Supplementary information

Framing Emission Gain Layers for Perovskite Light-Emitting Diodes Using Polycaprolactone-Silver Nanoparticles Featuring Förster Resonance Energy Transfer and Purcell Effects

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Experimental section:

The TEM analysis for AgNPs. Drop 10 μl of AgNPs on the carbon-copper grid and take the overnight vacuum to dry. Field Emission Transmission Electron Microscopy (FE-TEM) image was recorded using a JEOL JEM-2100F (at the Instrumentation Center, National Taiwan University) was used to measure.

The DLS and zeta potential analysis for AgNPs. Take 1 ml of AgNPs and dilute to 3 ml with DMF. DLS of the particle size was measured with an Otsuka / ELSZ-2000ZS.

The FTIR analysis for AgNPs. Drop 1 ml of AgNPs on the KBr substrate and dry it. An FTIR spectrometer (Perkin Elmer Spectrum One) was used to measure.

The RAMAN analysis for AgNPs. Drop 1 ml of AgNPs on the bare wafer. A Raman spectrometer (HORIBA Instruments Incorp(HII)-iHR320, laser 785 nm) was used to measure and analyze by Labspec 6.

AgNPs and P.V.S.K thin film characterization. The surface of the AgNPs and P.V.S.K thin film was measured with Field Emission scanning electron microscopy (FE-SEM; Hitachi S4800) at an acceleration rate of 10 kV and Atomic Force Microscope (AFM; Bruker Innova). The UV–vis absorption spectra of the perovskite films were measured with a Jasco V-730 Spectrophotometer. The varied excitation photoluminescence of the perovskite was determined using dynamic photoluminescence excitation (PLE) spectroscopy (Nanolog, Horiba Scientific). TRPL spectra and Photoluminescence decay time were detected using a spectrometer (iHR320, HORIBA) coupled with a Hamamatsu C10910 streak camera; excitation source- PLP-10 Laser diode head-M10306-27 and an M10913 slow single-sweep unit at the National Synchrotron Radiation Research Center (NSRRC, Taiwan).

PeLEDs device characterization. The current density–voltage (IV) and luminance-voltage (LV) characteristics were taken using Keithley 2400 and SpectraScan PR670 photonic multichannel analyzer. The electroluminescence spectrum was collected using SpectraScan PR670 photonic multichannel analyzer.

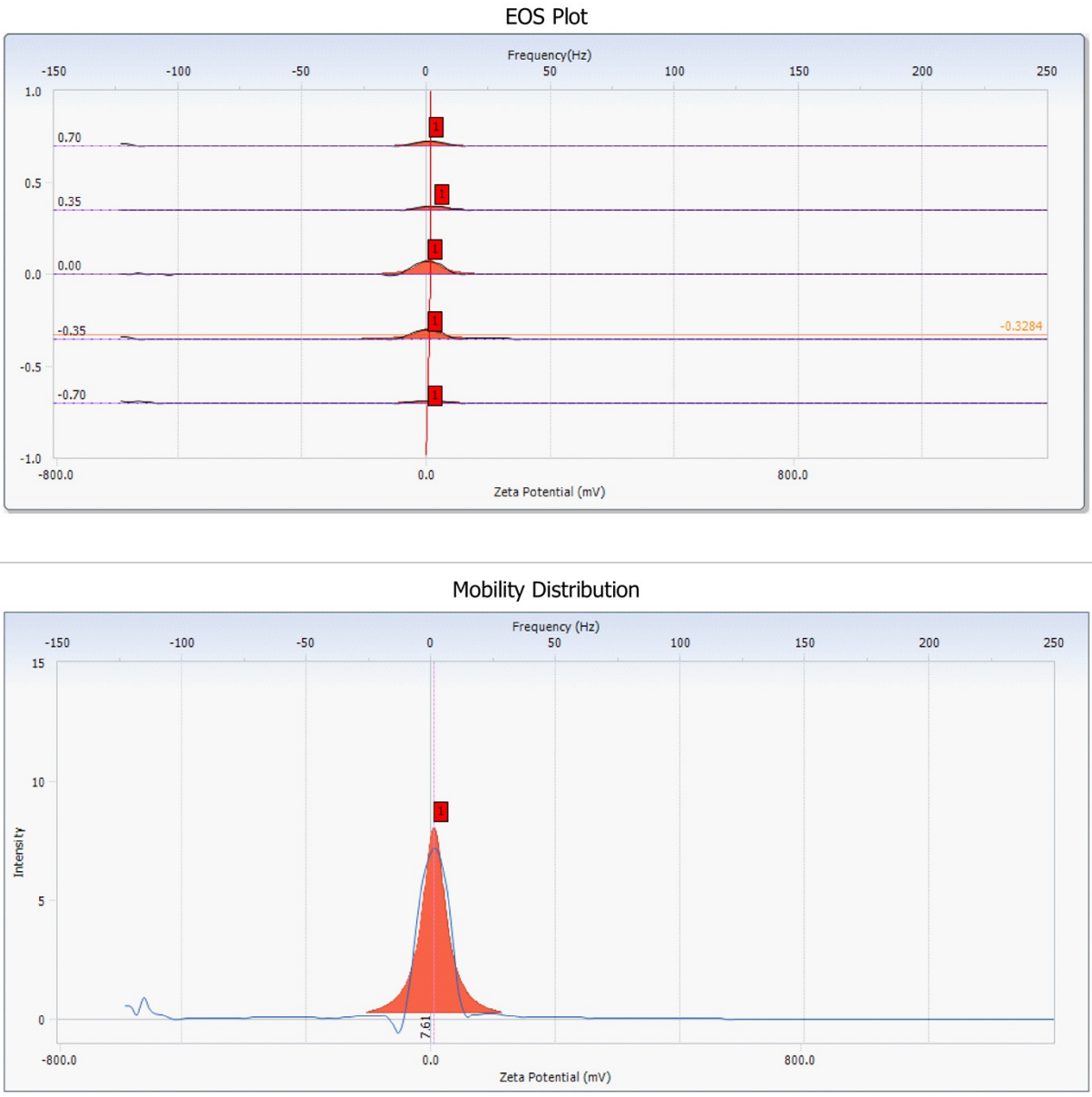

Fig. S1. The zeta potential's EOS plot and mobility distribution of DMF@AgNPs.

