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# Assessment Of Millimeter Wave And Terahertz Technology For Detection And Identification Of Concealed Explosives And Weapons

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Electromagnetics Institute, Technical University Denmark

Scientific and Technical Aerospace Reports

Fiscal Year 2015

Technology Assessment

Assessment of Millimeter-Wave and Terahertz Technology for Detection and Identification of Concealed Explosives and Weapons

Millimeter Wave Wireless Communications

Millimeter wave sounder modelling assessment study : final report. R 452 (Nov. 1990)

2011-2012 Assessment of the Army Research Laboratory

Millimeter Wave Sounder Modelling Assessment Study

An Assessment of the National Institute of Standards and Technology Physical Measurement Laboratory

Modelling Assessment Study ; ESTEC Contract No 8374/89/NL/JS ; Executive Summary

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Non-Imaging Microwave and Millimetre-Wave Sensors for Concealed Object Detection

The Silent Crisis: a Report on Telecommunication Science and the Federal Government

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Real-Time Three-Dimensional Imaging of Dielectric Bodies Using Microwave/Millimeter Wave Holography

Millimeter-Wave Integrated Circuits

2017-2018 Assessment of the Army Research Laboratory

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Digitally Assisted, Fully Integrated, Wideband Transmitters for High-Speed Millimeter-Wave Wireless Communication Links

Millimeter Wave Communication Systems

DA Pam

Materials Characterization Using Nondestructive Evaluation (NDE) Methods

2007-2008 Assessment of the Army Research Laboratory

Assessment of Checkpoint Security

2020 11th IEEE Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)

Millimeter-wave and Terahertz Imaging Techniques  
Descriptive Summaries for Program Elements of the Research, Development, Test and Evaluation, Army Program FY ... (U).  
Infrared and Millimeter Waves V10  
Are Our Airports Keeping Passengers Safe? : Hearing Before the Subcommittee on Transportation Security and Infrastructure Protection of the Committee on Homeland Security, House of Representatives, One Hundred Eleventh Congress, Second Session, March 17, 2010  
Electromagnetic Spectrum Utilization  
mmWave Massive MIMO  
הסיפורים והטיוולים שלנו  
Systems-Level Packaging for Millimeter-Wave Transceivers  
Executive Summary  
Airport Passenger Screening Using Millimeter Wave Machines  
Aperture Antennas for Millimeter and Sub-Millimeter Wave Applications  
Explosives Detection Technologies to Protect Passenger Rail  
Assessment of Possible Hazards Associated with Applications of Millimeter-Wave Systems

*Assessment Of  
Millimeter Wave And  
Terahertz Technology  
For Detection And  
Identification Of  
Concealed Explosives  
And Weapons*

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## **JOSEPH SKYLAR**

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Electromagnetics Institute, Technical University Denmark Pearson Education  
In response to the ever-increasing global threat of terrorist attacks, the personal screening industry has been growing at a rapid rate. Many methods have been developed for detecting concealed weapons and explosives on the human body. In this important new book, the authors discuss their experiences over the last decade designing and testing microwave and millimetre wave detection and screening systems. It includes examples of actual devices that they have built and tested, along with test results that were obtained in realistic scenarios. The book focuses on the development of non-imaging detection systems, which are similar to radar. These systems do not form a

conventional image of the scene and the person(s) being screened. Instead, the sensors detect and analyze the effect that the body, and any concealed objects, has on a transmitted waveform. These systems allow remote detection of both metallic and dielectric devices concealed on the human body in both indoor and outdoor environments. The book discusses a number of sensor types, including active millimetre wave sensors using the direct detection and the heterodyne approach, active microwave sensors for CNR-based object detection, passive millimetre wave sensors, and the role of shielding effects in operating non-imaging MM-wave sensors. The goal of this book is to systemize the test results obtained by the authors, helping specialists to develop improved screening systems in the future. Another goal is to show how the use of non-imaging systems can reduce the cost of the screening process.  
*Scientific and Technical Aerospace Reports Artech House*

