Photonics Tools for Biomedical Applications: Imaging, Diagnostics and Treatments.

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Abstract:

In recent years, there has been a growing demand for compact, cost-effective, and broadly tunable laser sources capable of generating continuous-wave (CW) and ultra-short pulses across the visible and near-infrared spectral ranges. These light sources are enabling technologies in numerous applications, from advanced spectroscopy and telecommunications to cutting-edge biomedical imaging and therapy.

In this talk, we present recent advancements in the development of novel compact laser systems based on semiconductor and nonlinear optical technologies. We highlight the design and realisation of highly efficient CW and femtosecond-pulsed lasers using quantum dot (QD) gain media, and waveguided frequency conversion techniques. The pioneering demonstration of femtosecond pulse generation from QD lasers, and the integration of these sources with nonlinear platforms to achieve visible and mid-infrared emission, represents a major step forward in ultrafast photonics.

We also explore how these versatile sources are being tailored for applications in biomedicine. Examples include compact lasers used for label-free imaging modalities such as two-photon microscopy and optical coherence tomography, as well as for therapeutic techniques including photothermal therapy and nonlinear spectroscopy for cellular diagnostics. These laser systems have been applied to probe tissue morphology and metabolic activity with high spatial and temporal resolution, enabling non-invasive diagnostics and real-time treatment monitoring.

We will conclude by outlining future directions for miniaturisation, integration, and clinical translation of next-generation photonic sources, with an emphasis on their transformative potential in healthcare and personalised medicine.