Supporting Information for

Carrier Decay Properties of Mixed Cation Formamidinium-Methylammonium Lead Iodide Perovskite $[HC(NH_2)_2]_{1-x}[CH_3NH_3]_xPbI_3$ Nanorods

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Experimental Method

The $FA_{1-x}MA_xPbI_3$ nanorods were synthesized following the solution method. A drop of $PbAc_2 \cdot 3H_2O$ solution (50 μL) with a concentration of 100 mg/mL was dispersed on a glass substrate with area of ~ 1 cm^2. After dried at 50 °C for 10 min, a thin film formed on the substrate, which served as the Pb precursor source for perovskite growth. The substrate was then placed in a vial with the $PbAc_2$-coated side facing up together with a mixed MAI/FAI solution (1 mL) with various FA/MA ratios. After a reaction time of 24 h at room temperature, the substrates were taken out and washed with 2-isopropanol for several seconds, and then dried with nitrogen gas.

The SEM images of various samples were examined with a LEO SUPRA 55 VP scanning electron microscope. Powder XRD spectra were measured by a Bruker D8 Advance Powder X-ray Diffractometer with Cu Kα radiation. The ^1H NMR spectra were measured by a Bruker Ascend 400 NMR spectrometer. The photoluminescence (PL) spectra were collected by a Horiba Yobin Yvon FL-1057 spectrometer, the excitation wavelength was 550 nm. The micro-photoluminescence spectra were measured by confocal Raman/PL spectrometer (LabRAM Aramis Horiba Jobin Yvon) with CW 532 nm laser as excitation source. For time-resolved PL study, the as-grown $FA_{1-x}MA_xPbI_3$ nanorods were dry-transferred and dispersed onto clean glass coverslips. The sample was placed on an inverted microscope (Nikon Eclipse Ti-U) and a 639 nm picosecond diode laser (PicoQuant LDH-D-C640), with a repetition frequency of 125 kHz and pulse duration ~500 ps, was focused on the sample through a CFI Plan Fluor 40× air objective (NA 0.75) (Nikon). The laser was focused to a spot size of ~0.5 μm^2, smaller than an individual nanorod. A 635 nm dichroic beamsplitter (Semrock) and a long wavelength pass filter with a cutoff wavelength about 653 nm (Semrock) were used to block the excitation laser in the optical path of photon counting. A 200 μm pinhole was placed in the optical path to block other scattered light. The photoluminescence decay of an individual $FA_{1-x}MA_xPbI_3$ nanorod was collected through the same objective, detected on a τ-SPAD avalanche photodiode (PicoQuant) and recorded using a time-correlated single photon counter (PicoHarp 300). Before fitting, the TRPL data was smoothed using the adjacent averaging function in Origin.

