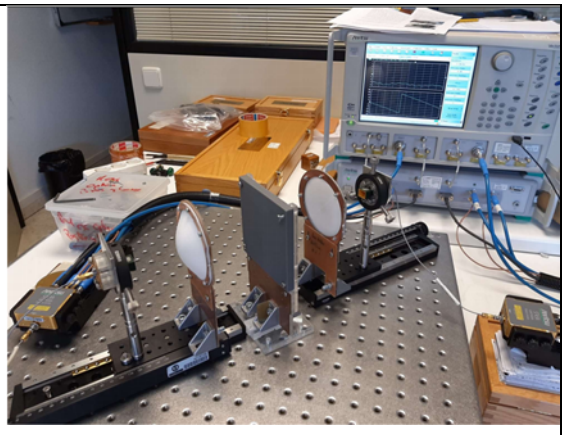
Scientific Workshop SW02

Challenges in Modern Material Measurements (AMTA Workshop)

Abstract:



In the past, electromagnetic material characterization measurements focused primarily on extracting the permittivity and permeability of simple media at microwave frequencies. However, recent advancements in technology have made it possible to fabricate and consequently measure more exotic (i.e., non-simple) media well into the optical regime. These modern materials present many challenges to the measurement community since they may exhibit nonlinear, non-isotropic, spatially nonlocal, time-varying and/or nonreciprocal behaviour. The primary goals of this workshop are to discuss challenges encountered in extracting electromagnetic constitutive parameters of exotic materials and to subsequently identify potential solutions via invited talks and group participation.

Workshop Program (Thursday 25 March 2021, 10h-11.40h)

The workshop is essentially dedicated to invited talks on the various types of modern materials and their constitutive relations, including nonlinear, non-isotropic, spatially/temporally nonlocal, spatially/temporally nonhomogeneous media. The talks will discuss techniques and challenges of measuring the electromagnetic properties of these modern materials, and material measurement techniques in challenging frequency bands, as the millimetrewave one and beyond.

10.05h-10.05h, *Welcome and Workshop Opening*
Prof. Amedeo Capozzoli, Università di Napoli Federico II, AMTA Liaison;

10.05h-10.35h, *Homogenization and Effective Constitutive Parameters of Electromagnetic Metamaterials*,
Prof. Andrea Alù, City College of New York,;

10.35h-11.05h, *Homogenization of metamaterials and possible material sensing strategies with exceptional points*,
Prof. Filippo Capolino, University of California Irvine;

11.05h-11.35h, *Material Characterization in the Millimeterwave Frequency Range and Beyond*,
Dr. Jan Barowski, Ruhr-Universität Bochum;

11.35h-11.40h, Conclusions.

The 15th European Conference on Antennas and Propagation (EuCAP)
22 – 26 March 2021 | Virtual Conference

Homogenization and Effective Constitutive Parameters of Electromagnetic Metamaterials

Andrea Alù

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In this talk, I discuss the challenges associated with properly modeling the electromagnetic response of metamaterials made of complex subwavelength inclusions. In particular, I discuss how their homogenization presents inherent challenges stemming from frequency and spatial dispersion, and cannot rely on common assumptions used in the theory of mixtures and composite materials. The non-negligible size of the inclusions composing these artificial materials, their strong interactions with the electromagnetic waves, and their near-field and far-field interactions with other inclusions requires a careful consideration of nonlocality, which can be properly treated by carefully considering the underlying phenomena around the unusual effects emerging in metamaterials. In the talk, I will discuss the impact of these issues for various metamaterial geometries, and provide examples of how a careful consideration of these phenomena enables an efficient yet rigorous description of metamaterials as homogeneous media for various applications.