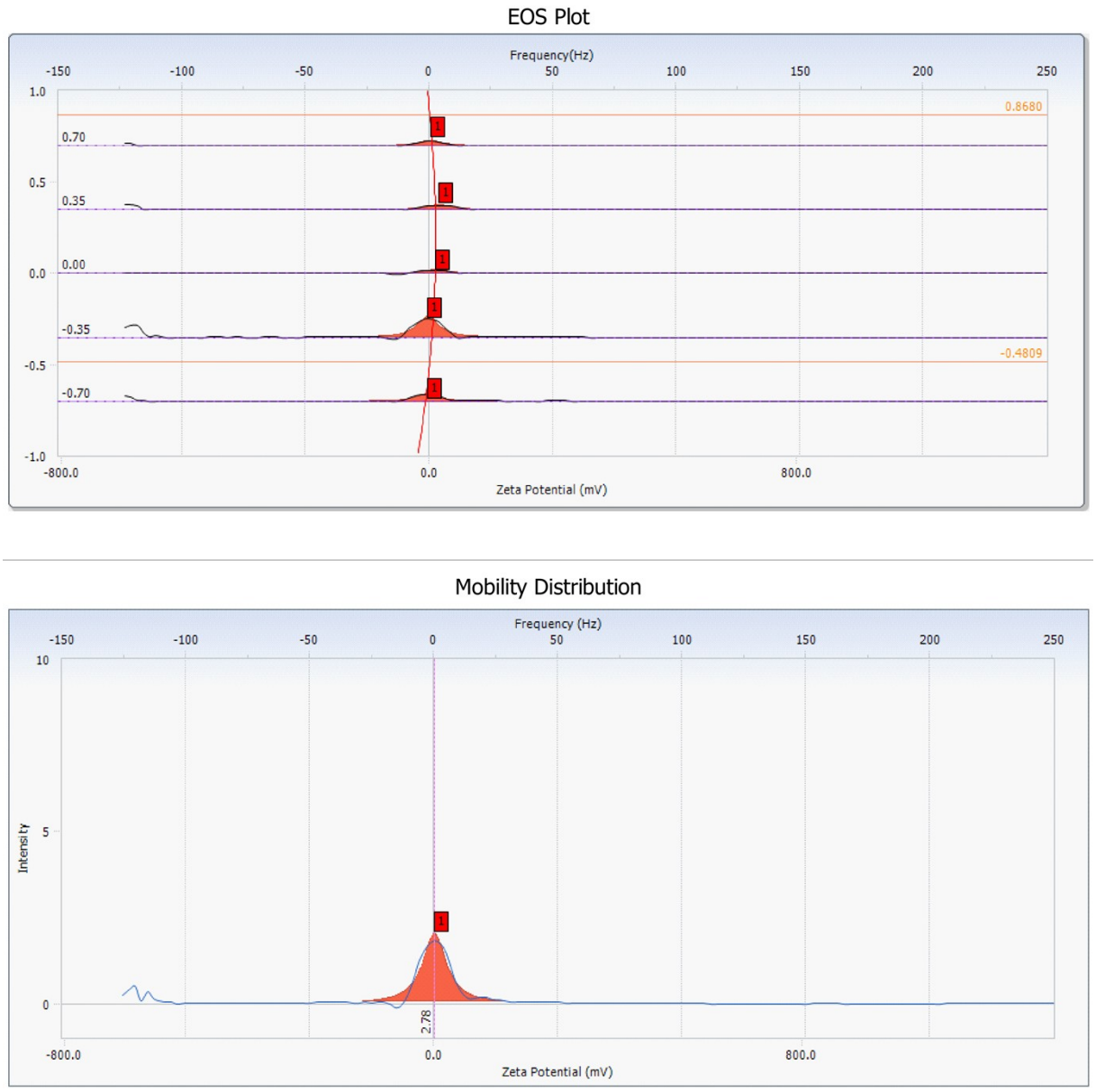

Fig. S2. The zeta potential's EOS plot and mobility distribution of PCL@AgNPs-O.

