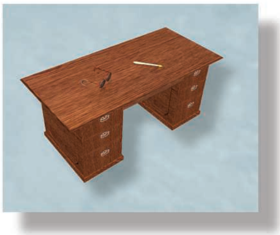


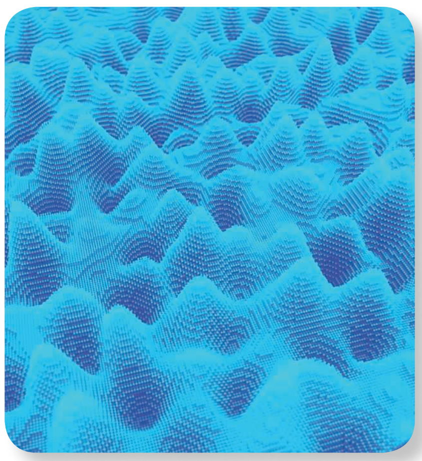
From the Guest Editor's Desk

The Field of Microwave Magnetics

■ Christopher D. Nordquist

This issue of *IEEE Microwave Magazine* contains three focus articles covering nonreciprocal and tunable devices and circuits using novel magnetic materials, which provide essential functions for modern RF and microwave front ends. This multidisciplinary field involves materials, device physics, electromagnetics, circuit design, fabrication, and testing. Accordingly, microwave magnetics provides a rich landscape for scientific discovery and advanced device development with the potential of producing differentiating technologies that improve the performance of future RF and microwave systems.

The IEEE Microwave Theory and Technology Society (MTT-S) has a long history in developing and applying magnetic materials to microwave applications. The first mention of ferrites for high-frequency use appears in the IEEE and predecessor Institute of Radio Engineers literature in 1949 [1], followed over the next decade by reports of waveguide circulators [2], ferrite phase shifters [3], and the now-ubiquitous stripline circulator [4]. These developments progressed to using nonlinear magnetic spin waves to realize frequency-selective limiters [5] and signal-to-noise enhancers [6] for interference mitigation. This early work provided the foundation for the current availability of these types of devices for everyday use in microwave systems.



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Seven decades after these initial developments, a relatively small but dedicated community within the MTT-S continues to advance and develop these types of technologies that supplement and complement recent promising efforts to use parametric switching to realize nonreciprocal circuit responses [7]. This work is driven by desires for improved interference mitigation and simultaneous transmit and receive [8]; miniaturized and tunable passives and sensors [9], [10]; and integration with other technologies, such as integrated circuits and antennas [11]. At the same time, improvements in material synthesis and integration techniques have enabled devices that operate at higher frequencies and allow integration with electronics [12], [13]. Finally, the combination of different materials properties, often referred to as *multiferroics*, has provided opportunities for miniature antennas and resonant devices [14], [15], [16] that couple electric, magnetic, and acoustic effects.

The three articles in this issue provide an overview and introduction to this field of microwave magnetics. The first article, by Qian Gao et al. at the University of California, Los Angeles

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provides a mathematical background for micromagnetic devices and provides methods for and insight into circuit modeling approaches for making the physics of these types of devices accessible in modern circuit simulators. The second article, by Jinqun Ge et al. at the University of South Carolina, describes the application and micropatterning of ferromagnetic thin films to realize magnetically tunable inductors, filters, phase shifters, antennas, and other components. Finally, Tetsuya Ueda, at the Kyoto Institute of Technology, describes using nonreciprocal magnetic metamaterials to realize steerable leaky wave antennas with improved dispersion and squint. These three articles provide only a glimpse into the new capabilities offered by magnetic materials, and interested readers may find additional information in the references for this editorial and the articles themselves.

These focus articles have been sponsored by the MTT-S Technical Committee on Microwave Control Techniques (MTT-13), which focuses on novel materials and device technologies for controlling and manipulating RF and microwave signals. In addition to magnetic materials, these control technologies include tunable materials, such as ferroelectrics; phase change materials, such as metal–insulator transition switches; and tunable liquid crystal polymers. These types of materials provide compelling new functions when compared to traditional microwave and electronic technologies, and the purpose of the MTT-13 committee is to preserve the history and knowledge of prior developments and to foster new research in these areas, with the ultimate goal of improving the efficiency and effectiveness of future microwave systems. We hope that you find this topic and these articles interesting and informative.

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MTT-S Society News

(continued from page 19)

More than 250 participants showed up to enjoy a casual food and beverage reception while listening to, and asking questions of, our journal editors and publications committee chair. A couple of takeaways included the very wide range of career levels (0–40 years after highest degree level) that have a desire to participate in our publications and the much stronger than anticipated interest from the commercial and industrial side of our MTT-S community. The event was so successful that we plan to try to hold it again in 2023 at the San Diego IMS.