Intermediate State Charge Transport in Multilevel Photochromic Light-Emitting Memory Devices

R. Clayton Shallcross, Peter O. Körner, Eduard Maibach, Philipp Zacharias, Anne Köhnen, Klaus Meerholz

Universität zu Koln, Department of Chemistry

richard.shallcross@uni-koeln.de

Dithienylethenes (DTEs) represent an exceptional class of thermally stable and fatigue resistant photochromic molecular switches that undergo a change in both their UV-visible absorption and frontier orbital energy levels due to a photo- and/or electrically-induced ring-opening and -closing reaction, which may be exploited in electrically-addressed nonvolatile organic memory devices.[1,2] Here, we present a multifunctional light-emitting organic memory (LE-OMEM) diode employing a DTE transduction layer that affords the ability for both optical and electrical writing and readout. Optimized LE-OMEM diodes show impressive ON/OFF ratios (OORs) for both electroluminescence (EL) and current readout of ca. 10^4 for optical switching and ca. 10^3 for electrical switching. By systematically controlling the fraction of closed isomers in the transduction layer (***X***), both optical and electrical writing protocols demonstrate the ability to write a continuum of states (i.e. levels) between totally OFF and ON (see Figure), offering an alternative technology for increased data storage density compared to typical binary memory cells. We elucidate the difference in the molecular-scale mechanisms that are responsible for the optically- and electrically-driven memory effect and discuss the charge transport properties of these intermediate states. Furthermore, we present results for integration of LE-OMEM diodes into a prototype passive memory array and discuss the device design considerations as well as the number of statistically discernable grey levels per pixel.

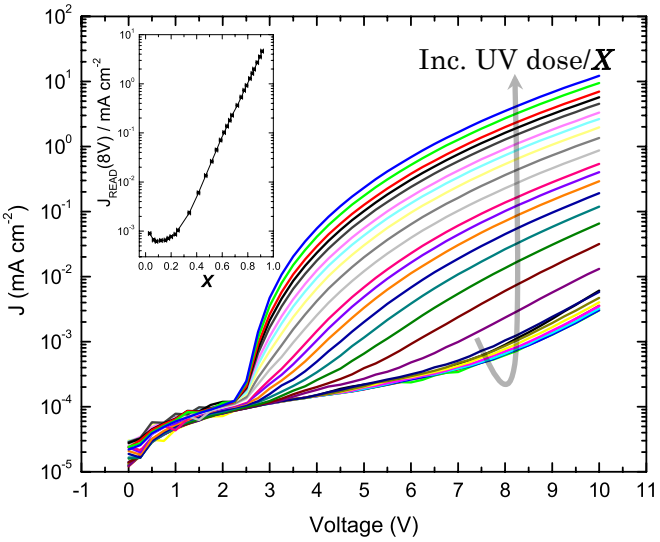

Figure. LE-OMEM diode J-V characteristics throughout the optical (UV-312 nm) ring-closing reaction of the DTE transduction layer. The inset shows the read current density at 8 V as a function of the fraction of closed isomer (***X***) in the DTE layer.

References

[1] Zacharias et al. *Angew. Chem. Int. Ed.* **48**, 4038-4041 (2009).

[2] Shallcross et al. *Adv. Mater.* (2012). DOI : 10.1002/adma.201202186.