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PREFACE

Heterostructure terahertz devices

Guest Editor

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The terahertz (THz) range of frequencies is borderline between microwave electronics and photonics. It corresponds to the frequency bands of molecular and lattice vibrations in gases, fluids, and solids. The importance of the THz range is in part due to numerous potential and emerging applications which include imaging and characterization, detection of hazardous substances, environmental monitoring, radio astronomy, covert inter-satellite communications, as well as biological and medical applications.

During the last decades marked progress has been achieved in the development, fabrication, and practical implementation of THz devices and systems. This is primarily owing to the utilization of gaseous and free electron lasers and frequency converters using nonlinear optical phenomena as sources of THz radiation. However, such devices and hence the systems based on them are fairly cumbersome. This continuously stimulates an extensive search for new compact and efficient THz sources based on semiconductor heterostructures. Despite tremendous efforts lasting several decades, the so-called THz gap unbridged by semiconductor heterostructure electron and optoelectron devices still exists providing appropriate levels of power of the generated THz radiation. The invention and realization of quantum cascade lasers made of multiple quantum-well heterostructures already resulted in the partial solution of the problem in question, namely, in the successful coverage of the high-frequency portion of the THz gap (2–3 THz and higher). Further advancement to lower frequencies meets, perhaps, fundamental difficulties. All this necessitates further extensive theoretical and experimental studies of more or less traditional and novel semiconductor heterostructures as a basis for sources of THz radiation.

This special issue includes 11 excellent original papers submitted by several research teams representing 14 institutions in Europe, America, and Asia. Several device concepts which appear to be feasible for the realization of novel THz devices are put forward and discussed in this collection of experimental and theoretical papers.

The issue starts with a paper by Akis *et al* which deals with a theoretical study of the operation of high electron mobility transistors at THz frequencies. For this, the authors use the numerical simulations using a full-band, cellular Monte Carlo transport model coupled to a full Poisson equation solver.

The next three papers by Reklaitis, Balocco *et al*, and Mikhailov and Zieglel are devoted to considering new ideas related to frequency multiplication which can lead to the up-conversion of ac signals to THz frequencies. For this purpose, different concepts of the devices based on nontrivial heterostructures and materials are proposed and studied.

The paper by Knap *et al* provides an overview of the authors experimental results on the plasma effects in field effect transistors. These effects can be used for the resonant detection of THz radiation and its emission. The observed THz emission from more complex device structures, namely, dual grating gate heterostrucures, which is attributed to the self-excitation of plasma waves, is discussed by Otsuji and his co-workers.

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The following two papers (by Ryzhii *et al* and Popov *et al*) deal with the development of device models and using the one which could explain the results of experimental observations described in the paper by Otsuji *et al*. In both these papers, the mechanisms of plasma wave instability in spatially periodic heterostructures are analyzed.

In the paper by Starikov and his colleagues, an idea to utilize the transit-time resonance assisted by optical phonon emission is revived and revisited. As demonstrated, this mechanism in the electron system in nitride-made heterostructures can lead to negative dynamic conductivity in the THz range of frequencies and, hence, be used for the generation of THz radiation.

In the paper by Millithaler *et al*, Monte Carlo simulations are used to study the voltage fluctuations affected by the plasma oscillations in two-terminal heterostructures with an n-type InGaAs channel.

Finally, the paper by Liu *et al* is devoted to the concept of quantum cascade THz lasers using resonant tunneling in quantum dot systems instead of the standard multiple quantum well heterostructures.

I would like to express my deep gratitude to all of the authors for having submitted high-quality papers. I am confident that this special issue will substantially promote further progress in THz technology.