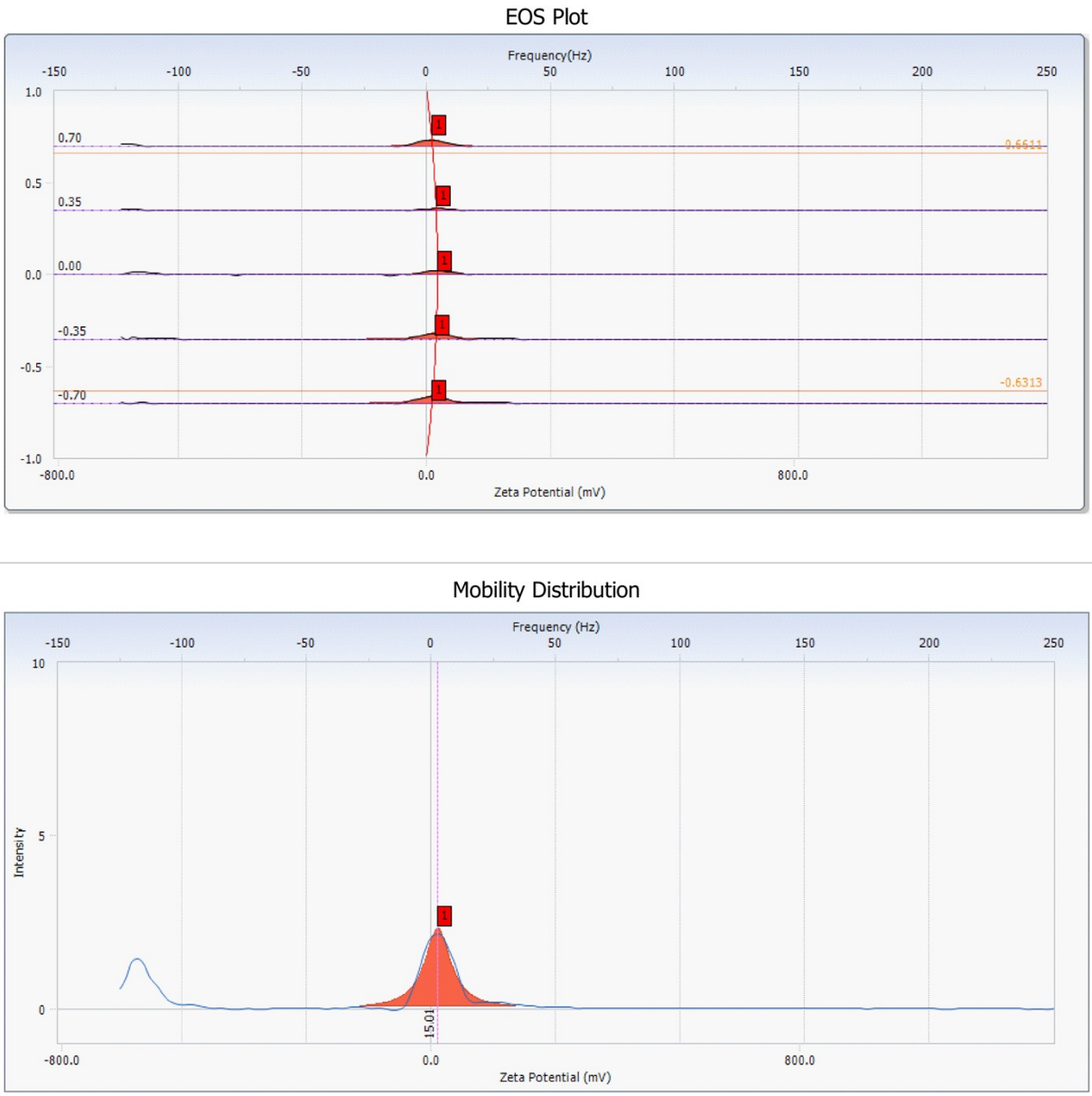

Fig. S3. The zeta potential's EOS plot and mobility distribution of PCL@AgNPs-P.

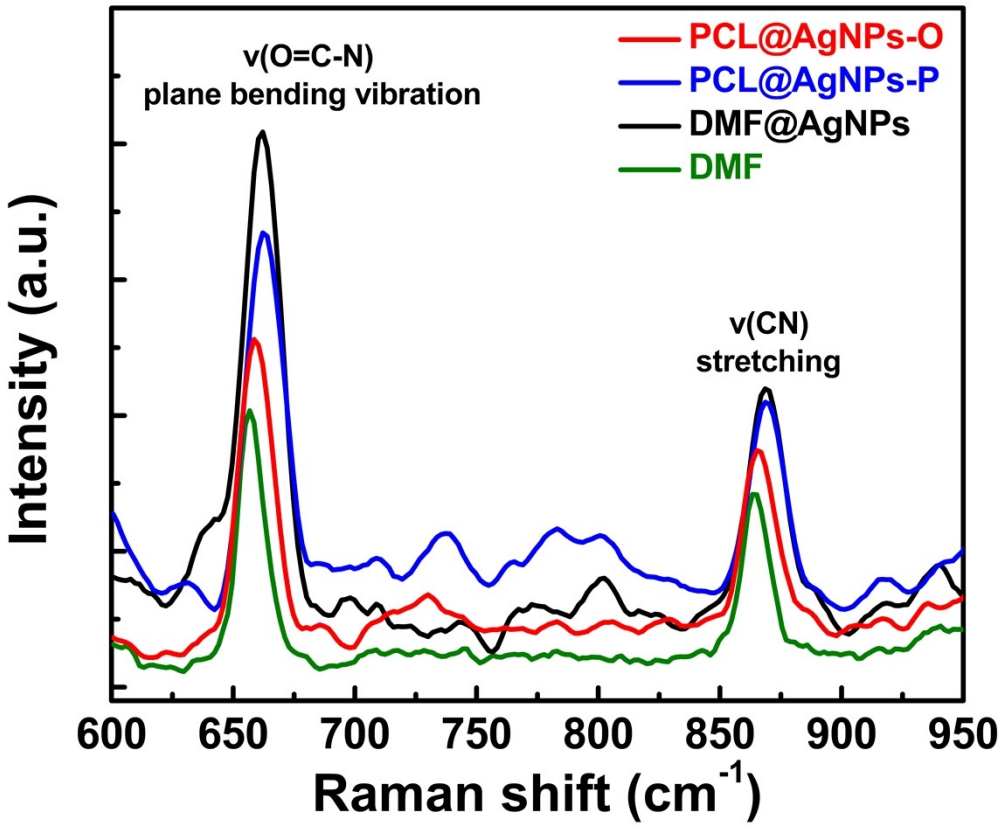

Fig. S4. Raman-shifted characteristic peaks of ν(O=C-N) and ν(CN) (DMF, DMF@AgNPs, PCL@AgNPs-P, PCL@AgNPs-O).

