Advanced Building Blocks for (Sub-)Millimeter-Wave Applications in Space, Communication and Sensing Using III/V mHEMT Technology

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Abstract

The transmission of electromagnetic waves in the atmosphere features local maxima in the distinguished frequency bands around 94, 140, 220, 340, 410, 480, 660, and 850 GHz, making them especially attractive for millimeter-wave high-speed data links and long-distance high-resolution radar and imaging systems. High operating frequencies allow for precise geometrical resolution due to high absolute bandwidth and small wavelength. It also reduces the size of components and antennas, predestining them for lightweight spaceborne and airborne systems. In comparison to visible and infrared radiation, a particular benefit of millimeter-waves for imaging and sensing applications is the penetration of dust, fog, rain, snow, and textiles.

The presentation covers a broad variety of MMICs and modules developed at the Fraunhofer IAF for manifold applications in the frequency range up to 600 GHz and above, using the advanced metamorphic high electron mobility transistor (mHEMT) technology based on the InGaAs/InAlAs material system on 4” GaAs substrates. To achieve very high MMIC operating frequencies, the transit frequency of transistors was boosted to over 600 GHz by increasing the indium content in the transistor channel up to 100 % and reducing the gate length to 20 nm. The presented MMICs act as key components in wireless communication systems (satellite and radio links, mobile communication), sensor systems (atmospheric sensors, non-destructive materials testing, collision avoidance radar), as well as radio astronomic receivers (cryogenic ultra-low-noise amplifiers.

The presentation will specifically address a variety of high-performance MMICs, such as ultra-low-noise amplifiers mixers, oscillators, switches, frequency dividers, frequency multipliers, transmitters, receivers, as well as complete transmit/receive and radar circuits. Different approaches for module packaging and system realization will be also covered. As an example, multifunctional transmitter and receiver chip sets for millimeter-wave high-speed data links and active imaging systems up to 350 GHz will be discussed.

Curriculum Vitae

Michael Schlechtweg received the Dipl.-Ing. Degree in Electrical Engineering from the Technical University Darmstadt in 1982, and the Dr.-Ing. Degree from the University of Kassel in1989. He joined the Fraunhofer Institute for Applied Solid State Physics, Freiburg, Germany, working on the design of millimeter-wave integrated circuits and on nonlinear characterization and modeling of active RF devices. In 1994, he became head of the simulation and modeling group at Fraunhofer IAF.

Since 1996, he has led the RF Devices and Circuits Department, focusing on the design and the characterization of devices and integrated circuits based on III–V compound semiconductors for RF applications, as well as the development of integrated circuits and modules for sensor and communication systems up to 500 GHz and above.

He has coauthored 300 scientific publications and holds two patents. He received the Fraunhofer Prize in 1993 and the European Microwave Prize in 1998. Michael Schlechtweg has been acting in the Program Committees of numerous conferences, such as EuMIC, EuMC, CSICS, IEDM, IPRM and TWHM, as well as a reviewer for IEEE Transactions MTT, Transactions ED, IEEE MGWL/MCL, EDL and Electronics Letters.