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Field-induced switch from heterojunction to bulk charge recombination in bilayer light-emitting diodes CARLOS SILVA, ARNE MORTEANI, RICHARD FRIEND, University of Cambridge — Optoelectronic devices made from semiconductor polymers often employ partially phase-separated binary polymer blends with distributed heterojunctions in the polymer film. We investigate the photo- and electroluminescence from bilayers of electron- and hole-transporting polyfluorene derivatives at different device temperatures. For low driving voltages (below $2.4\times10^5\,\mathrm{V/cm^2}$ at room temperature), we give direct evidence for barrier-free charge capture at the heterojunction. In this mechanism, charge capture produces an interfacial excited state (exciplex) directly and bulk exciton electroluminescence is only achieved through endothermic transfer (activation energy 200 meV) from the exciplex. For high driving voltages (above $8.3\times10^5\,\mathrm{V/cm^2}$ at 43 K), however, we find that charges are injected over the heterojunction barriers and subsequent charge capture occurs in the polymer bulk. Furthermore, if bulk excitons migrate to another heterojunction site within their lifetime they are re-trapped at the interface and again form exciplex states or dissociate completely. We demonstrate that in polymer blend light-emitting diodes this can reduce the exciton population by more than 70% and strongly influences the emission spectrum. We then analyze exciton re-trapping in detail using time-resolved photoluminescence spectroscopy on blends with different morphologies and find that for nm-scale phases exciton emission is completely suppressed.

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