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Time-Resolved Photoluminescence Spectroscopy for Exploring Advanced Optical Materials and Devices

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○ **초록**

Time-resolved photoluminescence (TRPL) spectroscopy is a powerful technique for investigating photo-induced dynamics of excitons generated in hybridized optical materials and devices. Recent advances in chemometric analysis of spectrally and temporally resolved TRPL data have enabled the disentanglement of complex excitonic dynamics, including surface trapping, exciton–phonon coupling, and exciton–surface scattering. In this talk, we highlight the applications of ultrafast TRPL spectroscopy to complex photonic materials and devices, extending beyond conventional studies of isolated molecules. First, we introduce our home-built TRPL setups and advanced chemometric analysis methods specifically designed for material characterization. The performance of our TRPL setups is demonstrated by successfully probing ultrafast reaction dynamics in surface-anchored photosensitizing monolayers, despite their inherently weak emission signals. Next, we extend these capabilities to study the intermolecular carrier transfer dynamics in inhomogeneous catalytic materials (MOF and HER systems with high densities of structural defects). For these applications, we introduce a modified Stern-Volmer analysis and a dual excitation TRPL detection scheme to resolve complex excited-state dynamics. Finally, we present a newly developed operando spectroscopic technique for OLED diagnostics that enables simultaneous electrical and optical probing under operational bias conditions, thereby allowing us to identify various parasite exciton scattering processes.

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