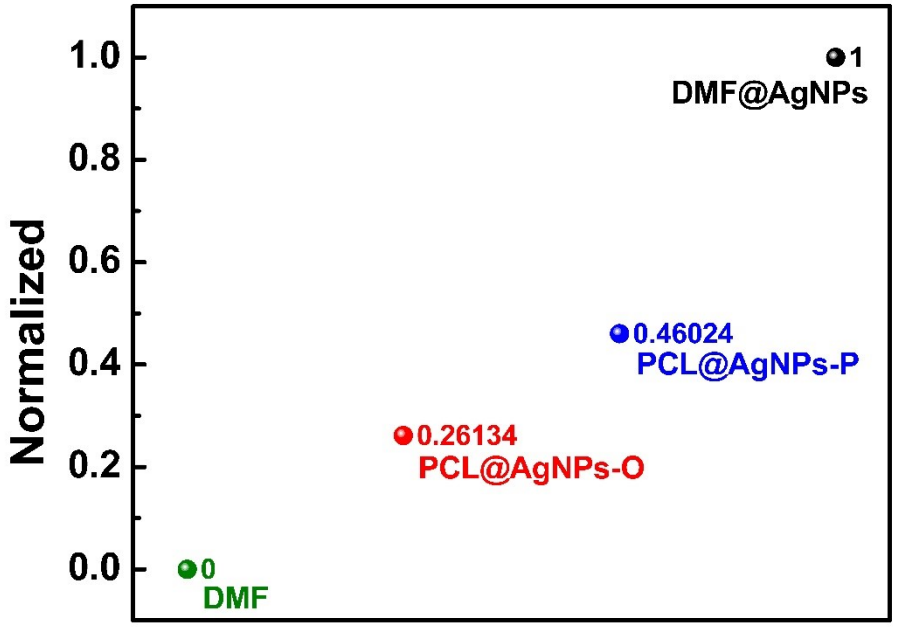

Fig. S5. Extent of DMF involvement in the reduction of AgNPs (DMF, DMF@AgNPs, PCL@AgNPs-P, PCL@AgNPs-O).

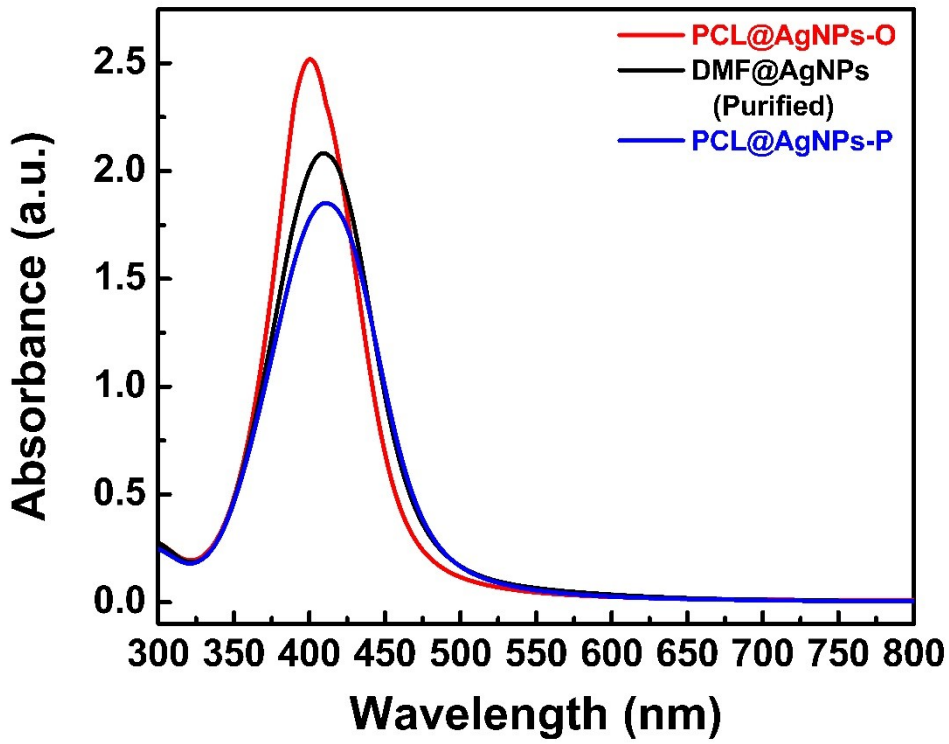

Fig. S6. Maximum UV-Vis absorption intensity of AgNPs on the fifth day (purified DMF@AgNPs, PCL@AgNPs-P, PCL@AgNPs-O).