Supporting Figures

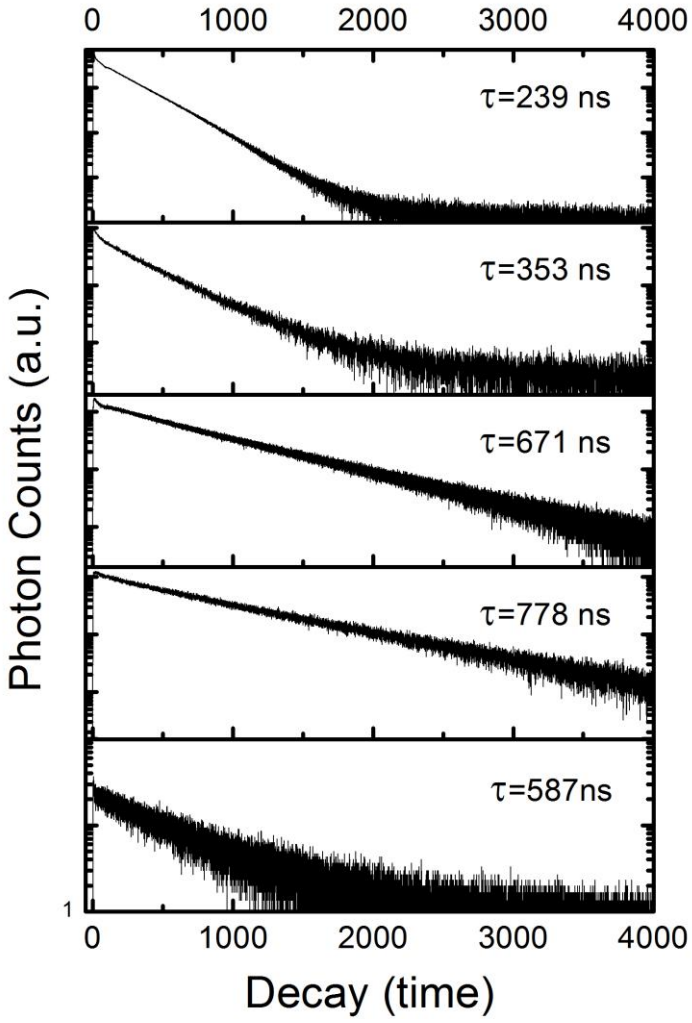

Figure S1. TRPL spectra of five representative alloyed $MAPbI_3$ nanorods at the excitation energy density of 1.09×10^{-9} J/cm^2/pulse.

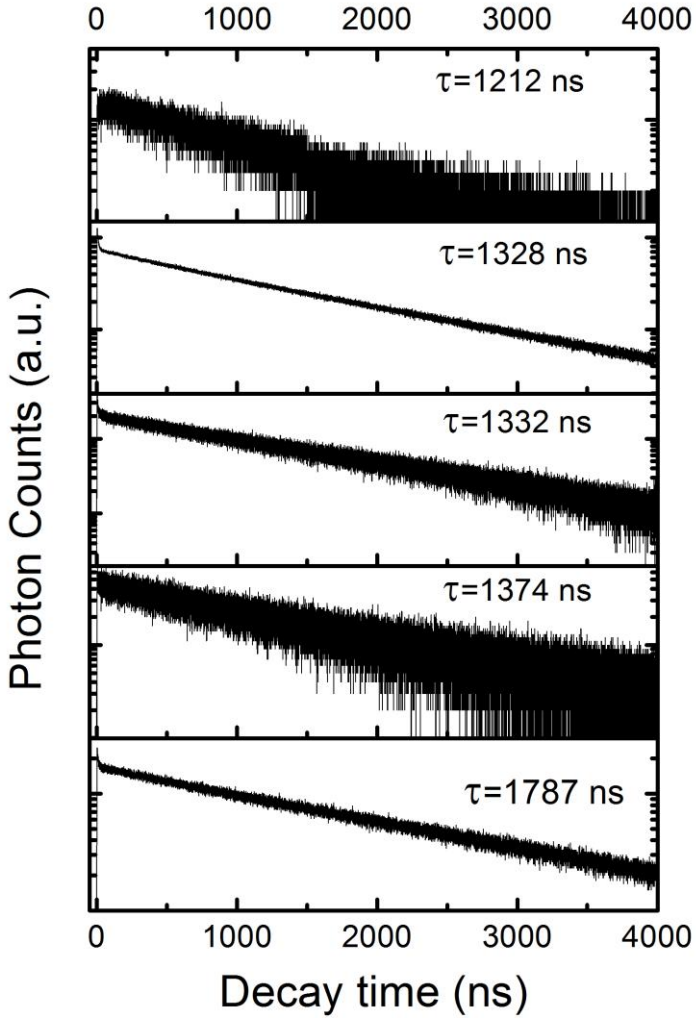

Figure S2. TRPL spectra of five representative alloyed $FA_{0.2}MA_{0.8}PbI_3$ nanorods at the excitation energy density of 1.09×10^{-9} J/cm^2/pulse.