This book presents design methods and considerations for digitally-assisted wideband millimeter-wave transmitters. It addresses comprehensively both RF design and digital implementation simultaneously, in order to design energy- and cost-efficient high-performance transmitters for mm-wave high-speed communications. It covers the complete design flow, from link budget assessment to the transistor-level design of different RF front-end blocks, such as mixers and power amplifiers, presenting different alternatives and discussing the existing trade-offs. The authors also analyze the effect of the imperfections of these blocks in the overall performance, while describing techniques to correct and compensate for them digitally. Well-known techniques are revisited, and some new ones are described, giving examples of their applications and proving them in real integrated circuits.

#### Fiscal Year 2015 MDPI

The Definitive, Comprehensive Guide to Cutting-Edge Millimeter Wave Wireless Design "This is a great book on mmWave systems that covers many aspects of the technology targeted for beginners all the way to the advanced users. The authors are some of the most credible scholars I know of who are well respected by the industry. I highly recommend studying this book in detail." —Ali Sadri, Ph.D., Sr. Director, Intel Corporation, MCG mmWave Standards and Advanced Technologies Millimeter wave (mmWave) is today's breakthrough frontier for emerging wireless mobile cellular networks, wireless local area networks, personal area networks, and vehicular communications. In the near future, mmWave products, systems, theories, and devices will come together to deliver mobile data rates thousands of times

faster than today's existing cellular and WiFi networks. In Millimeter Wave Wireless Communications, four of the field's pioneers draw on their immense experience as researchers, entrepreneurs, inventors, and consultants, empowering engineers at all levels to succeed with mmWave. They deliver exceptionally clear and useful guidance for newcomers, as well as the first complete desk reference for design experts. The authors explain mmWave signal propagation, mmWave circuit design, antenna designs, communication theory, and current standards (including IEEE 802.15.3c, Wireless HD, and ECMA/WiMedia). They cover comprehensive mmWave wireless design issues, for 60 GHz and other mmWave bands, from channel to antenna to receiver, introducing emerging design techniques that will be invaluable for research engineers in both industry and academia. Topics include Fundamentals: communication theory, channel propagation, circuits, antennas, architectures, capabilities, and applications Digital communication: baseband signal/channel models, modulation, equalization, error control coding, multiple input multiple output (MIMO) principles, and hardware architectures Radio wave propagation characteristics: indoor and outdoor applications Antennas/antenna arrays, including on-chip and in-package antennas, fabrication, and packaging Analog circuit design: mmWave transistors, fabrication, and transceiver design approaches Baseband circuit design: multi-gigabit-per-second, high-fidelity DAC and ADC converters Physical layer: algorithmic choices, design considerations, and impairment solutions; and how to overcome clipping, quantization, and nonlinearity Higher-

layer design: beam adaptation protocols, relaying, multimedia transmission, and multiband considerations 60 GHz standardization: IEEE 802.15.3c for WPAN, Wireless HD, ECMA-387, IEEE 802.11ad, Wireless Gigabit Alliance (WiGig)

Technology Assessment John Wiley & Sons

A guide to the applications of holographic techniques for microwave and millimeter wave imaging Real-Time Three-Dimensional Imaging of Dielectric Bodies Using Microwave/Millimeter Wave Holography offers an authoritative guide to the field of microwave holography for the specific application of imaging dielectric bodies. The authors—noted experts on the topic—review the early works in the area of optical and microwave holographic imaging and explore recent advances of the microwave and millimeter wave imaging techniques. These techniques are based on the measurement of both magnitude and phase over an aperture and then implementing digital image reconstruction. The book presents developments in the microwave holographic techniques for near-field imaging applications such as biomedical imaging and non-destructive testing of materials. The authors also examine novel holographic techniques to gain super-resolution or quantitative images. The book also includes a discussion of the capabilities and limitations of holographic reconstruction techniques and provides recommendations for overcoming many of the limitations. This important book: • Describes the evolution of wide-band microwave holography techniques from synthetic aperture radar principles • Explores two major approaches to near-field microwave holography: Using the

