Eksitonų difuzija bifluoreno organiniuose kristaluose

Exciton diffusion in bifluorene single crystals

Paulius Baronas[1], Patrik Ščajev[1], Vladislavas Čerkasovas[1], Gediminas Kreiza[1], Povilas Adomėnas[1], Karolis Kazlauskas[1], Jean-Charles Ribierre[2], Chihaya Adachi[2] and Saulius Juršėnas[1]

[1] Institute of Applied Research, Vilnius University, Saulėtekio 3, LT-10222 Vilnius, Lithuania
[2] Center for Organic Photonics and Electronics Research (OPERA), Kyushu University, Kyushu University, 744 Motooka, Nishi, Fukuoka 819-0395, Japan
paulius.baronas@tmi.vu.lt

Organic solid state lasers are often associated with easy and low-cost fabrication, broad tunability of emission wavelength and other features competitive to their inorganic counterparts [1]. Nonetheless, challenges such as low charge carrier mobility and high amplified spontaneous emission (ASE) threshold have yet detained researchers from presenting any electrically driven laser action in organic materials. Recently, organic single crystal materials have been under intense investigation for applications in novel field effect transistor configurations allowing high current densities that are essential for lasing action [2]. Our recent contribution in this field included developing new bifluorene single crystals with record low ASE threshold reaching 700 W/cm2 (0.35 µJ/cm2) [3]. Nonetheless, investigation of other crucial parameters considering high density effects associated with laser operation are still needed.

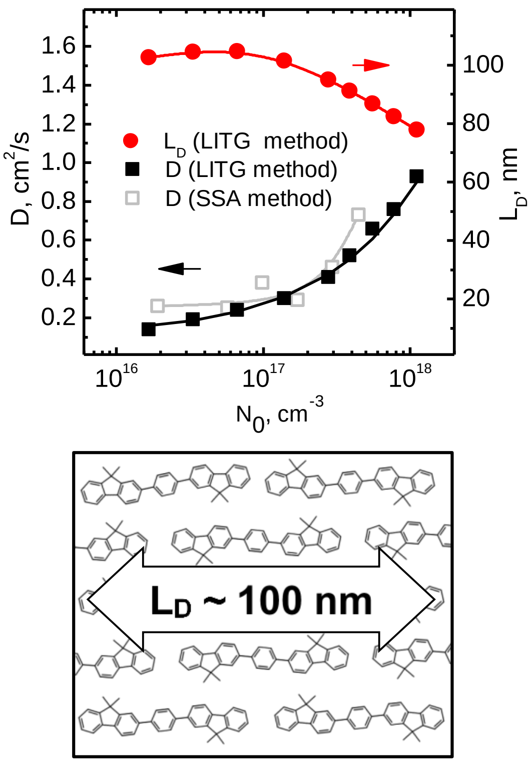

Fig. 1. Top: Diffusion parameters as a function of excitation density obtained by the LITG and SSA methods. Bottom: Simplified bifluorene crystal structure with diffusion direction indicated.

One of the key parameters in organic materials is exciton diffusion, which influences high density effects such as exciton-exciton annihilation, degrading the device performance. In this work we have investigated exciton diffusion properties in bifluorene single crystals by two time resolved “pump-probe” methods: light induced transient grating (LITG) and singlet-singlet annihilation (SSA). The results shown on fig. 1 revealed highly anisotropic singlet exciton transport with diffusion length L_D reaching 100 nm in bifluorene single crystals, which is longer than for most organic crystals at room temperature. To our knowledge, the anomalous behavior of increasing exciton diffusion coefficient D at higher exciton densities has not been observed yet in organic single crystal materials.

Additional studies of exciton diffusion in similar organic single crystals of slightly modified bifluorene molecules allowed to estimate the interplay between diffusion mediated exciton annihilation processes and ASE properties as a function of molecular and crystal structure. Future studies will include measuring charge transport properties and employing knowledge about ASE threshold and diffusion constants for optimizing exciton interaction in an organic single-crystal light-emitting field-effect transistor device architecture.

Key words: Organic single crystal, exciton diffusion, light induced transient gratings, singlet-singlet annihilation

Literature

[1] A. J. C. Kuehne, M. C. Gather, “Organic Lasers: Recent Developments on Materials, Device Geometries, and Fabrication Techniques” Chem. Rev. **116**, 13823-12864 (2016).

[2] S. Hotta, T. Yamao, S. Z. Bisri, T. Takenobu, Y. Iwasa, “Organic single-crystal light-emitting field-effect transistors”, J. Mater. Chem. C **2**, 965 (2014).

[3] G. Kreiza, P. Baronas, E. Radiunas, P. Adomėnas, O. Adomėnienė, K. Kazlauskas, J. C. Ribierre, C. Adachi, S. Juršėnas, “Bifluorene single crystals with extremely low-threshold amplified spontaneous emission”, Adv. Opt. Mater. (2017).