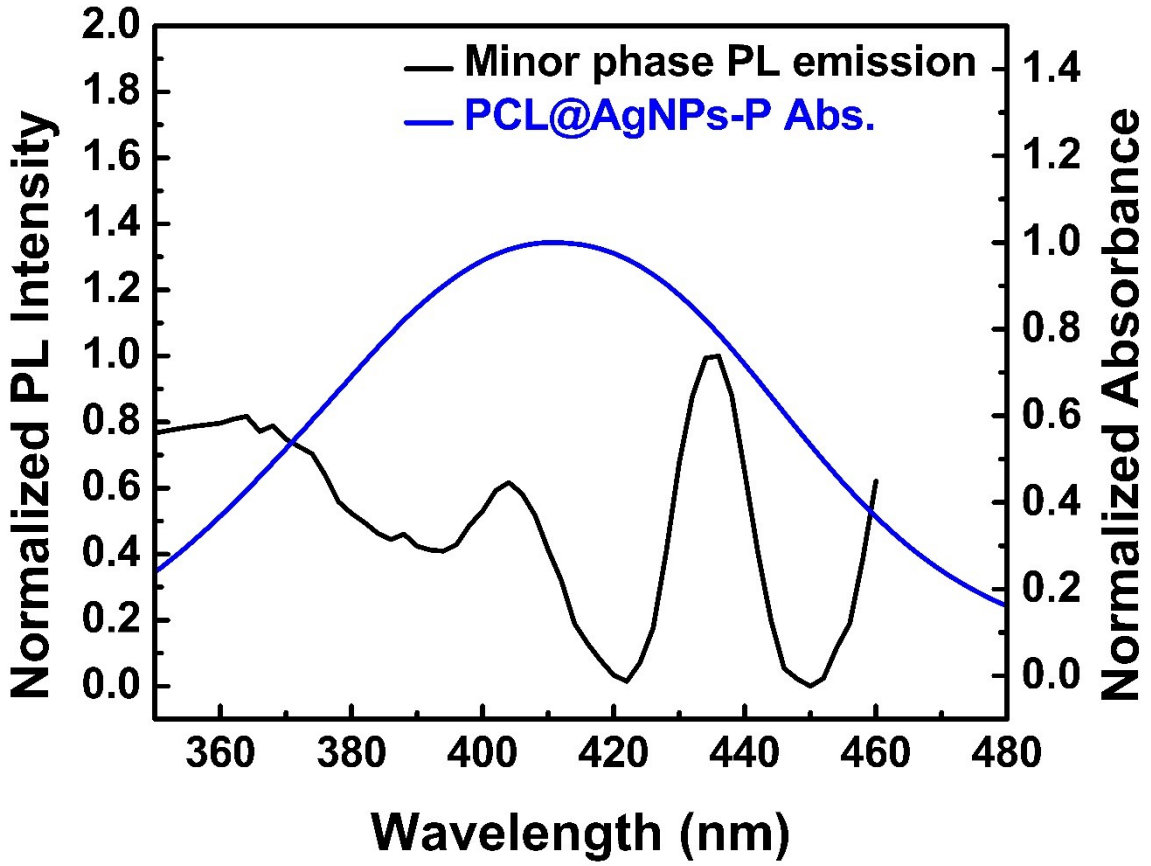

Fig. S7. Spectra of the minor-phase PL and PCL@AgNPs-P absorption overlap.

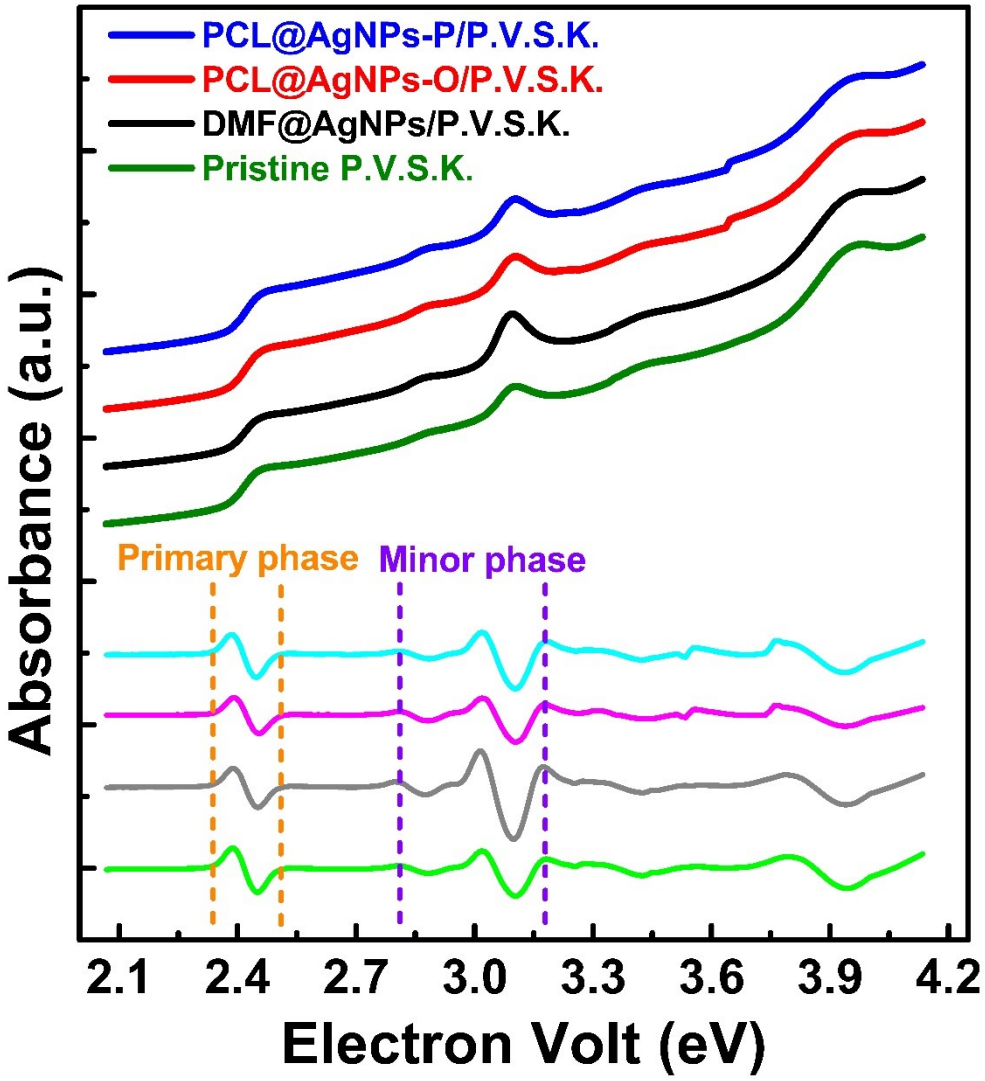

Fig. S8. The UV-Vis absorption spectra and second derivative profiles of different crystalline substratess of P.V.S.K. are compared.