incident field and Green's function information and using point-spread function of the imaging system • Introduces the "diffraction limit" in the resolution for techniques that are based on the Born approximation, and provides techniques to overcome this limit Written for students and research associates in microwave and millimeter wave engineering, Real-Time Three-Dimensional Imaging of Dielectric Bodies Using Microwave/Millimeter Wave Holography reviews microwave and millimeter-wave imaging techniques based on the holographic principles and provides information on the most current developments.

**Assessment of Millimeter-Wave and Terahertz Technology for Detection and Identification of Concealed Explosives and Weapons** National Academies Press

The Physical Measurement Laboratory (PML) at the National Institute of Standards and Technology (NIST) is dedicated to three fundamental and complementary tasks: (1) increase the accuracy of our knowledge of the physical parameters that are the foundation of our technology-driven society; (2) disseminate technologies by which these physical parameters can be accessed in a standardized way by the stakeholders; and (3) conduct research at both fundamental and applied levels to provide knowledge that may eventually lead to advances in measurement approaches and standards. This report assesses the scientific and technical work performed by the PML and identifies salient examples of accomplishments, challenges, and opportunities for improvement for each of its nine divisions.

*Millimeter Wave Wireless*

*Communications* National Academies Press

The millimeter-wave frequency band (30–300 GHz) is considered a potential candidate to host very high data rate communications. First used for high capacity radio links and then for broadband indoor wireless networks, the interest in this frequency band has increased as it is proposed to accommodate future 5G mobile communication systems. The large bandwidth available will enable a number of new uses for 5G. In addition, due to the large propagation attenuation, this frequency band may provide some additional advantages regarding frequency reuse and communication security. However, a number of issues have to be addressed to make mm-wave communications viable. This book collects a number of contributions that present solutions to these challenges.

**Millimeter wave sounder modelling assessment study : final report. R 452 (Nov. 1990)** John Wiley & Sons

Materials Characterization Using Nondestructive Evaluation (NDE) Methods discusses NDT methods and how they are highly desirable for both long-term monitoring and short-term assessment of materials, providing crucial early warning that the fatigue life of a material has elapsed, thus helping to prevent service failures. Materials Characterization Using Nondestructive Evaluation (NDE) Methods gives an overview of established and new NDT techniques for the characterization of materials, with a focus on materials used in the automotive, aerospace, power plants, and infrastructure construction industries. Each chapter focuses on a different NDT technique and indicates the potential of the method by selected

examples of applications. Methods covered include scanning and transmission electron microscopy, X-ray microtomography and diffraction, ultrasonic, electromagnetic, microwave, and hybrid techniques. The authors review both the determination of microstructure properties, including phase content and grain size, and the determination of mechanical properties, such as hardness, toughness, yield strength, texture, and residual stress. Gives an overview of established and new NDT techniques, including scanning and transmission electron microscopy, X-ray microtomography and diffraction, ultrasonic, electromagnetic, microwave, and hybrid techniques Reviews the determination of microstructural and mechanical properties Focuses on materials used in the automotive, aerospace, power plants, and infrastructure construction industries Serves as a highly desirable resource for both long-term monitoring and short-term assessment of materials 2011-2012 Assessment of the Army Research Laboratory Academic Press Millimeter-wave systems introduce a set of particular severe requirements from the antenna point of view in order to achieve specific performances. In this sense, high directive antennas are required to overcome the huge extra path loss. Moreover, each particular application introduces additional requirements. For example, in very high throughput (VHT) wireless personal area networks (WPANs) communication systems at 60 GHz band beam-steering antennas are needed to deal with high user random mobility and human-body shadowing characteristic of indoor environments. Similarly, beam-steering capabilities are also needed in automotive radar applications at 79 GHz,