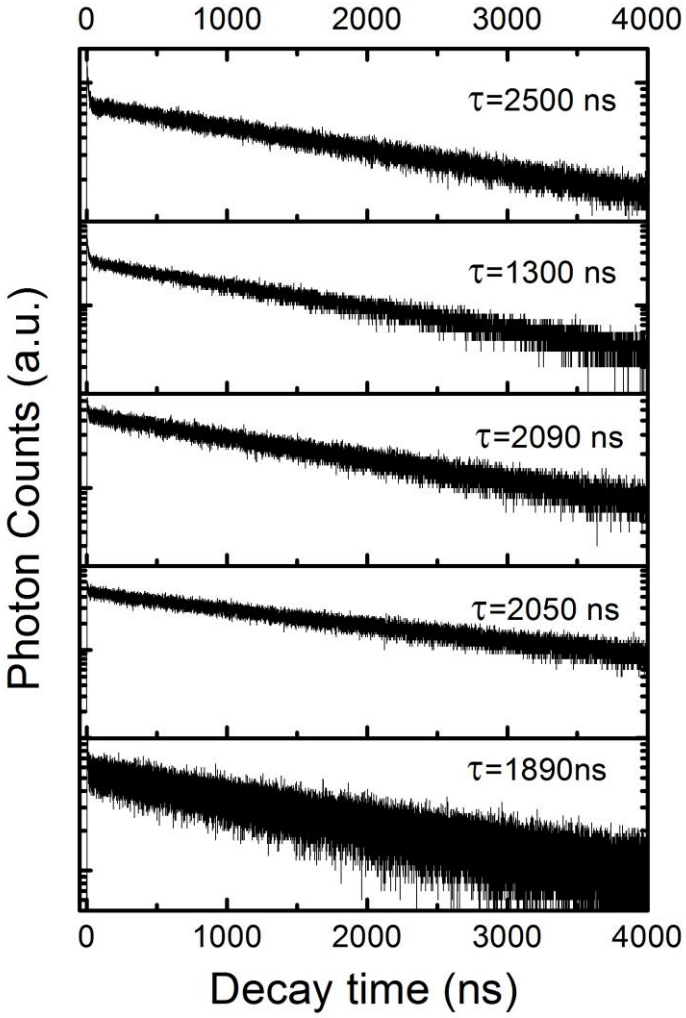

Figure S3. TRPL spectra of five representative alloyed $FA_{0.4}MA_{0.6}PbI_3$ nanorods at the excitation energy density of 1.09×10^{-9} J/cm^2/pulse.

