIW Filtering and Passive Components Toward Advanced Systems on Substrates

Abstract: Introduced in the early 2000s, the substrate integrated waveguide (SIW) technology, has trigged a huge interest from academia to industry with the focus on the design and development of low-loss, compact, integrated, self-packaged and low-cost microwave and millimeter-wave circuits, antennas and systems. However, the classical metallic waveguide technology, which offers better performances such as lower insertion loss and higher power handling, has still been used in the design of microwave and millimeter-wave systems, despite its higher cost and bulky structure. To offer a highly integrated, further loss-reduced, low-cost alternative to the conventional waveguide and also to allow a wide-spread use of the millimeter-wave spectrum, a new SIW structure called Air-Filled SIW (AFSIW) has been introduced. This new structure has been theoretically and experimentally studied in details with a substantial amount of results. At millimeter wave frequencies, compared to the SIW topologies, the proposed AFSIW scheme exhibits a substantially lower insertion loss (three times at Ka-band, for example) and a much higher average power handling capability (four times, at Ka-band for example). Numerous AFSIW passive components have been investigated designed and demonstrated, which take advantages of the well-established multilayer printed circuit board (PCB) fabrication process. Couplers, phase shifters, power dividers, antennas and filters have been modeled, designed, prototyped and measured based on the introduced technology. Their performances have theoretically and experimentally been compared with their SIW counterparts to demonstrate and validate the benefits of the proposed technology.

Biography: Anthony Ghiotto (Senior Member, IEEE) received the M.Sc. and Ph.D. degrees (Hons.) in optics, optoelectronics, and microwave engineering from the Grenoble Institute of Technology, Grenoble,

France, in 2005 and 2008, respectively.,From 2009 to 2012, he was a Post-Doctoral Research Associate with the École Polytechnique de Montréal, Montreal, QC, Canada. In 2012, he joined the Department of Electronics, ENSEIRB-MATMECA Engineering School, Bordeaux Institute of Technology, University of Bordeaux, Talence, France, and also with the Laboratory of Integration from Materials to Systems (IMS), University of Bordeaux, where he is currently an Associate Professor (with a Full Professor habilitation). In 2016 and 2017, he joined the University of Pavia, Pavia, Italy, as a Guest Professor. His current research interests include the analysis, design, and integration of microwave and millimeter-wave passive and active circuits in printed circuit board (PCB) [including substrate integrated waveguide (SIW) and air-filled SIW], dielectric waveguide, and BiCMOS and CMOS technologies. Dr. Ghiotto was a member of the Organization Committee of the 2015 European Microwave Week and the 2015 French National Microwave Days. He is a member of the MTT Technical Coordination and Future Directions Committee (TCFDC), the MTT-1 Field Theory and Computational EM, the MTT-4 Microwave Passive Components and Transmission Line Structures, and the MTT-5 Filters Committees of the IEEE Microwave Theory and Technique Society (MTT-S). He was a recipient of the Young Scientist Award of the International Union of Radio Science in 2008, the Post-Doctoral Fellowship from the Merit Scholarship Program for Foreign Students of the Fonds Québécois de la Recherche sur la Nature et les Technologies of Québec in 2009, and the IEEE SPI Young Investigator Training Program Award in 2016 and 2017. He was the TPC Chair of the 2019 European Microwave Conference (EuMC). He is an Associate Editor of the EuMA International Journal of Microwave and Wireless Technologies and a Technical Reviewer for the IEEE Transaction on Microwave Theory and Techniques, the IEEE Transaction on Antenna and Propagation, the IEEE Microwave and Wireless Components Letters, and the IEEE Antennas and Wireless Propagation Letters. Since 2017, he has been the Chair of the IEEE MTT French Chapter. He was the Counselor of the IEEE Student Branch of Bordeaux: the BEE Branch, from 2012 to 2019, and the Advisor of the MTT and AP BEE Branch Chapters.