since the determination of the exact position of an object is essential for most of the functions realized by the radar sensor. In the same way, beam-scanning, which is still commonly mechanically performed nowadays, is also needed in passive imaging systems at 94 GHz. Finally, from the integration perspective, the antennas must be small, low-profile, light weight and low-cost, in order to be successfully integrated in a commercial millimeter-wave wireless system. For these reasons, many types of antenna structures have been considered to achieve high directivity and beam-steering capabilities for the aforementioned millimeter-wave communication, radar and imaging applications at 60, 79 and 94 GHz. The most part of the currently adopted solutions are based on the expensive, complex and bulky phased-array antenna concept. Actually, phased-array antenna systems can scan the beam at a fast rate. However, they require a complex integration of many expensive, lossy and bulky circuits, such as solid-state phase shifters and beam-forming networks. This doctoral thesis has contributed to the study, development, and assessment of the performance of innovative antenna solutions in order to improve the existing architectures at millimeter-wave frequencies, conveniently solving the problems related specifically to short-range high data rate communication systems at 60 GHz WPAN band (including future 5G millimeter-wave systems), automotive radar sensors at 79 GHz band, and communications, radar, and imaging systems at 94 GHz. The specific goals pursued in this work, focused on defining an alternative antenna architecture able to achieve a full reconfigurable 2-D beam-scanning of

high gain radiation beams at millimeter-wave frequencies, has been fulfilled. In this sense, this thesis has been mainly devoted to study in depth and practically develop the fundamental part of an innovative switched-beam antenna array concept: novel inhomogeneous gradient-index dielectric flat lenses, which, despite their planar antenna profile configurations, allow full 2-D beam-scanning of high gain radiation beams. A transversal study, going from theoretical investigations, passing by numerical analysis, new fabrication strategies, performance evaluation, and to full experimental assessment of the new antenna architectures in real application environment has been successfully carried out.

#### Millimeter Wave Sounder Modelling

Assessment Study Assessment of Millimeter-Wave and Terahertz Technology for Detection and Identification of Concealed Explosives and Weapons

Millimeter-Wave Integrated Circuits delivers a detailed overview of MMIC design, specifically focusing on designs for the millimeter-wave (mm-wave) frequency range. The scope of the book is broad, spanning detailed discussions of high-frequency materials and technologies, high-frequency devices, and the design of high-frequency circuits. The design material is supplemented as appropriate by theoretical analyses. The broad scope of the book gives the reader a good theoretical and practical understanding of mm-wave circuit design. It is best-suited for both undergraduate students who are reading or studying high frequency circuit design and postgraduate students who are specializing in the mm-wave field.

*An Assessment of the National Institute*

*of Standards and Technology Physical Measurement Laboratory National Academies Press*

Non-lethal weapons (NLWs) are designed to minimize fatalities and other undesired collateral damage when used. Events of the last few years including the attack on the USS Cole have raised ideas about the role NLWs can play in enhancing support to naval forces. In particular to what extent and in what areas should Department of the Navy (DoN) -sponsored science and technology (S&T) provide a research base for developing NLW capabilities? To assist with this question and to evaluate the current NLWs program, the Joint Non-Lethal Weapons Directorate (JNLWD) and the Office of Naval Research (ONR) requested the National Research Council perform an assessment of NLWs science and technology. The report presents the results of that assessment. It discusses promising NLW S&T areas, development accomplishments and concerns about NLW, and series of recommendations about future NLW development and application.

**Modelling Assessment Study ; ESTEC Contract No 8374/89/NL/JS ; Executive Summary** John Wiley & Sons

This review examines the characteristics of millimeter-wave radiofrequency radiation, predicts possible exposure levels, and analyzes the millimeter-wave bioeffects literature. Data gaps and possible mechanisms of millimeter-wave bioeffects are examined. (Author).