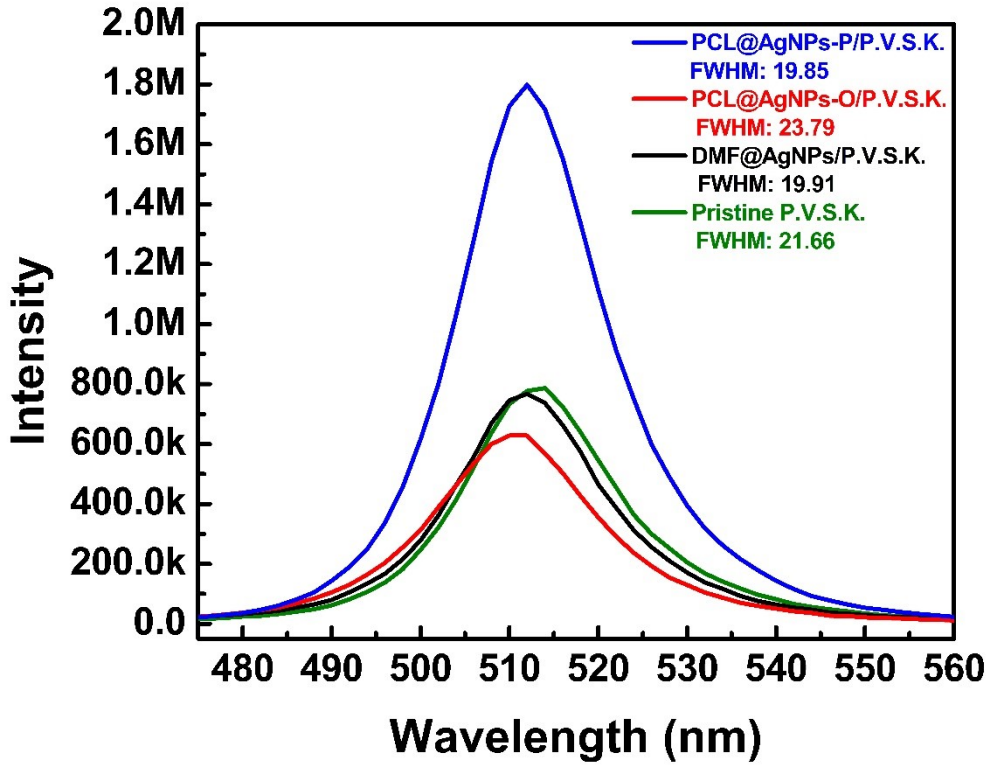

Fig. S9. PL spectra of quasi-2D perovskites after introduction of an emission gain layer of AgNPs (pristine P.V.S.K., DMF@AgNPs/P.V.S.K., PCL@AgNPs-P/P.V.S.K., PCL@AgNPs-O/P.V.S.K.).

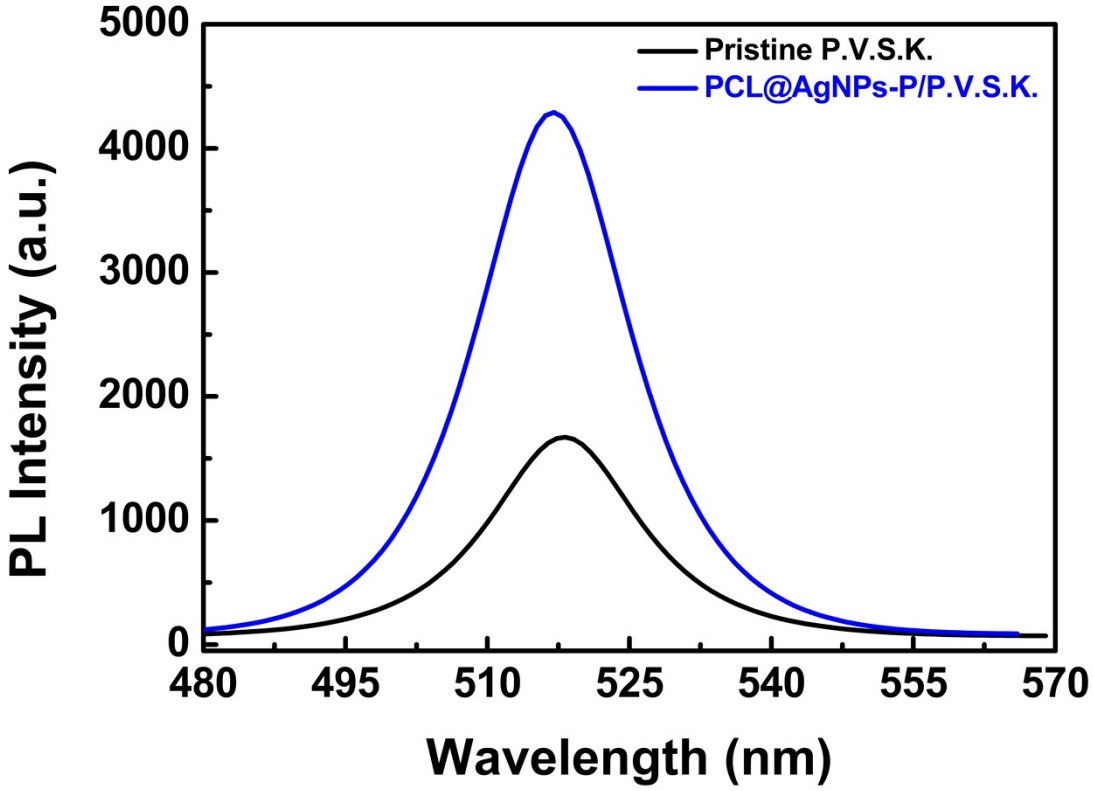

Fig. S10. PL spectra of pristine perovskite and PCL@AgNPs-P/perovskite.

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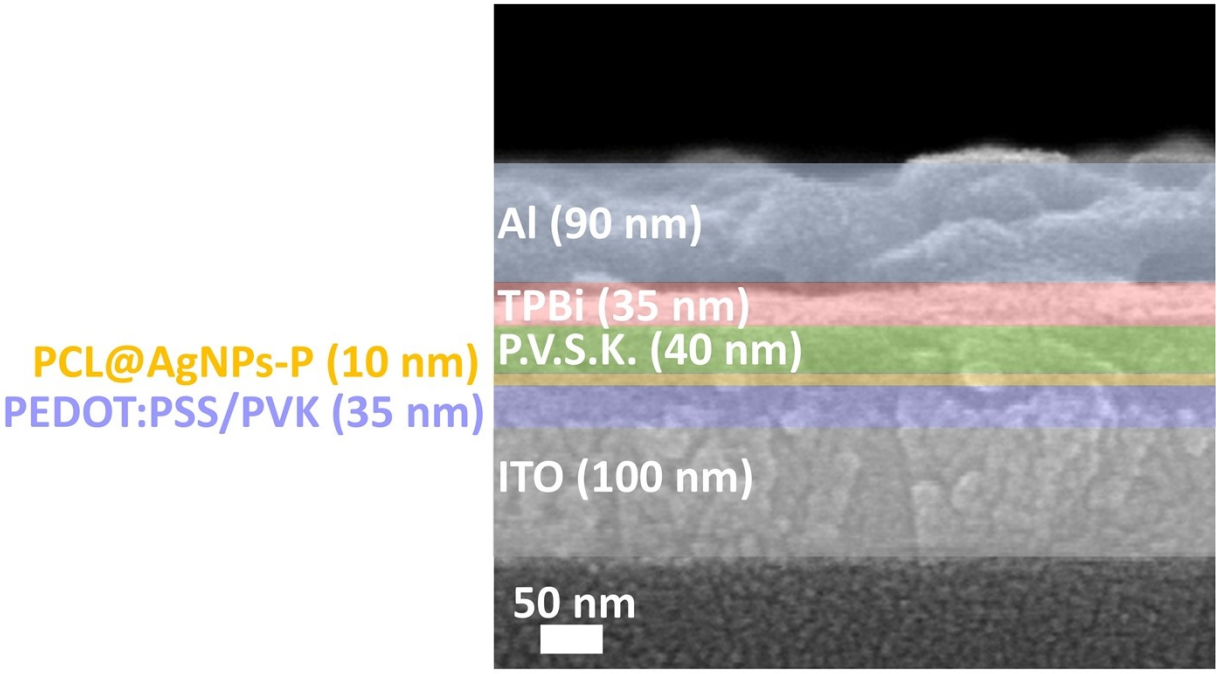

