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Charge transport and trap spectroscopy in organic molecular crystals

CLAUDIA GOLDMANN, ETH Zurich, Switzerland

Key issues in the field of organic semiconductors are the determination of the intrinsic transport properties and of the distribution and the role of the trap states. We report on the use of temperature-dependent space-charge limited current spectroscopy and of field-effect measurement techniques to determine the bulk and surface transport properties and the distribution of trap states in the bulk of organic molecular crystals (OMCs). Systematic studies of structurally and chemically pure rubrene crystals reveal deep states with a density as low as 10^{15} cm^{-3} and an exponentially increasing density of shallow tail states near the mobility edge. Furthermore, we are able to intentionally generate additional traps, determine their density and energetic position within the band gap, and their influence on the bulk transport. Charge transport at the surface of rubrene, tetracene, pentacene and alpha-sexithiophene crystals measured e.g. by a gated four-terminal "flip-crystal" FET technique indicates significant charge trapping with an estimated interface state density of 10^{11} to 10^{12} cm^{-2} in high purity OMCs. Being able to measure the energetic distribution of trap states, to create and characterize defect states, and to study their influence on charge transport in OMCs constitutes significant progress in understanding crystalline organic semiconductors on a microscopic level. In collaboration with C. Krellner, S. Haas, K. P. Pernstich, A. Kloke, D. J. Gundlach, and B. Batlogg.