Electromagnetics Institute, Technical University Denmark National Academies Press

The Transportation Security Administration requested a study by the National Research Council (NRC) to establish the Committee on Airport

Passenger Screening: Millimeter Wave Machines to evaluate two models of active millimeter wave scanners: the L3 ProVision 1 and L3 ProVision 2. Airport Passenger Screening Using Millimeter Wave Machines provides findings and recommendations on compliance with applicable health and safety guidelines and appropriateness of system design and procedures for preventing over exposure. This study addresses the issue of whether millimeter wave machines used at airports comply with existing guidelines and whether it would be possible for anything to go wrong with the machines so that, by mistake, it exposes a person to more than 10 W/m<sup>2</sup>.

Non-Imaging Microwave and Millimetre-Wave Sensors for Concealed Object Detection Springer

The aim of this book is to present the modern design and analysis principles of millimeter-wave communication system for wireless devices and to give postgraduates and system professionals the design insights and challenges when integrating millimeter wave personal communication system. Millimeter wave communication system are going to play key roles in modern gigabit wireless communication area as millimeter-wave industrial standards from IEEE, European Computer Manufacturing Association (ECMA) and Wireless High Definition (Wireless HD) Group, are on their way to the market. The book will review up-to-date research results and utilize numerous design and analysis for the whole system covering from Millimeter wave frontend to digital signal processing in order to address major topics in a high speed wireless system. This book emphasizes the importance and the requirements of high-gain antennas, low power transceiver,

adaptive equalizer/modulation, channeling coding and adaptive multi-user detection for gigabit wireless communications. In addition, the book will include the updated research literature and patents in the topics of transceivers, antennas, MIMO, channel capacity, coding, equalizer, Modem and multi-user detection. Finally the application of these antennas will be discussed in light of different forthcoming wireless standards at V-band and E-band.

**The Silent Crisis: a Report on Telecommunication Science and the Federal Government** CRC Press

IEMCON 2020 will provide an opportunity for researchers, educators and students to discuss and exchange ideas on issues, trends, and developments in Information Technology, Electronics and Mobile Communication The conference aims to bring together scholars from different disciplinary backgrounds to emphasize dissemination of ongoing research in the fields of Information Technology, Electronics and Mobile Communication The focus of the conference will be on the following areas of research but are not limited to Computer Network Evolutionary Computation and Algorithms Intelligent Information Processing Information System Integration and Decision Support Image Processing and Multimedia Technology VLSI and Microelectronic Circuit Embedded Systems System on Chip (SoC) Design FPGA (Field Programmable Gate Array) Design and Applications סובב גלעד Woodhead Publishing

Passenger rail systems are vital to the nation's transportation infrastructure, providing approximately 14 million passenger trips each weekday. Recent terrorist attacks on these systems around the world highlight the

vulnerability of these systems. The Transportation Security Admin. is the primary federal entity responsible for securing passenger rail systems. This technology assessment reviewed: (1) the availability of explosives detection technologies and their ability to help secure the passenger rail environment; and (2) key operational and policy factors that impact the role of explosives detection technologies in the passenger rail environment. It analyzed test reports on various explosives detection technologies. Charts and tables.

Real-Time Three-Dimensional Imaging of Dielectric Bodies Using

Microwave/Millimeter Wave Holography CRC Press

mmWave Massive MIMO: A Paradigm for 5G is the first book of its kind to hinge together related discussions on mmWave and Massive MIMO under the umbrella of 5G networks. New networking scenarios are identified, along with fundamental design requirements for mmWave Massive MIMO networks from an architectural and practical perspective. Working towards final deployment, this book updates the research community on the current mmWave Massive MIMO roadmap, taking into account the future emerging technologies emanating from 3GPP/IEEE. The book's editors draw on their vast experience in international research on the forefront of the mmWave Massive MIMO research arena and standardization. This book aims to talk openly about the topic, and will serve as a useful reference not only for postgraduates students to learn more on this evolving field, but also as inspiration for mobile communication researchers who want to make further innovative strides in the field to mark their legacy in the 5G arena. Contains tutorials on the



