Book/Software Reviews

RF Front-End Technologies–30 Years of Applied Research and Development

■ **James Chu**

Mike Harris was a principal research engineer, division chief, and associate director in the Electro-Optical Systems Laboratory at Georgia Technical Research Institute. He has 40 years experience in semiconductor materials and device technology. He developed semiconductor processes for gallium nitride (GaN) high-electron-mobility transistors (HEMTs) and gallium arsenide (GaAs) pseudomorphic HEMTs (pHEMTs). He invented thermal management and package concepts to permit the use of high-power-density wide-bandgap semiconductors in phased-array radars. He has been involved in transmit/receive (T/R) module programs for over 30 years.

Rick Sturdivant has 26 years of industry experience designing products for microwave and millimeter-wave systems. He developed the world's first array module for phased-array radar.

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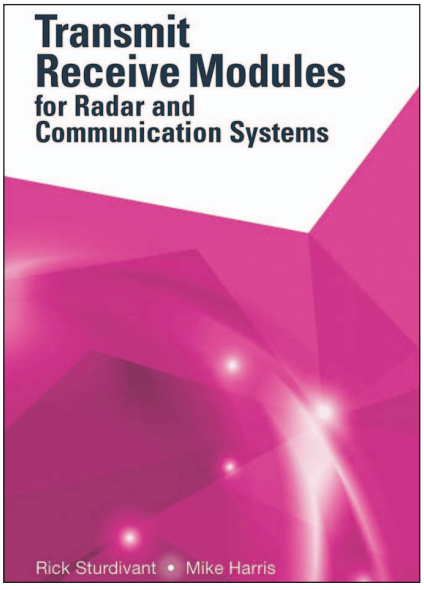

Transmit Receive Modules for Radar and Communication Systems
by Rick Sturdivant and Mike Harris
Artech House, 2016
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He is currently president of Microwave Packaging Technology, Inc.

Their book *Transmit Receive Modules for Radar and Communication Systems* focuses on RF application-specific integrated circuit chip set design for active electronically scanned arrays (AESAs) for radar and communication applications in both transmit and receive modules. It condenses 30 years of applied research and development of RF front-end technologies. T/R modules technology topics covered in the text include an introduction to phased arrays in radar and communication systems, T/R modules, and module components; monolithic microwave integrated circuits (MMICs); T/R module packaging; RF interconnect materials; thermal management for T/R modules, and MMICs; T/R module manufacturing and testing; module costs; and next-generation T/R modules.

Chapter 1 introduces the basic radar equation, radar target cross-section calculation, and phased array for communication systems. It provides many useful equations and examples. Chapter 2 introduces T/R modules, with an emphasis on MMIC modules, which include switch, phase shifters, attenuators, driver amplifiers, power amplifiers,

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Figure 7. *Prof. Quan Xue (right) presenting one of the student paper awards at IMWS-AMP 2016.*

Jian Cheng introduced the TPC and presented details of various technical activities (Figure 6). As the highlight of the banquet, Award Committee Chair Prof. Kai Kang hosted the Student Paper Award ceremony. In the Best Student Paper Award competition, 21 papers qualified for the final list, and four papers won prizes based on the TPC's review (Figure 7). Immediately following the ceremony, performances representing Chinese tradition were presented, including a concert featuring the traditional Chinese instrument guzheng and the famous face-changing of the Sichuan Opera. Attendees enjoyed the proceedings greatly.

All in all, the success of IMWS-AMP 2016 is due to the contributions of many people and organizations. We would like to express our thanks to the keynote and invited speakers, reviewers, committee members, session chairs, presenters, our sponsors and exhibitors, and, finally, our amazing volunteers and organizers. IMWS-AMP 2016 provided a broad forum for established scientists and engineers from around the world and both academia and industry to share their research and discuss collaborations in the field of microwaves and millimeter waves.

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circulators, duplexers, limiters, low-noise amplifiers, and others. The authors provide a detailed explanation of each type of device along with many examples of calculating critical parameters, such as the noise temperature on an RF chain and the third-order intercept point on an amplifier. They also discuss RF complementary–metal-oxide semiconductor (CMOS), silicon germanium (SiGe), and bipolar junction/CMOS transistors. The most unusual aspect of this chapter is that the authors include a device specification table for each type of device, which is very useful for any system and circuit designer. Each is a great starting point for a designer trying to define a device requirement without sorting through many documents or catalogs.

The authors also suggest using the hexagonal field-effect transistor (HEXFET) from International Rectifier to maximize overall T/R module efficiency by turning off the drain voltage to the transmit amplifiers immediately after the transmit pulse is sent and then turning the drain voltage on just prior to sending out the next RF pulse. The HEXFETs are silicon-based power MOSFETs characterized by extremely fast turn-on and switching-off performance.

Chapter 3 introduces semiconductors for T/R modules, including manufacturing and wafer-fabrication processes for GaAs, Si carbide, GaN, indium phosphide, SiGe, and more. The authors indicate that GaN HEMT devices and circuits can change the way power is routed through a phased-array radar. This may permit smaller and lighter-weight T/R modules to be built having transmit performance that is the same as or better than GaAs pHEMT-based modules.

Chapter 4 addresses interconnect issues, including chip-level interconnects, such as wire-bonding and flip-chip methods, and module-level interconnects, such as surface-mount-package and transmission-line interconnects. The authors also warn about module resonances associated with module package design and discuss the assessment of such resonances.

Chapter 5 on materials for T/R modules introduces dielectric materials, thin-film and thick-film ceramic materials, and high/low temperature cofired ceramic. It also discusses thick-film processing and its drawbacks.

Chapter 6 covers heat issues and solutions for T/R modules. The authors discuss the junction temperature of a power amplifier transistor and related thermal issues as well as SPICE simulation, thermal measurement, and solutions to the problem, which include the reliability calculation.

Chapters 7 and 8 introduce MMIC fabrication and T/R module manufacturing and testing; a typical MMIC T/R module specification item list, as required by MIL-STD-490A, is included here. Chapter 9 focuses on MMIC and T/R module costs and lists the typical cost of all AESA elements, including antenna, power and cooling, signal data processor, receiver, exciter, and system integration. It provides the radar designer and program manager with an initial breakdown for cost estimation purposes. Chapter 10 covers next-generation T/R modules, including the future of low-cost, single-module T/R modules on wafer-scale phased arrays and digital beamforming without using analog phase shifters.

Transmit Receive Modules for Radar and Communication Systems provides a comprehensive overview of the design, fabrication, integration, and implementation of a T/R chip module for AESA radar and communication systems. This book is a "must have" item on a T/R module and AESA radar and communication designer's bookshelf. It will save you many hours of information search time.