3. Prof. Joachim Oberhammer, KTH Royal Institute of Technology (joachimo@kth.se, +46737652368)

Title: "Silicon micromachining enabling high-Q filter solutions from D-band to THz frequencies"

Abstract: Silicon micromachining is a key enabling fabrication technology for high performance components and system integration at advanced frequencies from 100 GHz to THz frequencies. Since micromachined waveguides have among the lowest losses reported in any technology (0.07 dB/mm at 300 GHz, 0.008 dB/mm at 150 GHz) which results in very high Q-factor components, due to the high fabrication accuracy down to micrometers, and due to the capability of manufacturing very high aspect ratio 3-dimensional geometries, silicon-micromachining provides outstanding performance for cavity resonators and complex filters based on such resonators. This talk summarizes the latest achievements in micromachined filters at sub-THz frequencies, including the first 1% fractional-bandwidth filters above 300 GHz, demonstrated for a 4-pole filter at 700 GHz achieving 2.5 dB insertion loss with cavity resonators with an unloaded Q-factor of 950, and a D-band diplexer with 1.5 dB insertion loss and 60 dB adjacent channel isolation based on cavity resonators with unloaded Q-factors of 1600. The talk will also investigate the limitations and influence of fabrication tolerances, as well as the potential for volume manufacturability with high product uniformity, and the integration of such filters in complete micromachined sub-THz system solutions and in conventional waveguide systems.

Biography: Joachim Oberhammer, born in Italy in 1976; M.Sc. EE from Graz University of Technology, Austria, in 2000; Ph.D. from KTH Royal Institute of Technology in Stockholm, Sweden, in 2004. Post-doctoral research fellow at Nanyang Technological University, Singapore, in 2004, and at Kyoto University, Japan, in 2008. Since 2005 leading radio-frequency/microwave/terahertz micro-electromechanical systems research at KTH; Associate Professor at KTH in 2010; Professor in Microwave and THz

Microsystems at KTH since 2015. Guest researcher at Nanyang Technological University, Singapore, in 2007; guest researcher at NASA-Jet Propulsion Laboratory, USA, in 2014; guest professor "Chair of Excellence" at Universidad Carlos III de Madrid in 2019/2020. He is author and co-author of more than 100 reviewed research papers and holds 4 patents. In 2004, 2007, and 2008 he got an award by the Ericsson Research Foundation, a grant by the Swedish Innovation Bridge, and a scholarship by the Japanese Society for the Promotion of Science, respectively. The research work he is heading received six Best Paper Awards (five of which at IEEE conferences), and four IEEE Graduate Fellowship Awards (by MTT-S and by AP-S) since 2009. He served as TPRC member of IEEE Transducers (2009, 2015, 2019), IEEE International Microwave Symposiums (2010-2018), IEEE Micro Electro Mechanical Systems (2011, 2012), IEEE Radio and Wireless Week (2015, 2016), EuMCE (2019). Dr Oberhammer is Steering Group member of the IEEE MTT-S and AP-S Chapers Sweden since 2009. In 2013, he received an ERC Consolidator Grant by the European Research Council. Steering Group Member of the Young Academy of Sweden 2014-2016. Representative of Sweden/Norway/Iceland in the European Microwave Association 2016-2018. Associate Editor of IEEE Transactions on Terahertz Science and Technology since 2018. PI of two SEK 35-million SSF framework grants on electronics (2014-2020; 2021-2025). Scientific coordinator of the EU RIA projects M3TERA and Car2TERA (both H2020).

4. Dr. Yi Yang, University of Birmingham, UK (Y.Wang.1@bham.ac.uk)

Title: Waveguide-based filtering components using new manufacturing techniques

Abstract: Waveguide structures are the preferred transmission media for their low loss in a number of application areas. High-power microwave filters in satellites rely on high-Q and temperature-stable resonators to meet the stringent frequency-band and performance requirements. At mm-wave and sub-terahertz frequencies, air-filled waveguides offer competitively low transmission losses and present significant advantages over many other transmission media when decent powers are hard to come by and efficiency becomes one key design drive. Whether it is at microwave or up to sub-terahertz frequencies, the main workhorse in manufacture has always been traditional machining. This talk will explore new manufacturing techniques for waveguide-based filtering components at the two different frequency bands. At microwave frequencies, some recent work on the use of additive manufacturing and/or new materials will be presented for the design and fabrication of high-power filters. At D-band (110-170 GHz) and above, a number of devices will be demonstrated by using several different precision-manufacturing techniques such as high-precision 3D printing, and various micromachining processes. The presented devices will include filters, multiplexers and other signal distribution networks with embedded filtering functions.

