Development of Multi-Boron Embedded Delayed Fluorescence Materials with Narrowband Emissions

楊, 旻朗

出版情報：九州大学, 2022, 博士（工学）, 課程博士
バージョン：
権利関係：やむを得ない事由により本文ファイル非公開（3）

（様式２）

氏　　名　：Minlang Yang (楊 旻朗)

論 文 名　：Development of Multi-Boron Embedded Delayed Fluorescence Materials with Narrowband Emissions
(狭帯発光を示す含ホウ素遅延蛍光材料の創製)

区　　分　：甲

論　文　内　容　の　要　旨

Boron-doped multi-resonance thermally activated delayed fluorescent (MR-TADF) emitters fascinated the researchers with their unprecedented luminescent property and excellent performance in application of organic light-emitting diodes (OLEDs). Although the MR-TADF emitters have potentially overcome the major obstacles of state-of-the-art D–A-type TADF emitters, they are suffering from two main drawbacks which may affect their commercialization in OLEDs. Firstly, MR-TADF usually exhibited slow reverse intersystem crossing rate (k_{RISC}), resulting in severe efficiency roll-off and poor operational stability. Moreover, it is still difficult to realize ultrawide color gamut emitters covering deep blue to deep red. In this thesis, I have provided the several different design strategies to solute these problems.

In Chapter 2, full-color and narrowband MR-TADF emitters covering the entire visible region from blue to red have been firstly demonstrated. Wide-range emission color (or bandgap) tuning can be achieved via systematic electronic modulation by combining boron atom and carbazole units in different numbers and substitution positions. In dilute solutions, these compounds exhibited full-color photoluminescence (PL) from deep blue to deep red (λ_{PL} = 466–615 nm) with full-width at half maxima as small as <40 nm and absolute PL quantum yields as high as 85%–98%. The transient PL decay measurements revealed the TADF characteristics. Owing to their ideal emission properties, we achieved, for the first time, full-color and narrowband organic light-emitting diodes based on this family of emitters. Notably, all devices showed impressively high maximum external electroluminescence quantum efficiencies (η_{ext}) of 22%–32%.

In Chapter 3, two new green MR-TADF emitters ***p*-CzB** and ***m*-CzB** were designed and synthesized employing a wise dimerization approach. The interconnection position between the two parent cores served as a conjugation valve for regulating the physicochemical properties of the materials. The design retained MR-TADF characteristic for materials similar to their parent core with concurrently achieving pure green emission, λ_{PL} ~ 505–515 nm and narrow emission spectra. Indeed, the ***m*-CzB** exhibited high k_{RISC} and short delayed lifetime (τ_d) compared to its analogue ***p*-CzB**. As a result, the ***m*-CzB** based OLED device outperformed over the ***p*-CzB** by demonstrating high η_{ext} of 23.5% and pure green CIE(x,y) coordinates of (0.20, 0.70). It is worth to mention that the CIE coordinates of the ***m*-CzB** precisely matched with the green coordinates set by the NTSC. Importantly, the ***m*-CzB** displayed low efficiency roll-off and more than four-fold improved operational lifetime compared to ***p*-CzB**.

In Chapter 4, by using the substitution of O and S atoms into B/N framework, five long-wavelength emissive MR-TADF emitters were designed and synthesized. Compared to asymmetrical isomers (**BN-Y** and **BO-G**), the photophysical analysis proved that B-π-B and N-π-N conjugation of symmetrical **BN-R** and **BO-O** can effectively reduce energy gap and generates bathochromic shift in two symmetrical molecules, **BN-R** and **BO-O**. This design strategy realized a wide color tuning ranging from green to red with extreme narrow FWHM (~19−22 nm). In addition, long-wavelength emissive OLEDs with η_{ext} as high as 12.2–21.6 % and superb color purity could be fabricated by using this family of MR-TADF emitters.

In Chapter 5, the dissertation is summarized, and perspectives are discussed.

〔作成要領〕

１．用紙はＡ４判上質紙を使用すること。
２．原則として，文字サイズ１０．５ポイントとする。
３．左右２センチ，上下２．５センチ程度をあけ，ページ数は記入しないこと。
４．要旨は２，０００字程度にまとめること。
（英文の場合は，２ページ以内にまとめること。）
５．図表・図式等は随意に使用のこと。
６．ワープロ浄書すること（手書きする場合は楷書体）。
この様式で提出された書類は，「九州大学博士学位論文内容の要旨及び審査結果の要旨」の原稿として写真印刷するので，鮮明な原稿をクリップ止めで提出すること。