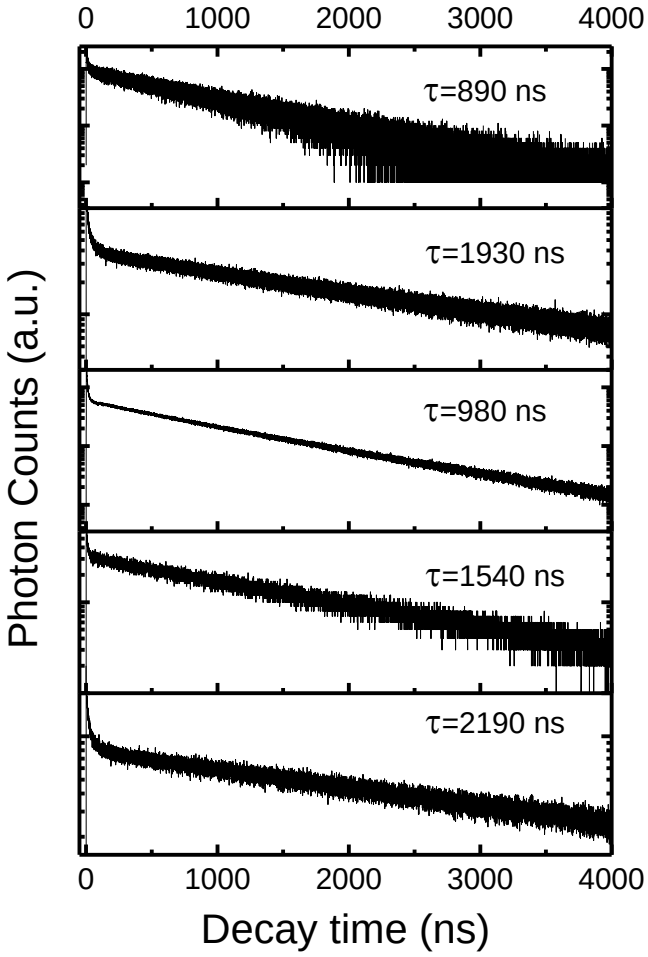

Figure S4. TRPL spectra of five representative alloyed $FA_{0.6}MA_{0.4}PbI_3$ nanorods at the excitation energy density of 1.09×10^{-9} J/cm^2/pulse.

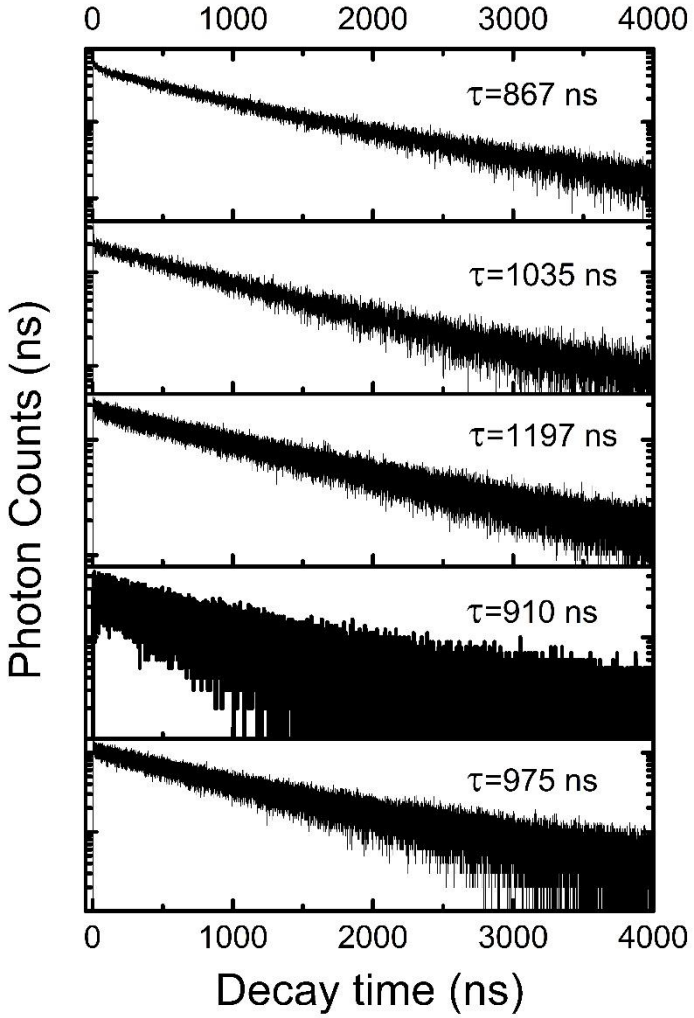

Figure S5. TRPL spectra of five representative alloyed $FA_{0.8}MA_{0.2}PbI_3$ nanorods at the excitation energy density of 1.09×10^{-9} J/cm^2/pulse.

