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Editorial: Advances and applications of optical wireless communication in next-generation networks

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Editorial on the Research Topic

[Advances and applications of optical wireless communication in next-generation networks](#)

Optical Wireless Communication (OWC) has emerged as one of the most promising technologies enabling high-capacity, low-latency, secure, and spectrum-efficient communication for 6G and beyond. With its diverse modalities - Visible Light Communication (VLC), Free-Space Optical (FSO) links, Underwater OWC, and emerging photonic-radar integrations - OWC offers a unique platform for bridging terrestrial, aerial, and space networks. This Research Topic on “*Advances and Applications of Optical Wireless Communication in Next-Generation Networks*” was managed by Dr. Sushank Chaudhary (Guangdong University of Petrochemical Technology, China), Dr. Abhishek Sharma (National Institute of Technology Hamirpur, India), and Dr. Muhammad Saadi (Nottingham Trent University, United Kingdom). The aim of this Research Topic was to bring together recent advances that improve the performance, reliability, and applicability of OWC technologies, while exploring new architectures, hybrid systems, and use cases essential for next-generation networks. This Research Topic brings together five high-quality contributions covering inter-satellite optical networks, vehicular VLC architectures, hybrid FSO-fiber OAM systems, radio-over-FSO transport, and space-qualified optical hardware. Collectively, these works highlight the rapid maturation of OWC - from conceptual frameworks to field-validated systems - demonstrating its critical role in future communication infrastructures. The managing editor, Dr. Sushank Chaudhary, together with guest editors Dr. Abhishek Sharma and Dr. Muhammad Saadi, express their sincere appreciation to all authors who contributed their research to this Research Topic. We also extend our gratitude to the anonymous reviewers for their thorough and insightful evaluations, which greatly enhanced the quality of the published work, and to the Frontiers editorial team for their continued assistance throughout the process. The editors hope that this Research Topic will serve as a valuable resource for students, researchers, engineers, and professionals, offering meaningful insights into the evolving landscape of

Optical Wireless Communication and supporting future developments in this important research area.

- a. *Advances in Free-Space Optical and Space-Based OWC Systems:* Xu et al. present a ground-to-GEO-to-LEO satellite OWC architecture employing a spectrally efficient and secure hybrid DPSK–PPM modulation scheme. Their study shows error-free 30 Gbps multi-channel transmission and highlights how GEO relay satellites can enhance link availability for fast-moving LEO constellations. The work addresses practical challenges such as cloud blockage, beam alignment, and atmospheric turbulence, offering a realistic design pathway for secure and high-rate inter-satellite optical networks. Carrasco-Casado et al. contribute essential hardware-level innovation through the development and environmental qualification of a compact dual-stage EDFA integrating a high-power amplifier and low-noise amplifier for CubeSat-based OWC missions. Their system, designed for the CubeSOTA payload, achieves a 2-W output in a 0.56-kg footprint and withstands vacuum, thermal cycling, and vibration conditions. This work directly supports the miniaturization and scalability required for future large-constellation optical networks.
- b. *OWC for Vehicular and Smart-City Applications:* Garai et al. explores the integration of VLC into intelligent transportation systems through a tree-structured VLC VANET architecture using hierarchical optical codewords for node identification. Their design reduces collisions, improves routing efficiency, and adapts to mobility Research Topic using dynamic attachment and QoS mechanisms. Through mobility-model-based simulations, the authors demonstrate improved scalability, latency, and throughput—highlighting VLC’s viability for next-generation V2X communication where RF congestion and latency remain critical bottlenecks.
- c. *Hybrid OWC Architectures and Multiplexing Technologies:* Singh et al. propose a hybrid optical communication system combining FSO and single-mode fiber, enhanced by orbital angular momentum (OAM) multiplexing. Supporting four 10-Gbps channels under heterogeneous atmospheric and fiber conditions, their system demonstrates strong resilience, including under fog and turbulence. By enabling multi-user access and flexible connectivity, the work advances scalable hybrid optical networks suited for last-mile delivery, urban backhaul, and emergency links. Chaudhary et al. investigated a hybrid Mode-Division-Multiplexed MIMO Radio-over-FSO system operating at an 80-GHz mm-wave carrier. Their results confirm that 4×4 MIMO-MDM configurations significantly improve spectral efficiency and BER performance under both weak and strong atmospheric scintillation. The work highlights the relevance of RoFSO links for high-capacity 5G/6G backhaul, emergency communications, and satellite integration, especially in environments where RF-only solutions struggle with blockage or attenuation.

Collectively, the contributions in this Research Topic demonstrate the breadth, maturity, and accelerating pace of research in Optical Wireless Communication. From secure inter-satellite relays to smart vehicular VLC networks, from OAM-multiplexed hybrid architectures to MDM-MIMO RoFSO platforms and space-qualified amplifiers, the featured works advance OWC technologies

across theoretical, simulation, and experimental domains. As 6G envisions unified terrestrial–non-terrestrial networks, OWC stands out as a key enabler of ultra-high-capacity connectivity, secure channels, and resilient communication in challenging environments. We hope this Research Topic inspires further interdisciplinary collaboration and accelerates the integration of OWC into real-world networks.

We thank all authors, reviewers, and contributors for their valuable efforts and look forward to future advancements in this rapidly evolving field.

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