basics of mmWave and Massive MIMO Identifies new 5G networking scenarios, along with design requirements from an architectural and practical perspective Details the latest updates on the evolution of the mmWave Massive MIMO roadmap, considering future emerging technologies emanating from 3GPP/IEEE Includes contributions from leading experts in the field in modeling and prototype design for mmWave Massive MIMO design Presents an ideal reference that not only helps postgraduate students learn more in this evolving field, but also inspires mobile communication researchers towards further innovation

Millimeter-Wave Integrated Circuits

Elsevier

A one-stop reference to the major techniques for analyzing microwave planar transmission line structures The last two decades have seen important progress in the development of methods for the analysis of microwave and millimeter-wave passive structures, which contributed greatly to microwave integrated circuit design while also stimulating the development of new planar transmission lines. This timely and authoritative work introduces microwave engineers to the most commonly used techniques for analyzing microwave planar transmission line structures. Designed to be easily accessible to readers with only a fundamental background in electromagnetic theory, the book provides clear explanations of the theory and applications of Green's function, the conformal-mapping method, spectral domain methods, variational methods, and the mode-matching methods. Coverage for each method is self-contained and supplemented with problems and solutions as well as useful

figures. In addition to providing detailed formulations of the methods under discussion, this highly practical book also demonstrates how to apply the principles of electromagnetic theory to the analysis of microwave boundary value problems, customize methods for specific needs, and develop new techniques. Analysis Methods for RF, Microwave, and Millimeter-Wave Planar Transmission Line Structures is an excellent working resource for anyone involved in the design and engineering of RF, microwave, and millimeter-wave integrated circuits.

*2017-2018 Assessment of the Army Research Laboratory* National Academies Press

Assessment of Millimeter-Wave and Terahertz Technology for Detection and Identification of Concealed Explosives and Weapons National Academies Press  
*Millimeter wave sounder modelling assessment study. R 452 (Nov. 1990)* National Academies Press

This book presents the technology of millimetre waves and Terahertz (THz) antennas. It highlights the importance of moderate and high-gain aperture antennas as key devices for establishing point-to-point and point-to-multipoint radio links for far-field and near-field applications, such as high data-rate communications, intelligent transport, security imaging, exploration and surveillance systems. The book provides a comprehensive overview of the key antenna technologies developed for the mm wave and THz domains, including established ones - such as integrated lens antennas, advanced 2D and 3D horn antennas, transmit and reflect arrays, and Fabry-Perot antennas - as well as emerging metasurface antennas for near-field and far-field applications. It describes the pros and cons of each

antenna technology in comparison with other available solutions, a discussion supplemented by practical examples illustrating the step-by-step implementation procedures for each antenna type. The measurement techniques available at these frequency ranges are also presented to close the loop of the antenna development cycle. In closing, the book outlines future trends in various antenna technologies, paving the way for further developments. Presenting content originating from the five-year ESF research networking program 'Newfocus' and co-authored by the most active and highly cited research groups in the domain of mm- and sub-mm-wave antenna technologies, the book offers a valuable guide for researchers and engineers in both industry and academia.

Digitally Assisted, Fully Integrated, Wideband Transmitters for High-Speed Millimeter-Wave Wireless Communication Links National Academies Press

Packaging of electronic components at microwave and millimeter-wave frequencies requires the same level of engineering effort for lower frequency electronics plus a set of additional activities which are unique due to the higher frequency of operation. This resource presents you with the electronic packaging issues unique to microwave and millimeter-wave frequencies and reviews lower frequency packaging techniques so they can be adapted to higher frequency designs. You are provided with 30 practical examples throughout the book, as well as three free downloadable software analysis programs.

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