Study and control of recombination zone in organic semiconductor laser diode

Sahar Alasvand Yazdani, Fatima Bencheikh, Chihaya Adachi
Kyushu University, Center for organic photonics and electronics research (OPERA)
E-mail: alasvand@opera.kyushu-u.ac.jp and adachi@cstf.kyushu-u.ac.jp

In decades, a vast amount of research has been allotted to development of organic lasers. However, the reduction of the current threshold in organic semiconductor laser diodes (OSLDs) is still a challenge. To obtain the maximum modal gain in OSLDs, the recombination zone (RZ) should be at the maximum of electric field of the optical resonant mode inside the optical cavity. As the desired position of electric field maxima varies in different cavity type such as distributed feedback (DFB) laser and vertical-cavity surface-emitting laser (VCSEL) which can be seen in figure (1-a) and (1-b) respectively, the control of recombination zone is essential to decrease the laser threshold and improve the overall laser performance.

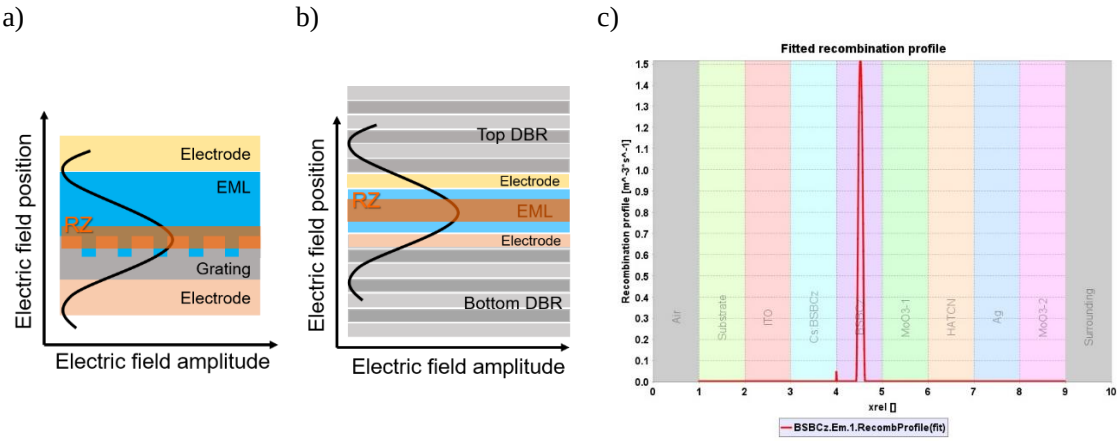

Figure 1: schematic representation for desired place of electric field of optical mode in a) DFB cavity and b) VCSEL cavity and c) recombination zone in inverted structure with DMD

Usually, for electrical injection in OSLDs, an efficient organic light-emitting diode (OLED) is inserted into the micro-cavity. The RZ position and distribution in the OLED stack are determined by charge carrier density and mobility inside the emissive layer. In this study, 4, 4′-bis [(N-carbazole) styryl] biphenyl (BSBCz) which is a promising material for OSLDs, is used as emission layer. The factor that can control the recombination zone is the injected carrier density in the emission layer. Therefore, three different electrodes (Ag, Al and dielectric-metal-dielectric(DMD)) are used to study their impact on RZ position by changing the charge injection in standard and inverse structures. Despite lower hole current compared to electron current in all devices, the inverse structures showed better electrical performance due to better charge balance and confinement of the RZ inside the emission layer. Among them, in the inverted OLED with DMD, the recombination zone is confined at the center of the emission layer as it is shown in Figure (1- c) that is suitable for VCSEL structure.