第190回　OPERA研究交流セミナー
第181回　ISIT有機光エレクトロニクス研究特別室セミナー
第248回　未来化学創造センターセミナー

日時：2018年7月17日（火）17:00～
場所：九州大学　共進化社会システムイノベーション施設　2F大会議室

Towards ultrafast organic lasers

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Organic solid-state lasers bring to the world of lasers a variety of novel properties, especially an ultrawide wavelength tuning capability, compactness, low cost or a very high sensitivity to the environment that are unique. Under low-cost optical diode (or LED)-pumping and potentially under electrical pumping, these lasers get closer to real-life applications but their operating conditions (pulse duration, repetition rate, stability, spectral coverage outside of the visible spectrum) and their coherence properties (linewidth, beam quality...) still need to be improved to meet the marketplace.
In this talk I will present a few recent works on the improvement of coherence properties of Vertical External-cavity Surface-emitting Organic lasers (VECSOLs) : with a design that is directly inspired from inorganic semiconductor lasers, we show it is possible to greatly enhance the spatial coherence (beam quality) but also the temporal coherence with the help of diffractive Volume bragg Gratings in the laser cavity, achieving linewidths of the order of a fraction of picometer. Control over laser dynamics and polarization can also be exploited in those resonators.
In a last section I will expose why organic semiconductors lasers are good candidates for operating in the regime of mode-locking, and what are the prospects to attain this regime. In a mode-locked laser, multiple longitudinal modes are driven to oscillate in phase to build a very intense and short light pulse (ps or potentially shorter) in a high repetition-rate pulse train. Demonstrating mode-locking would open a new era of applications for organic lasers such as high-speed communications, switching, sensing or optical clocking, and broaden the spectral coverage of these sources. While liquid dye lasers were the first lasers to show mode locking, achieving this regime in solid-state organic semiconductors leads to several challenges that will be discussed.

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