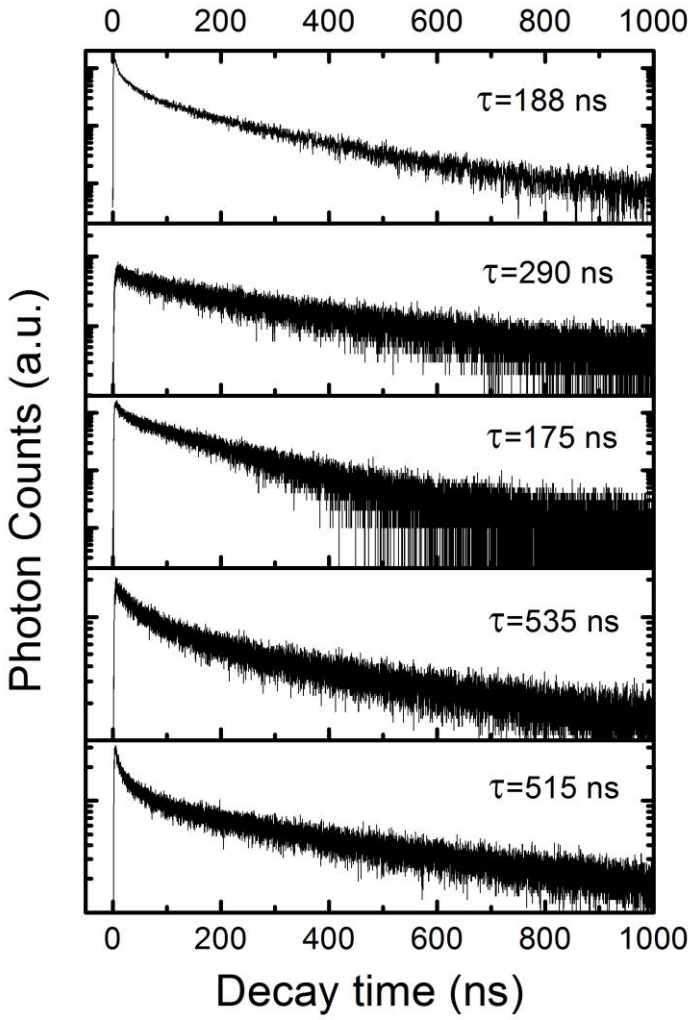

Figure S6. TRPL spectra of five representative alloyed $FAPbI_3$ nanorods at the excitation energy density of 1.09×10^{-9} J/cm^2/pulse.

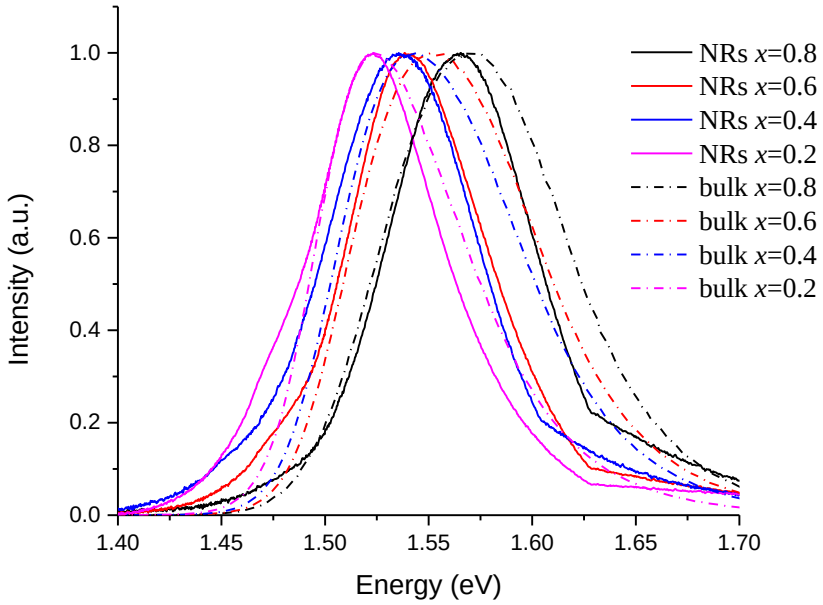

Figure S7. Comparison of summed single-particle photoluminescence spectra and bulk photoluminescence spectra.