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Editorial

Quantum and Optoelectronic Devices, Circuits and Systems

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1. Introduction

The fields of quantum electronics (e.g., quantum dots, superconducting circuits) as well as optoelectronics have produced many important research achievements in the past few years. They consist of quantum and optical platforms in combination with electronic and condensed matter systems, which can enable building blocks for a plethora of applications in quantum computing, optical technology, and information processing, such as, e.g., machine learning.

In this Special Issue, we have selected a series of works in this area dealing with a wide variety of topics, ranging from quantum dot applications, to quantum information processing, as well as machine learning for industry operations. We hope that the research here described may induce further developments in this area, and produce significant applications for industry and society alike.

In Section 2 we summarize the articles included in the Special Issue. Subsequently, in Section 3 we give a scope for future developments.

2. Brief Description of the Published Articles

Juárez-Barojas et al. [1] introduced a maintenance system that relies on artificial intelligence to monitor online the support bed expansion in a 30-L pilot-scale inverse fluidized bed reactor (IFBR). Their aim was to obtain a condition-based maintenance strategy by employing a single-level sensor for a biofilm inverse fluidizing bed as a source for virtual sensors. They implemented an artificial neural network on an embedded electronic system (Raspberry Pi 4) to achieve this.

Moiseev et al. [2] studied aspects of the electroluminescence spectra of narrow-gap type II InAs/InSb/InAs heterostructures containing a single layer of InSb quantum dots placed into a p-n-InAs junction. They used a forward and reverse bias in the temperature range of 77–300 K to investigate these luminescence properties as a function of the surface density of nano-objects buried in the narrow-gap matrix. Under certain conditions, they observed the suppression of negative interband luminescence and the dominance of interface recombination transitions at the InSb/InAs type II heterojunction at room temperature.

Gijare et al. [3] studied the electrochemical measurements of reduced graphene oxide-titanium oxide (rGO)/TiO_2) electrodes for the application of a glucose sensor. The paper analyses the sensitivity, stability, and reproducibility of the sensor electrodes employed to evaluate the concentration of glucose in the serum. This sensor was used for glucose level detection in natural blood serum and showed a relative standard deviation of 1.88%, which was in good agreement with the commercial glucose sensor values.

Venkatesan et al. [4] fabricated a planar Si/PEDOT: PSS heterojunction solar cell using three different solvents—ethylene glycol, acetonitrile, and dimethyl sulfoxide—to elucidate the best one. The obtained samples were characterized by diverse techniques, including diffuse reflectance spectroscopy, scanning electron microscopy, X-ray diffraction, and the current–voltage technique.

Balakirev et al. [5] explored the influence of arsenic pressure during low-temperature GaAs overgrowth of InAs quantum dots on their optical properties. They observed a single broad line corresponding to the unimodal size distribution of quantum dots in the spectrum of quantum dots overgrown at a high arsenic pressure. Meanwhile, they also observed two distinct peaks (~1080 and ~1150 nm) at larger wavelengths in the spectra of samples with quantum dots overgrown at a low arsenic pressure.

Cherckesova et al. [6] developed a quantum protocol modification to standard quantum cryptography algorithms, increasing the cryptographic strength of the quantum protocol BB84.

Roslan et al. [7] analysed the charge transport properties of organic vanadyl 3,10,17,24-tetra-tert-butyl-1,8,15,22-tetrakis(dimethylamino)-29H,31H phthalocyanine (VTP). They showed that the I-V profile, demonstrated by a single VTP, showed a rectifying behaviour, and Schottky diode parameters, including the ideality factor, barrier height, shunt, and series resistance, were computed, among other studies.

Kotb et al. [8] demonstrated all basic optical logic operations, including XOR, AND, OR, NOT, NOR, XNOR, and NAND, through simulations using K-shaped compact silicon waveguides at the 1.55 μm telecommunication wavelength. These waveguides comprised three waveguide strips made of silicon and printed on silica.

Mohanty et al. [9] explored the effect of the tungsten nitride (WNx) diffusion barrier layer on resistive switching operations of the aluminum nitride (AlN)-based conductive bridge random access memory.

Quapp et al. [10] studied the twist map, with an interest in its use for the finite Frenkel–Kontorova model, explaining the meaning of tensile forces in some proposed models.

Sun et al. [11] proposed a wide reflected angle Ti_3O_5/SiO_2 DBR (WRA-DBR) for AlGaInP-based red and GaN-based green/blue flip-chip micro LEDs (RGB flip-chip micro-LEDs) to solve the drawbacks of the double-stack distributed Bragg reflector in micro-LEDs.

Shabbir et al. [12] reviewed the advantages of quantum dots in solar cells and quantum dot lasers, followed by a more in-depth discussion of applications in photodetectors. The diverse types of metallic materials, such as lead sulfide and indium arsenide, as well as nonmetallic materials, such as graphene and carbon nanotubes, were discussed.

Ahmad et al. [13] reviewed the usefulness of hybrid quantum dots as a theranostic system in different cancers and analysed diverse biomolecules conjugated hybrid quantum dots investigated for diagnostic/therapeutic applications in cancer. The properties of different biomolecules, such as folic acid, PEG, etc., as well as hybrid quantum dots on their biopharmaceutical attributes, were also discussed.

Parvin et al. [14] reviewed the diverse protocols for producing mono- and few-/multi-layer graphene. The impact of mono-/few-/multi-layer graphene was then studied concerning its quality and properties. The unique electrical features of graphene were highlighted, such as good carrier mobility, typical ambipolar behaviour, and a specific energy band structure, which might be employed in field effect transistors (FETs) and utilized in radio frequency (RF) circuits, sensors, memory, and other applications.

3. Future Directions

We expect that the field of quantum and optoelectronics will only grow in the future; a research avenue that could have a significant impact is the connection of the former with machine learning and artificial intelligence. This could serve, on the one hand, to facilitate the better design and control of the quantum and optoelectronics devices using machine learning and employing the physical devices in these areas to carry out more efficient machine learning through, e.g., neuromorphic architectures, memristors, and similar. Even if it is often difficult to predict the future evolution of a scientific field, our impression is that many applications for industry and society in these areas are yet to be developed.

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