Two-dimensional distributed feedback structures for quasi-continuous wave lasing from organic semiconductors

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Continuous-wave (CW) lasing from organic semiconductors is highly desirable for many practical applications. However, to achieve CW lasing, reducing the lasing threshold is a must as high threshold affects degradation and thermal ablation of organic materials. Therefore, in this study, we focus on reducing the lasing threshold by introducing two-dimensional (2D) distributed feedback (DFB) structures, which have the ability to more confine photons and more enhance the feedback of light two-dimensionally when compared with our previously reported one-dimensional DFB structures[1]. First, we fabricated a series of 2D DFB structures such as second-order 2D square, second order 2D square lattice, second-order circular, and mixed-order circular grating structures. The organic gain layer was a bis[(*N*-carbazole)styryl]biphenyl (BSBCz) emitter doped into a 4,4′-bis(*N*-carbazolyl)-1,1′-biphenyl (CBP) host layer at 6 wt.%. This doped layer is well known to have the spectral separation between singlet emission and excited-state triplet absorption[1], which can avoid the quenching of singlets by triplets. Out of these four DFBs, the circular mixed-order grating structure provided the best laser performance. The threshold was 10 W cm^{-2} under 1,000 ms of long-pulse photoexcitation (Fig. 1). This performance is much better than that of our previous BSBCz-based laser devices with a mixed-order one-dimensional grating structure, in which the threshold was 1 kW cm^{-2} and the pulse duration was limited at 30 ms[1]. Overall, this study provides the evidence that largely decreasing the laser threshold and increasing the excitation pulse duration to a quasi-CW level are possible by optimizing the grating structures.

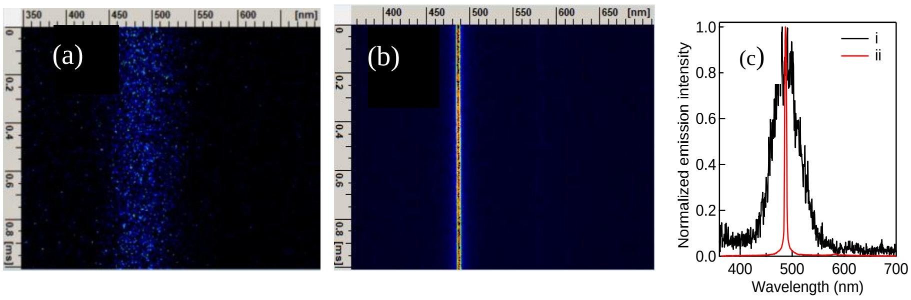

Figure 1. Streak camera images taken (a) below and (b) above the lasing threshold with long pulse operation of 1000 ms and (c) corresponding laser emission spectra (i) below and (ii) above threshold.

Reference: (1) A. S. D. Sandanayaka *et al. Sci. Adv.* **2017,** *3,* e1602570. “This work was supported by JSPS Core-to-Core Program."