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First example of organic/inorganic LEDs based on tandem emission of organic electromers and inorganic perovskite

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In the present work we show for the first time the tandem double-channel emission from organic exciplexes coupled to inorganic nanoparticles. The process is demonstrated for yellow-green emission in light-emitting diodes based on organic exciplexes hybridized with perovskite-type dispersed $BaZrO_3$ nanoparticles. Such double-channel emission provides the broadening of the electroluminescence spectrum and, therefore, produces the soft yellow-green emission color of the device that is harmless to the human eye. We have successfully realized an unusual energy transfer from the exciplexes between the tris(4-carbazoyl-9-ylphenyl)amine (TCTA) and 4,7-diphenyl-1,10-phenanthroline (Bphen) molecules to spherical-shaped $BaZrO_3$ nanoparticles sporadically deposited on the organic interface. The fabricated device exhibits high current efficiency values of 3.88 Cd/A, maximum brightness of 3465 cd/m^2 (at 15V), and external quantum efficiency of about 1.26%. In order to estimate the efficiency of the energy transfer from the exciplex to the $BaZrO_3$ nanoparticle we have applied the Förster model for the dipole-dipole energy transfer. We have found that the Förster-type energy transfer in the TCTA/Bphen–$BaZrO_3$ system is the most efficient in the short range of donor-acceptor distances and varies from 50% (at Förster radius R_0=3.1 Å) to 17% (at R=4 Å). We believe, that future developments in the field of organic-inorganic LEDs will lead to the new branch of low cost and non-toxic LEDs with the simplified structure that should be a background to achieve commercial success of such hybrid LEDs.