


IEEE

microwave

MAGAZINE

for the Microwave & Wireless Engineer 

Volume 22 • Number 5 • May 2021

IMS2021 Microwave Week

6–11 June 2021
Atlanta, Georgia



IEEE

Editor

Robert H. Caverly, Villanova University, Pennsylvania, USA, microwave.editor@ieee.org

Assistant Editor

Sharri Shaw, JWM Consulting LLC, USA, microedt@outlook.com

Associate Editors

Nuño Borges Carvalho, University of Aveiro, Portugal, nbcarvalho@ua.pt

Simone Bastioli, RS Microwave, New Jersey, USA, sbastioli@rsmicro.com

Chia-Chan Chang, National Chung-Cheng University, Taiwan, ccchang@ee.ccu.edu.tw

Ali Darwish, American University in Cairo, Egypt, ali@darwish.org

Christian Fager, Chalmers University of Technology, Sweden, christian.fager@chalmers.se

Jianguo Ma, Guangdong University of Technology, China, mjpg@gdut.edu.cn

Alfy Riddle, Quanergy Systems, Inc., Sunnyvale, California, USA, alfred.riddle@quanergy.com

Luca Roselli, University of Perugia, Italy, urlofi@tin.it; luca.roselli@unipg.it

Kamal Samanta, Sony Europe, U.K., kmlsamanta@googlemail.com

Almudena Suarez, University of Cantabria, Spain, almudena.suarez@unican.es

Anding Zhu, University College Dublin, Ireland, anding.zhu@ucd.ie

Columns and Departments

MicroBusiness

Fred Schindler, Newtonville, Massachusetts, USA, m.schindler@ieee.org

Health Matters

James C. Lin, University of Illinois-Chicago, Chicago, Illinois, USA, lin@uic.edu

Microwave Surfing

Rajeev Bansal, University of Connecticut, Storrs, Connecticut, USA, rajeev@engr.uconn.edu

Book Reviews

James Chu, Kennesaw State University, Marietta, Georgia, USA, jameschu@bellsouth.net

Education Corner

Wenquan Che, Nanjing University of Science and Technology, China, yeeren_che@163.com

Women in Microwaves

Sherry Hess, Cadence Design Systems, Inc., sherry.hess.us@ieee.org

Membership News

Bela Szendrenyi, Advantest, San Jose, California, USA, bela.szendrenyi@advantest.com

New Products

Ken Mays, The Boeing Company, Washington, USA, microwave.newproducts@ieee.org

In Memoriam Contributions

Jerry Hausner, USA, j.hausner@ieee.org

Ombuds Officer

Edward C. Niehenke, Niehenke Consulting, USA, e.niehenke@ieee.org

IEEE Periodicals Magazines Department

Mark Gallaher, Managing Editor

Geraldine Krolin-Taylor, Senior Managing Editor

Janet Dudar, Senior Art Director

Gail A. Schnitzer, Associate Art Director

Theresa L. Smith, Production Coordinator

Felicia Spagnoli, Advertising Production Manager

Peter M. Tuohy, Production Director

Kevin Lisankie, Editorial Services Director

Dawn Melley, Senior Director, Publishing Operations

Advertising Sales

Mark David, Director, Business Development—Media & Advertising
+1 732 465 6473, fax +1 732 981 1855

Digital Object Identifier 10.1109/MMM.2021.3056832



IEEE prohibits discrimination, harassment, and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.



Volume 22 • Number 5 • May 2021 • ISSN 1527-3342

features

78 Label-Free Noninvasive Cell Characterization

A Methodology Using Broadband Impedance Spectroscopy
James C.M. Hwang

88 Terahertz Wireless Communications

Recent Developments Including a Prototype System for Short-Range Data Downloading
Ho-Jin Song

100 Millimeter-Wave Gallium Nitride Devices for 5G

Massive MIMO Antenna Arrays for Sub-6 Ghz and mm-Wave Bandwidth
Akira Inoue

IMS2021

- 32 IMS2021 General Chairs' Welcome**
■ Steve Kenney and John Papapolymerou
- 34 The Journey Toward a Smarter, Safer, and Connected World With IMS2021 Technical Program**
■ Debabani Choudhury, Hua Wang, and Jenshan Lin
- 38 IMS2021 Focus Sessions**
■ Manos M. Tentzeris, Omeed Momeni, and Yong-Kyu Yoon
- 40 IMS2021 Panel Sessions**
■ Ruonan Han, Rui Ma, and Jennifer Kitchen
- 42 IMS2021 Microwave Week Workshops**
■ Kaushik Sengupta, Glenn Hopkins, Danilo Manstretta, Mona Mostafa Hella, and Patrick Roblin
- 60 IMS2021 Technical Lectures**
■ Jeffrey Nanzer and Steven Bowers
- 63 The IMS2021 Microwave Week Virtual 3MT Competition**
■ John W. Bandler, Erin M. Kiley, Daniel Tajik, and Aline Eid



on the cover:

IMAGE COURTESY OF OMNI HOTELS

IEEE Microwave Theory and Techniques Society

The IEEE Microwave Theory and Techniques Society (MTT-S) is an organization, within the framework of the IEEE, of members with principal professional interests in the field of microwave theory and techniques. All Members of the IEEE are eligible for membership in the Society. Information about joining the IEEE or the Society is available on the web, <http://www.ieee.org/> membership.