Biography: Dr Yi Wang is an Associate Professor at University of Birmingham in the UK. He received the B.Sc. and M.Sc. degree in physics from the University of Science and Technology, Beijing and the Ph.D. degree in electronic and electrical engineering from the University of Birmingham. He is currently leading the Emerging Device Technology (EDT) Research Lab. He is also the academic lead of the Engineering Cleanroom and the THz VNA facility at Birmingham. He is the author of over 160 research papers. He served as the TPC Chair of 2021 European Microwave Conference. His current research interests include multiport filtering networks, millimeter-wave and terahertz antennas and devices. He is particularly interested in new materials and novel manufacturing techniques for high-frequency device applications.

5. Dr. Reinhard Teschl , Graz University of Technology, Austria (reinhard.teschl@tugraz.at)

Title: Additive manufacturing processes in ceramic and metal for the fabrication of RF filters

Abstract: The continuous improvement of additive manufacturing (AM) technologies facilitates and stimulates also the RF community. In particular, the design and manufacture of typical passive components like RF filters underwent a change with the new possibilities of rapid prototyping, the implementation of new forms and geometries, right up to the use of novel materials. However, each of the different AM-technologies and the applied materials introduce certain constraints. This presentation will focus on the process categories *lithography-based manufacturing* and *selective laser melting* and the materials *ceramics* and *metals* and will show examples of different stages of the RF filter development and fabrication. Also the influence of certain pre- and post-processing steps like machine process optimization, sintering, and post-processing treatments to reduce the surface roughness will be discussed, thus, addressing also the practical aspects of the fabrication process.

Biography: Reinhard Teschl was born in Graz, Austria. He studied information and computer engineering at Graz University of Technology (TU Graz), and received master's level and doctor's degree in 2001 and 2010 respectively. From 2010 to 2017, he was as a senior scientist, at the radar and microwave propagation group within the Institute of Microwave and Photonic Engineering (IHF) at TU Graz, were he investigated weather radar systems and conducted data-based atmospheric- and hydrological studies. Since 2017 he is a university assistant at IHF, teaching courses on communication engineering, antennas and RF/microwave component design. He is currently a project leader in the IHF research group on antennas and filters and an associated researcher at the TU Graz research center 'Dependable Internet of Things in Adverse Environments'. His research interests include adaptable passive microwave components and related manufacturing challenges. Dr. Teschl is acting as a reviewer for journals on microwave engineering, co-supervisor of PhD students, and involved in the organization of scientific conferences (Organizing Committee Co-Chair: CoBCom 2020, ConTEL 2019)

6. Dr Nicolas Delhote, Xlim, CNRS/University of Limoges, France (nicolas.delhote@xlim.fr)

Title: Advanced ceramics and manufacturing technologies applied to 3D filters

Abstract: This talk will be focused on the use of advanced ceramics and related manufacturing technologies (additive manufacturing, laser micromachining, etc) for the creation of 3D filters. These filters will present specific properties such as high quality factor, small size, temperature stability and surface mounting capabilities for microwave and millimetre wave applications up to 40 GHz.

Biography: Dr. Nicolas Delhote (40 years old) received his Ph.D. degree in 2007 from the XLIM Research Institute and has been with XLIM since that date. He specialized in 3D manufacturing technologies to fabricate RF and millimeter wave passive components (filters, waveguides, and RF transitions) and tunable counterparts. He particularly focused most of his activity on additive manufacturing technologies and advanced materials for high-end applications (space telecommunications, airborne radar applications, and high-frequency wireless telecommunications). He is the head of the MACAO group since 2016 (8 faculty members, 12 Ph.D. students and postdocs).

7. Prof. Dimitra Psychogiou, University College Cork and Tyndall National Institute, Ireland, University of Colorado at Boulder, USA (DPsychogiou@ucc.ie)

Title: Monolithic integration concepts for highly-versatile and highly-miniaturized coaxial RF filters enabled by SLA 3D printing

Abstract: Additive manufacturing (AM) has been paving the way to a new era of microwave and millimeter-wave RF components whose performance, shape and form factor is no longer limited by the tolling and manufacturing capabilities of the manufacturing process. Thus, AM RF systems with smaller size, advanced capabilities and new functionalities can be envisioned for the next generation of wireless and satellite communication systems. This workshop will present an overview of a new manufacturing concept for coaxial-resonators, and coaxial frequency selective RF components that enables the realization of monolithic components with complex geometrical features. The proposed integration concept is based on SLA 3D printing and facilitates the realization of RF filters with high levels of geometrical complexity, transfer function versatility and highly-miniaturized form factor. The workshop will demonstrate the design, manufacturing and testing of various proof-of-concept prototypes of bandpass, multi-band and reconfigurable filtering configurations with state-of-the-art RF performance.