Fig. S11. The SEM cross-section image of PeLEDs.

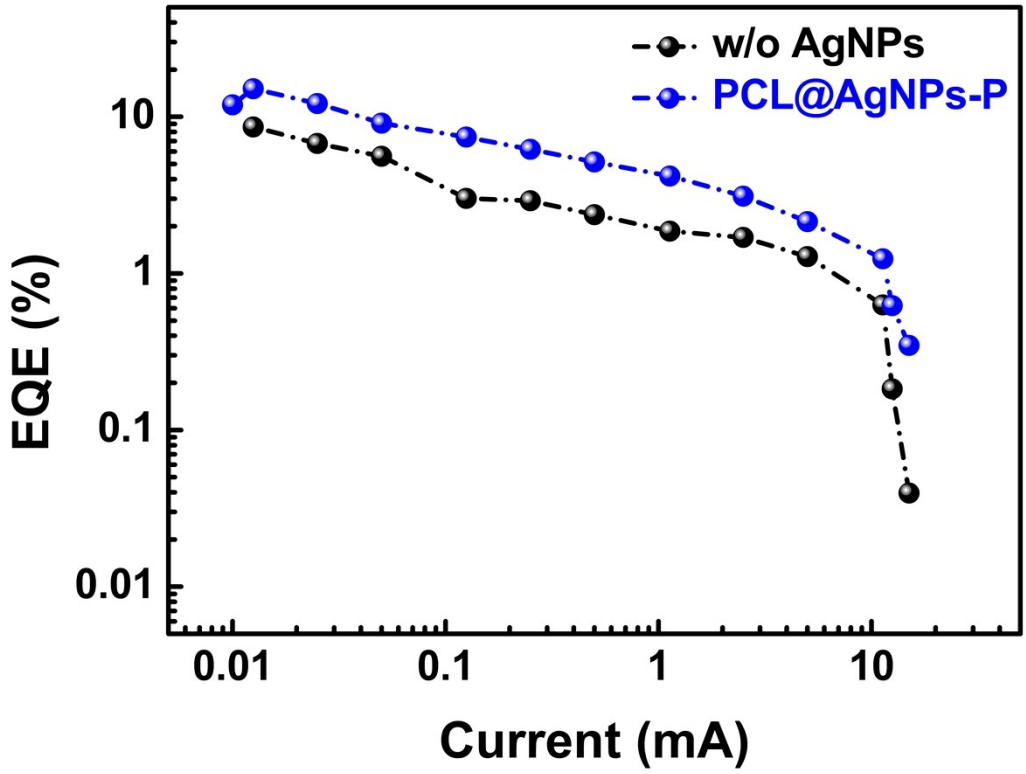

Fig. S12. EQE trend under variable current operation.

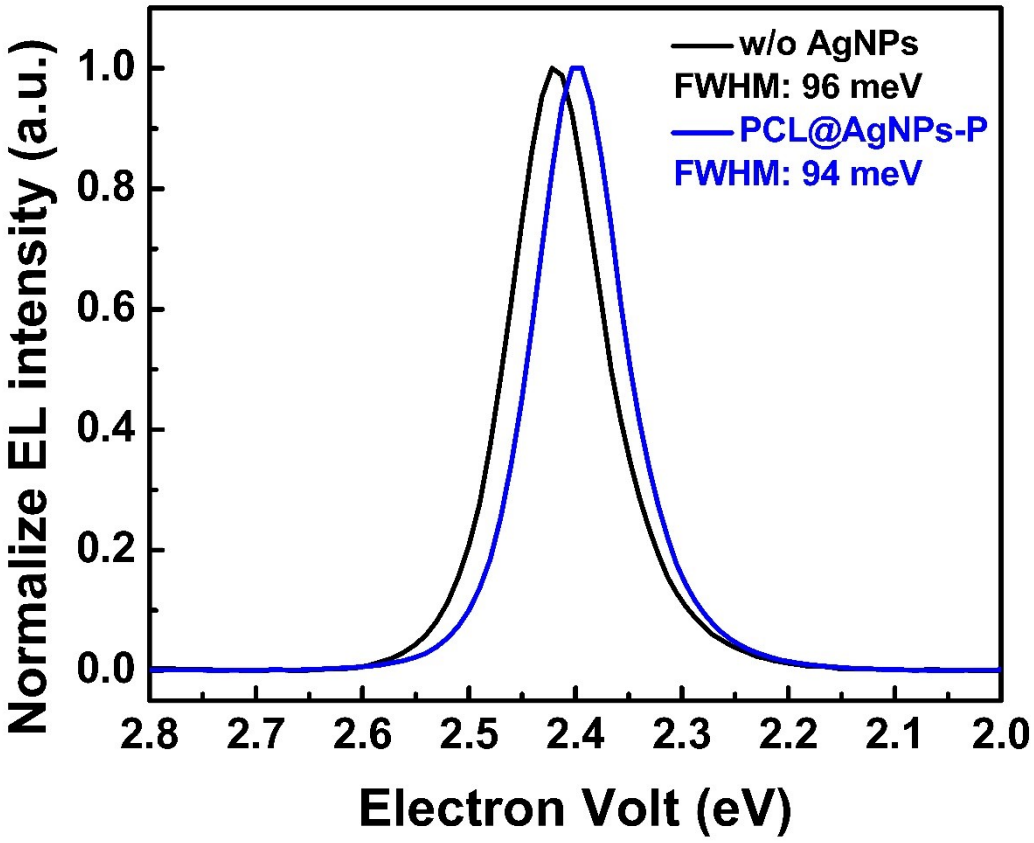

Fig. S13. Electroluminescence spectra at maximum luminance (w/o AgNPs, PCL@AgNPs-P).

