Influence of in-situ x-ray exposure on the magnetotransport properties of NPB and MADN based blue OLED structures.

Jean-François Bobo (1) , Richard Monflier (2), Ludovic Salvagnac (2), Elena Bedel Pereira (2) and Isabelle Séguy (2)
(1) CEMES, CNRS 29 rue Jeanne Marvig, 31055 Toulouse Cedex 4, France
(2) LAAS- CNRS, Université de Toulouse, CNRS, Toulouse, France
jfbobo@cemes.fr

Magnetic Field Effects (MFE) on Organic Semiconductors (OSC) have a large fundamental and technological interest presently due to the development of organic electronics devices like OLED (organic light emitting diodes) or OPV (organic photovoltaic). Up to now, the largest observed MFE[1] have been reported for OLED-type devices. They are related to the interaction between excited states (singlet, triplet) and charge carriers, either free or trapped.[2] The origin of the magneto-conductance (MC) is still controversial and depends on the device structure. In particular, the materials choice plays an important role, as well as film thickness, fabrication process, temperature. For example, x-ray exposure during the deposition of metal layers with an electron gun may modify optoelectronic properties of OSC and MC, as reported by several authors.[3, 4] They are assumed to cause punctual trap defects in OSC films. We contribute to this issue in this work.
We have decided to compare two HTL organic materials, NPB and MADN, since they display almost the same HOMO and LUMO with huge differences in published values for hole mobility which are respectively 10^{-4} and 3.10^{-7} $cm^2/V.s$ for NPB and MADN.[5, 6] We have prepared devices with an OSC single-layer, ITO anode and Al cathode. For photoluminescence (PL) experiments, similar OSC single layers were deposited on bare silicon substrates. All organic layers of one sample set were grown during the same evaporation run, then individually x-ray treated at various acceleration voltages of the e-gun.
In the case of NPB, we report a dramatic dependence of current onsets that increase with the e-gun voltage (typically from 4 to 8 V for 100 nm NPB respectively pristine and 5 kV exposed). X-ray exposure is less significant for MADN-based devices with a shift from 4 to 5 V. However, they gave the optimal MFE with up to +6.3 % at 300 mT applied magnetic field for a 4 kV exposed sample. We also report a neat dependence of MFE on the voltage conditioning of the samples, *i.e.* applying direct polarization to the device. All these results strongly support the fact that MFE is governed by a combination of extrinsic x-rays-induced local defects in OSC layers. We will analyze the observed effects in terms of trap formation, occupancy and polaron-triplet exciton coupling according to present models and the obtained PL spectra.

[1] Y. Wang, K. Sahin-Tiras, N. J. Harmon, M. Wohlgenannt, and M. Flatté, *Phys. Rev. X*, 6, 011011 (2016)
[2] M. Gobbi and E. Orgiu, *J. Mater. Chem. C*, 5, 5572 (2017)
[3] M. Yamada, M. Matsumura, and Y. Maeda, *Thin Solid Films*, 519, 62190 (2011)
[4] J. Rybicki, R. Lin, F. Wang, M. Wohlgenannt, C. He, T. Sanders, and Y. Suzuki, *Phys. Rev. Lett.*, 109, 076603 (2012)
[5] M.H. Ho et al., *Appl. Phys. Lett*., 89, 252903 (2006)
[6] S.W. Liu et al., *Scientific Reports*, 5, 10384 (2015)