Biography: Prof. Dimitra Psychogiou received the Dipl.-Eng. degree in Electrical and Computer Engineering from the University of Patras, Patras, Greece, in 2008, and the Ph.D. degree in Electrical Engineering from the Swiss Federal Institute of Technology (ETH), Zürich, Switzerland, in 2013. She is currently a Professor of Electrical and Electronic Engineering with the University College Cork (UCC) and the Tyndall National Institute, Cork, Ireland and an Assistant Professor at UC Boulder, USA (on leave). Her current research interests include RF design and characterization of reconfigurable microwave and millimeter-wave passive components, RF MEMS, acoustic wave resonator-based filters, tunable filter synthesis, reconfigurable antennas and additively-manufactured antenna front-end interfaces. She has received the 2020 CAREER Award from the National Science Foundation (NSF), the 2020 URSI Young Scientist Award, and the Junior Faculty Outstanding Research Award from UC Boulder. Furthermore, the research that she has been leading has led to three IEEE Best Student Paper Awards, six IEEE Student Design Awards, four Graduate Fellowship Awards and five Research Excellence Graduate Student Awards. Prof. Psychogiou serves on the Technical Review Board for various IEEE and EuMA conferences and journals. She is also the Chair of MMT-13 and the Secretary of USNC-URSI Commission D. From 2015-2019 she was an Associate Editor of the IET Microwaves, Antennas & Propagation Journal. She is currently an Associate Editor of the IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS and the International Journal of Microwave and Wireless Technologies. She is also a Senior Member of IEEE and URSI and a member of the IEEE MTT-S Filters and Passive Components (MTT-5) and Microwave Control Materials and Devices (MTT-13) committees.

8. Mr. Petronilo Martín-Iglesias, European Space Agency, Netherlands and Public University of Navarre (petronilo.martin.iglesias@esa.int) and:

Fernando Teberio, Public University of Navarre, Spain

Jon Percaz, , Public University of Navarre and National Institute of Aerospace Technology (INTA), Spain

Santiago Martín-Iglesias, Public University of Navarre, Spain

Israel Arnedo, Public University of Navarre - Spain

Txema Lopetegi , Public University of Navarre - Spain

Ivan Arregui, Public University of Navarre - Spain

Miguel A.G. Laso, Public University of Navarre, Spain (mangel.gomez@unavarra.es)

Title: High Power 3D printed parts: from multipactor to thermal aspects

Abstract: RF parts built using Additive Manufacturing (AM) present, in most of the cases, complex cross-sections and routing. This increase complexity does not come at the cost of higher price thanks to the inherent freedom obtained through a AM approach. When talking about the surface characterictics of a 3D printed part, roughness is the most obvious drawback with the consequent impact in the ohmic conductivity and hence, thermal aspects. Thermal aspects could be counterbalanced with a proposal RF-Thermal design optimization which, again, is enabled by the use of the design/manufacturing freedom provided by AM. However, a certain degree of roughness will have a positive contribution to the power handling performance in terms of multipactor. This presentation will provide an overview of the performance impact in RF parts when AM is used for the building.

Biography: Petronilo Martín-Iglesias was born in Caceres, Spain, on April 23, 1980. He received the Telecommunication Engineering degree from the Polytechnic University of Madrid, Madrid, Spain, in 2002, and the Master degree from The University of Leeds, Leeds, U.K., in 2012. He has been working in industry for over ten years as a Microwave Engineer involved with active (high power amplifiers for radar applications) and passive (filters, multiplexers, couplers, etc.) RF hardware design, including two years as a Radar System Engineer with Indra Sistemas, ISDEFE S.A., and Thales Alenia Space Spain. Since Summer 2012, he has been involved with research and development and project support activities related with RF passive hardware developments for the European Space Agency. His research interests are filter synthesis theory, electromagnetic (EM) design and high power prediction, as well as advanced manufacturing techniques for RF passive hardware. From January 2021 he is part of the Earth Observation Future Microwave Instruments Section at ESA-ESTEC. Currently, he is working in his PhD at Public University of Navarre under the supervision of Professor Miguel A.G. Laso