MTT-S AdCom

The Society is managed by an Administrative Committee (AdCom) consisting of 21 elected members of the Society plus additional ex-officio members as provided in the MTT-S Constitution and Bylaws, which is available on the web, <http://www.mtt.org>.

Officers

President: Gregory Lyons
President-Elect: Rashaunda Henderson
Secretary: Joseph Bardin
Treasurer: Maurizio Bozzi

Elected Members

Scott Barker	Sherry Hess
Maurizio Bozzi	Sridhar Kanamaluru
Nuno Borges Carvalho	Dietmar Kissinger
Robert H. Caverly	Gregory Lyons
Goutam Chattopadhyay	Raafat Mansour
Wenquan Che	Daniel Pasquet
Terry Cisco	Ajay Poddar
Kamran Ghorbani	Jose Rayas-Sanchez
Xun Gong	Peter Siegel
Ramesh Gupta	Anding Zhu
Rashaunda Henderson	

Ex-Officio Members

Immediate Past Presidents:

Alaa Abunjaileh* (2020)
Dominique Schreurs* (2018–2019)
Dylan Williams* (2017)

Honorary Life Members*
(max. three votes):

Józef Modelski
John T. Barr IV
Tatsuo Itoh
Richard Sparks
Peter Staecker

MTT-S Publications

IEEE Trans. Microwave Theory & Techniques Editor:	Jianguo Ma*
IEEE Microwave & Wireless Components Letters Editor:	Thomas Zwick*
IEEE Microwave Magazine Editor:	Robert H. Caverly
IEEE Trans. Terahertz Science & Technology Editor:	Imran Mehdi*
IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology Editor:	Yongxin Guo
IEEE Journal on Multiscale and Multiphysics Computational Techniques Editor:	Costas Sarris
IEEE Journal of Microwaves Editor:	Peter Siegel

*Indicates voting AdCom ex-officio member

IEEE Microwave Magazine (ISSN 1527-3342) (IEMMF) is published 12 times a year by the Institute of Electrical and Electronics Engineers, Inc. Headquarters: 3 Park Avenue, 17th Floor, New York, NY 10016-5997 USA. Responsibility for the contents rests upon the authors and not upon the IEEE, the Society, or its members. IEEE Service Center (for orders, subscriptions, address changes): 445 Hoes Lane, Piscataway, NJ 08854. Telephone: +1 732 981 0060, +1 800 678 4333. Individual copies: IEEE members US\$20.00 (first copy only), nonmembers US\$37.00 per copy. Subscription rates: Subscriptions for Society members are included with membership dues. Nonmember subscription rates available upon request. Copyright and reprint permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of U.S. Copyright law for the private use of patrons those articles that carry a code at the bottom of the first page, provided the per-copy fee is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923 USA. For other copying, reprint, or republication permission, write Copyrights and Permissions Department, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854 USA. Copyright © 2021 by the Institute of Electrical and Electronics Engineers, Inc. All rights reserved. Periodicals postage paid at New York, N.Y., and at additional mailing offices. Ride along enclosed. Postmaster: Send address changes to IEEE Microwave Magazine, IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 08854 USA. Canadian GST #125634188
PRINTED IN THE USA

Digital Object Identifier 10.1109/MMM.2021.3056833

IMS2021 (Continued)

- 66 **WiM Virtual Event: Leveraging the Past to Envision the Future**
■ Rhonda Franklin
- 68 **IMS2021 RF Boot Camp Rescheduled to IMS2022**
■ Larry Dunleavy, Joanne Mistler, and Angie Rogers
- 70 **IMS2021 Project Connect: Connecting to Broaden Participation**
■ Rhonda Franklin, Rashaunda Henderson, Netra Pillay, Heena Rathore, Abhay Samant, and Tom Weller
- 72 **The Hybrid 2021 RFIC Symposium**
■ Brian Floyd, Osama Shana'a, and Donald Y.C. Lie
- 76 **ARFTG at IMS2021 Microwave Week**
■ Marco Spirito and Basim Noori
- 128 **IMS2021 Program Preview**

columns & departments

- 6 **From the Editor's Desk**
■ Robert H. Caverly
Something for Everyone
- 10 **President's Column**
■ Gregory Lyons
IMS: Connecting Minds. Exchanging Ideas.
- 14 **MicroBusiness**
■ Fred Schindler
Success and Failure Part 3: Sustained Organizational Achievement
- 17 **Microwave Surfing**
■ Rajeev Bansal
Sic Transit Gloria Mundi
- 19 **Microwave Bytes**
■ Steve C. Cripps
Canned Electromagnetics
- 24 **Health Matters**
■ James C. Lin
Science, Politics, and Groupthink
- 27 **Women in Microwaves**
■ Sherry Hess and Rhonda Franklin
Interview With the 2021 IMS Women in Microwaves Event Chair
- 112 **MTT-S Society News**
■ Mohammad-Reza Tofghi, Chung-Tse Michael Wu, and Dominique Schreurs
TC-28 Technical Committee Report
- 114 **Education News**
■ Michael C. Hamilton, Rashaunda Henderson, and Robert Caverly
MTT-S Webinars Scheduled for May–December 2021
- 116 **Educator's Corner**
■ Madhu S. Gupta
The Role of CAD Training in Microwave Education
- 121 **Speaker's Corner**
■ George E. Ponchak
Is It a Conference or a "Conference"?
- 123 **Enigmas, etc.**
■ Takashi Ohira
Shunt Capacitor Voltage
- 126 **Conference Calendar**