Andrea Alù is the Founding Director and Einstein Professor at the Photonics Initiative, CUNY Advanced Science Research Center. He received his Laurea (2001) and PhD (2007) from the University of Roma Tre, Italy, and, after a postdoc at the University of Pennsylvania, he joined the faculty of the University of Texas at Austin in 2009, where he was the Temple Foundation Endowed Professor until Jan. 2018. Dr. Alù is a Fellow of NAI, IEEE, AAAS, OSA, SPIE and APS, and has received several scientific awards, including the IEEE Kiyo Tomiyasu Award, the Vannevar Bush Faculty Fellowship from DoD, the ICO Prize in Optics, the NSF Alan T. Waterman award, the OSA Adolph Lomb Medal, and the URSI Issac Koga Gold Medal.

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Homogenization of metamaterials and possible material sensing strategies with exceptional points

Filippo Capolino

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Metamaterials made of collections of subwavelength inclusions can be described in terms of homogenized parameter. However in many cases local permittivity and permeability may not be enough to characterize the electromagnetic properties of such metamaterials. Only after several years of attempts to homogenize metamaterials, people understood that is important to consider the effect of spatial dispersion in their homogenization. I will present a general method that will provide such description.
In the second part of the talk I will discuss how very sensitive material measurements at microwaves can be done using the rather novel concept of exceptional points. I will also discuss how such degeneracy can be achieved in coupled waveguides, like coupled microstrips.

Filippo Capolino received the Ph.D. degree in electrical engineering from the University of Florence, Italy, in 1997. He is currently a Professor with the Department of Electrical Engineering and Computer Science at the University of California, Irvine, CA, USA. Previously he has been an Assistant Professor at the Department of Information Engineering at the University of Siena, Italy. From 1997 to 1999, he was a Fulbright Scholar and Postdoctoral Fellow with the Department of Aerospace and Mechanical Engineering, Boston University, MA, USA. From 2000 to 2001, part of 2005 and in 2006, he was a Research Assistant Visiting Professor with the Department of Electrical and Computer Engineering, University of Houston, TX, USA. He has been a short term Visiting Professor at the Fresnel Institute, Marseille, France (2003) and at the Centre de Recherche Paul Pascal, Bordeaux, France (2010).
His research interests include applied electromagnetics in general, sensors in both microwave and optical ranges, photonics, microscopy, metamaterials and their applications, traveling wave tubes, antennas, propagation, wireless systems, chip-integrated systems, etc. He is an IEEE Fellow, and he is the editor of the two volume “Metamaterials Handbook”.

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Material Characterization in the Millimeterwave Frequency Range and Beyond

Jan Barowski

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The talk gives an overview of the fundamentals in free space as well as waveguide-based material characterization. Additionally, the aspect of systematic error correction and system calibration is explained with the aim to measure the reflection and transmission properties of the material under test in a very precise way. Based on these measurements, an extraction of the intrinsic electromagnetic properties, namely dielectric constant and loss tangent, has to be done. For this purpose, several approaches of different complexity are discussed with respect to varying applications. In addition to fundamental aspects, the talk especially addresses measurement opportunities and challenges that arise at very high frequencies beyond 100 GHz such as a higher sensitivity to positioning errors, higher attenuation and stronger dispersion inside the material under test. Amongst others, application examples from automotive radar radome and bumper characterization, building entry loss characterization and industrial pipe extrusion measurements are presented and discussed.
Furthermore, radar-based material characterization approaches are presented that only provide a reduced set of information to estimate the material parameters compared to standard vector network analyzer based measurements but offer the opportunity of an easier deployment into industrial scenarios.

Jan Barowski (S'12 - M'18 - SM'20) did his PhD in 2017 with the Institute of Microwave Systems at Ruhr University Bochum on a combination of synthetic aperture radar imaging and microwave material characterization. Since then he is working as post-doctoral Research Scientist at the Institute of Microwave Systems. His currents fields of research are concerned with radar signal processing, radar imaging and millimeter wave material characterization techniques in industrial and academic applications. His dissertation was awarded by the VDE (German Association for Electrical, Electronic & Information Technologies). In 2016 he received the IEEE APS Doctoral Research Award and in 2018 the Young Scientist Award of the German U.R.S.I. section.