9. Prof. Cristiano Tommassoni, University of Perugia, Italy, (cristiano.tomassoni@unipg.it)

Title: How to exploit the high flexibility of the additive manufacturing in filter design

Abstract: With the advent of the Internet of Things (IOT), new challenges are awaiting the scientific community in microwave and mm-wave technologies. Furthermore, the development of the fifth generation (5G) cellular mobile networks opens great perspectives for increased communication speed and new services. In this context there is the need for new flexible technologies that allow high/reasonable performance at low/moderate price, rapid prototyping and custom design. From this point of view, Additive Manufacturing (AM) technology is a very promising technology and in recent years, its use in the microwave area has been successfully discussed and presented in many scientific papers. In this talk, it will be shown the application of this technology to the manufacturing of microwave filters. In particular it will be shown how the flexibility of AM can be exploited to manufacture new classes of filters with non-conventional geometries that cannot be (or can hardly be) manufactured by traditional manufacturing techniques. It will also be shown the importance of AM oriented design and the importance of postprocessing in order to improve performances.

Biography: Cristiano Tomassoni is with the University of Perugia, where he currently teaches the 'Advanced design of microwave and RF systems' course and the 'Antennae' course. His main area of research concerns the modeling and design of waveguide devices and antennas. His research interests also include the development of reduced-size cavity filters, reconfigurable filters, and printed reconfigurable antenna arrays. Cristiano Tomassoni is an Associate Editor of the IEEE Transactions on

Microwave Theory and Techniques and a member of the MTT-5 Filters Technical Committee. He received the Best Paper Award (Second Place) at NEMO 2018 and the Best Paper Award (first place) at the 15th Mediterranean Microwave Symposium (MMS2015). He was the recipient of the 2012 Microwave Prize presented by the IEEE Microwave Theory and Technique Society (IEEE MTT-S), recognized to the authors of the paper judged to be the most significant contribution of the year in the field of interest of the MTT Society.

10. Prof. Adam Lamerki, Gdansk University of Technology and EM Invent sp. z.o.o, Poland, (adam.lamecki@gmail.com) and:

Prof. Michal Mrozowski, Gdansk University of Technology, Poland, (m.mrozowski@ieee.org)

Title: Shape deformation as a tool for miniaturization of 3D printed microwave filters

Abstract: The technological revolution initiated by the widespread accessibility of high-quality additive manufacturing (AM) technology proliferates rapidly in many areas of engineering. However, in microwave cavity filter design, we are often constrained in AM by the capabilities of design tools based on full-wave EM simulations that do not give one the modeling flexibility that is 100% compatible with the flexibility of the 3D printing technology. Even if an underlying numerical technique for solving Maxwell equations is fully general and capable of handling arbitrary shapes, in the design process, we often involve only a basic constructive solid geometry approach (CSG), which is a limiting factor to develop truly arbitrary, smooth, and parameterized surfaces of cavity resonators and filters. In this talk, we will focus on a novel paradigm of microwave filter design that involves shape deformation techniques. Such techniques give a designer an extra degree of freedom in filter modeling, allowing one to improve the electromagnetic performance of the component. Finally, we will discuss the advantages of shape deformation and show some of the recently developed filters for satellite communication systems with improved out-of-band performance.

Biography: Adam Lamecki received a Ph.D. and D.Sc. degrees in microwave engineering from Gdansk University of Technology (GUT), Gdansk, Poland, in 2007 and 2019, respectively. In 2007, he co-founded EM Invent, a spin-off company, Gdansk, which develops an electromagnetic field simulator InventSim, where he serves as the CTO. Since 2019, he has been an Associate Professor with the Department of Microwave and Antenna Engineering, GUT. His research interests include surrogate models and their application in the CAD of microwave devices, computational electromagnetics mainly focused on the finite element method, and filter design and optimization techniques. Dr. Lamecki was a recipient of the Domestic Grant for Young Scientists awarded by the Foundation for Polish Science in 2006. He received the Award of Prime Minister for the doctoral thesis in 2008 and a scholarship from the Ministry of Science and Higher Education in 2011.