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Thermally Activated Delayed Fluorescence Organic Light-Emitting Diodes

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Since the ground-breaking article of highly efficient organic light-emitting diodes from delayed fluorescence materials demonstrating nearly 100% internal efficiency of electroluminescence [*Nature* **492**, p. 234-238 (2012)], extensive studies on thermally activated delayed fluorescence (TADF) have been conducted. This has led to the rapid development of new TADF materials and positioned them as the third generation of OLED emitters. Supporting photophysical and theoretical studies have also been published on advanced exciton formation mechanisms under electrical excitation in an effort to comprehensively understand the impact of using these next-generation materials in OLEDs.

This special section of the Journal of Photonics Energy focuses on state-of-the-art TADF science and technology for OLEDs and covers novel TADF materials, interfaces, photophysics, and device physics. The breadth of new TADF materials being developed and studied is on display with several reports discussing new molecular designs with emission ranging from blue to the NIR. Jing An et al. report long-wavelength emission originating from thermally activated delayed fluorescence in chromophores based on fluorescein derivatives including a strong acceptor 2-(3-cyano-4,5,5-trimethylfuran-2(5H)-ylidene) malononitrile (TFM), demonstrating NIR TADF with emission maxima ranging from 681 nm to 755 nm and with a 9.02 microsecond delayed lifetimes. Kailong Wu et al. report a butterfly-shaped orange-red TADF emitter, ACFO, by integrating electron-donating (D) 9,9-dimethyl-9,10-dihydroacridine units into the γ-positions of an electron-accepting (A) fluorenone core to form a D-A-D configuration. Rajamalli Pachai Gounder et al. describe a new molecular design approach for blue-emitting TADF molecules having a pyridine-functionalized carbazole donor and a benzophenone acceptor, and Ryutaro Komatsu et al. review the recent progress of pyrimidine-based TADF materials with various combinations of donors.

In addition to the development of new materials, a deeper understanding of material and device physics is critical for improving performance and developing new applications, and these areas are also represented by several reports in this special section. Wei-Kai Lee et al. demonstrate an extremely high external quantum efficiency of 37% by combining TADF emitters exhibiting a favorable molecular orientation with low-refractive-index electron transport layers. Yuri Hasegawa et al. present the self-organization/orientation of TADF molecules on HOPG, indicating promise for application in OLEDs. Takuya Hosokai et al. study solvation effects on TADF molecules, and how these influence ΔE_{ST} due to the changes in the CT and LE nature of S_1 and T_1. Takashi Kobayashi et al. analyze ISC/RISC processes of TADF materials, demonstrating that a four-level model of the excited states in 4CzIPN derivatives provides the best explanation for the experimental results of the transient PL characteristics. Finally, Katsumi Tokumaru provides a historical perspective on insights into RISC and ISC in TADF compounds.

The articles in this special section provide a snapshot of the cutting-edge science and technology of TADF, providing insights for the TADF mechanism and advanced TADF materials design. We hope these articles will provide further inspiration into the study of TADF materials and devices.

Chihaya Adachi obtained his doctorate in materials science and technology in 1991 from Kyushu University. Before returning to Kyushu University as a professor of the Center for Organic Photonics and Electronics Research (OPERA) and the Department of Applied Chemistry, he held positions as a research chemist and physicist in the Chemical Products

R&D Center at Ricoh Co., a research associate in the Department of Functional Polymer Science at Shinshu University, research staff in the Department of Electrical Engineering at Princeton University, and an associate professor and professor at Chitose Institute of Science and Technology. He became a distinguished professor at Kyushu University in 2010, and has also been the director of the Fukuoka i3 Center for Organic Photonics and Electronics Research since 2013.

Eli Zysman-Colman obtained his PhD from McGill University in 2003. He then completed two postdoctoral fellowships, one in supramolecular chemistry at the Organic Chemistry Institute, University of Zurich, and the other in inorganic materials chemistry at Princeton University. After beginning his career at the Université de Sherbrooke, he moved to the University of St. Andrews, where he is presently Reader in optoelectronic materials and Fellow of the Royal Society of Chemistry. His research program focuses on the rational design of luminophores for energy-efficient visual displays and flat panel lighting based on OLED and light-emitting electrochemical cell (LEEC) device architectures; light-harvesting dyes for dye-sensitized solar cells and organic photovoltaics; sensing materials employed in electrochemiluminescence; and photoredox catalysts for organic reactions.