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Terahertz Generation and Detection in CMOS: State-of-the-Art, Physical Limits, and Emerging Applications

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Abstract

Terahertz technologies are moving from laboratory-scale optical and cryogenic systems toward compact, room-temperature electronic platforms [1,2]. A key enabler of this transition is the use of complementary metal–oxide–semiconductor technology, which offers high-yield fabrication, reproducibility, low cost, and the possibility of large-scale integration with signal-processing circuitry [3,4]. This tutorial will review the state of the art in terahertz generation and detection using standard and advanced CMOS foundry processes, with emphasis on the physical mechanisms, circuit architectures, and system-level trade-offs relevant for frequencies from the sub-THz range toward 1 THz.

The generation part will cover CMOS oscillators, frequency multipliers, harmonic extraction, injection locking, phase locking, and power-combining concepts using on-chip and in-package antenna arrays. The detection part will focus on field-effect transistor detectors, Schottky diodes, antenna-coupling peculiarities, and integrated imaging arrays. Particular attention will be given to sensitivity, noise-equivalent power, bandwidth, output power, impedance matching, packaging, calibration, and comparison with III–V, photonic, and thermal THz technologies.

The tutorial is intended for PhD students and early-stage researchers who have a background in electromagnetics, semiconductor devices, or high-frequency electronics. By the end of the session, participants will understand why CMOS has become a serious platform for scalable THz systems, what its current limitations are, and how CMOS-based sources and detectors can be applied to spectroscopy, imaging, and sensing.

REFERENCES

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