photonics

Editorial

Preface for Special Issue: Advancements in Semiconductor Lasers

Yanhua Hong [1,*], Cristina Masoller [2] and Min Won Lee [3]

1 School of Computer Science and Electronic Engineer, Bangor University, Bangor LL57 1UT, UK
2 Physics Department, Universitat Politecnica de Catalunya, Rambla St. Nebridi 22, 08222 Terrassa, Spain; cristina.masoller@upc.edu
3 Laboratoire de Physique des Lasers (UMR CNRS 7538), Université Sorbonne Paris Nord, 93430 Villetaneuse, France; min.lee@univ-paris13.fr
* Correspondence: y.hong@bangor.ac.uk

We are delighted to present this Special Issue of "Advancements in Semiconductor Lasers", which features a remarkable collection of 14 papers that explore the diverse and cutting-edge aspects of semiconductor lasers. This collection brings together the latest research and innovations in the field, covering topics ranging from new techniques for understanding laser dynamics to devices design and fabrication, the investigation of laser dynamics and their applications, and the characterization of compounded semiconductor materials.

Semiconductor lasers have revolutionized various industries, enabling critical advancements in telecommunications, data communication, sensing, and imaging applications. With the continuous pursuit of higher performance and novel functionalities, the field of semiconductor lasers has witnessed remarkable progress over the years. This Special Issue showcases some of the most exciting developments and discoveries from leading researchers around the world.

The first section of this Special Issue presents advancements in understanding the underlying determinism of semiconductor lasers, and a new method to distinguish chaotic regimes in a semiconductor laser with feedback is presented. Lenstra et al. offered a physical insight into the noise-triggered spiking mechanism in a two-section semiconductor laser under excitable and noisy conditions, with potential implications for studying stochastic spiking in biological neurons [1]. Nguyen et al. developed temporal and reversible dynamical symmetry (TARDYS) quantifiers, providing a powerful tool for characterizing chaotic regimes in other complex dynamical systems [2].

The second section of this Special Issue presents four papers dedicated to the exploration of new types of semiconductor lasers and devices. Among these, Panajotov et al. introduced a groundbreaking spin-VCSEL, which embeds a nematic liquid crystal in a second cavity, achieving an astonishing small-signal modulation response of several hundreds of GHz [3]. This advancement represents a significant breakthrough, outperforming conventional VCSELs by more than 10-times. Sun at al. focused on the design and fabrication of a trench mode-modulation-based edge-emitting laser operating at 650 nm [4]. This device not only demonstrates superior beam quality but also maintains high power output. Moreover, Liu et al. reported the successful fabrication of a 792 nm semiconductor laser with an impressive output power of 232 W and an electro-optic conversion efficiency of 48.6% [5]. Such high-power lasers hold great promise for various industrial and scientific applications. In another significant contribution, a monolithically integrated multi-section semiconductor laser was introduced, showcasing enhanced security with 248 key spaces and a data rate of 2.5 Gb/s [6].

Further expanding on the study of nonlinear dynamics of semiconductor lasers and their applications, Zhao et al. experimentally investigated the nonlinear dynamics of an inter-band cascade laser under variable-aperture optical feedback, revealing various

check for updates

Citation: Hong, Y.; Masoller, C.; Lee, M.W. Preface for Special Issue: Advancements in Semiconductor Lasers. *Photonics* **2023**, *10*, 944. https://doi.org/10.3390/photonics10080944

Received: 7 August 2023
Accepted: 16 August 2023
Published: 18 August 2023

dynamical states [7]. Additionally, the mode configuration of an excited-state quantum dot laser (ESQDL) under concave mirror optical feedback demonstrating the selective excitation of longitudinal modes was explored [8]. Bian et al. proposed a simple method using mutually coupled free-running VCSELs to generate broadband polarization chaos [9], while the locking map of a semiconductor laser under the injection of a frequency comb was studied [10]. Moreover, a new technique using feedback-delay signatures of a modulated semiconductor laser for fiber fault detection was introduced to enhance detection sensitivity [11]. The effect of VCSEL temperature on the quality of random number generation was explored [12], and the potential of generating high-quality photonic microwave signals in solitary QD spin-VCSELs with optical feedback was demonstrated [13].

Finally, Mikhailov et al. delved into the characterization of compound semiconductor materials [14], specifically the inter-band electron transition energy in multiple Hg1-xCdxTe/Hg1-yCdyTe quantum wells (MQWs) at room temperature.

The fascinating array of topics covered in this Special Issue highlights the vibrancy and dynamism of the field of semiconductor lasers. We would like to thank all the authors who submitted their exceptional work to this Special Issue. Additionally, we would like to extend our appreciation to the reviewers for their outstanding efforts in evaluating the manuscripts and offering valuable feedback. We would also like to acknowledge *Photonics* for initiating this Special Issue.

We hope this Special Issue will inspire further exploration and collaboration in the advancement of semiconductor laser technology, fostering continued progress and innovation in the years to come.

Author Contributions: Writing—original draft preparation, Y.H.; writing—review and editing, Y.H., C.M. and M.W.L. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Lenstra, D.; Puts, L.; Yao, W.M. First-passage-time analysis of the pulse-timing statistics in a two-section semiconductor laser under excitable and noisy conditions. *Photonics* **2022**, *9*, 860. [CrossRef]
2. Nguyen, N.V.; Pattanayak, A.K.; Aragoneses, A. TARDYS quantifiers: Extracting temporal and reversible dynamical symmetries. *Photonics* **2022**, *9*, 938. [CrossRef]
3. Panajotov, K.; Petrov, M.; Marinov, T. Liquid-crystal spin-VCSEL with electro-optically controllable birefringence. *Photonics* **2023**, *9*, 179. [CrossRef]
4. Sun, X.; Liu, P.; Ma, X.G.; Zhang, X.D.; Su, J.; Chen, K.; Liu, Q.; Jiang, K.; Tang, W.J.; Xia, W.; et al. Mode-modulation structure based on 650 nm ridge waveguide edge-emitting laser. *Photonics* **2023**, *10*, 302. [CrossRef]
5. Liu, P.; Sun, W.G.; Sun, X.; Zhu, Z.; Qin, H.B.; Su, J.; Liu, C.C.; Tang, W.J.; Jiang, K.; Xia, W.; et al. High–power 792 nm fiber–coupled semiconductor laser. *Photonics* **2022**, *9*, 619. [CrossRef]
6. Zhang, F.F.; Wang, Y.C.; Sun, Y.H.; Xu, J.P.; Li, P.; Wang, A.B.; Qin, Y.W. Key space enhancement in chaotic secure communication utilizing monolithically integrated multi-section semiconductor lasers. *Photonics* **2023**, *10*, 213. [CrossRef]
7. Zhao, M.R.; Xia, G.X.; Yang, K.; Liu, S.M.; Liu, J.Q.; Wang, Q.P.; Liu, J.L.; Wu, Z.M. Nonlinear dynamics of mid-infrared interband cascade lasers subject to variable-aperture optical feedback. *Photonics* **2022**, *9*, 410. [CrossRef]
8. Zheng, Y.F.; Xia, G.X.; Lin, X.D.; Wang, Q.Q.; Wang, H.P.; Jiang, C.; Chen, H.M.; Wu, Z.M. Experimental investigation on the mode characteristics of an excited-state quantum dot laser under concave mirror optical feedback. *Photonics* **2023**, *10*, 166. [CrossRef]
9. Bian, H.F.; Zhang, X.M.; Li, P.; Jia, Z.W.; Li, M.; Xu, B.J.; Shore, K.A.; Qin, Y.W.; Wang, Y.C. Sub-40 GHz broadband polarization chaos generation using mutually coupled free-running VCSELs. *Photonics* **2023**, *10*, 219. [CrossRef]
10. Al-Hosiny, N.M. Dynamics of the frequency shifts in semiconductor lasers under the injection of a frequency comb. *Photonics* **2022**, *9*, 886. [CrossRef]
11. Shi, Z.X.; Zhao, T.; Wang, Y.C.; Wang, A.B. High-sensitivity fiber fault detection method using feedback-delay signature of a modulated semiconductor laser. *Photonics* **2022**, *9*, 454. [CrossRef]
12. Rivero, I.; del Pozo, A.L.; Valle-Miñón, M.; Quirce, A.; Valle, A. Measurement of the temperature dependence of polarization switching in gain-switched VCSELs for quantum random number generation. *Photonics* **2023**, *10*, 474. [CrossRef]

13. Shen, Z.Y.; Huang, Y.; Zhu, X.; Zhou, P.; Mu, P.H.; Li, N.Q. Broad tunable and high-purity photonic microwave generation based on an optically pumped QD spin-VCSEL with optical feedback. *Photonics* **2023**, *10*, 326. [CrossRef]
14. Mikhailov, N.N.; Dvoretsky, S.A.; Remesnik, V.G.; Uzhakov, I.N.; Shvets, V.A.; Aleshkin, V.Y. Interband electron transitions energy in multiple HgCdTe quantum wells at room temperature. *Photonics* **2023**, *10*, 430. [CrossRef]