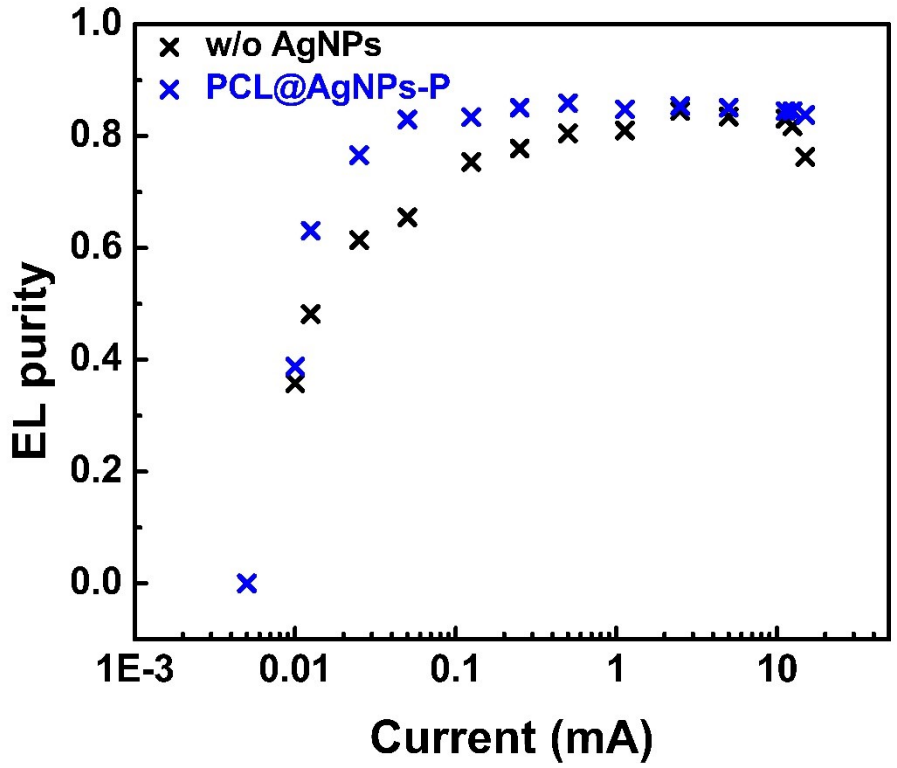

Fig. S14. Green wavelength EL purity of PeLEDs (w/o AgNPs, PCL@AgNPs-P).

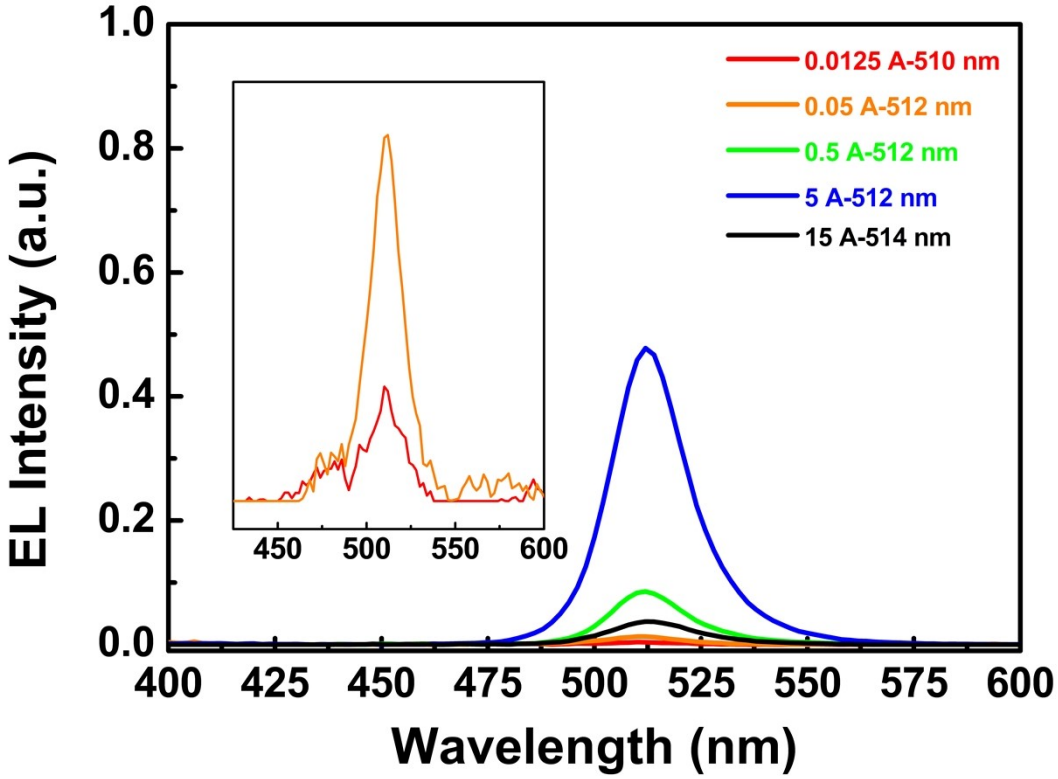

Fig. S15. w/o AgNPs of PeLEDs EL spectrum trend under variable current operation.

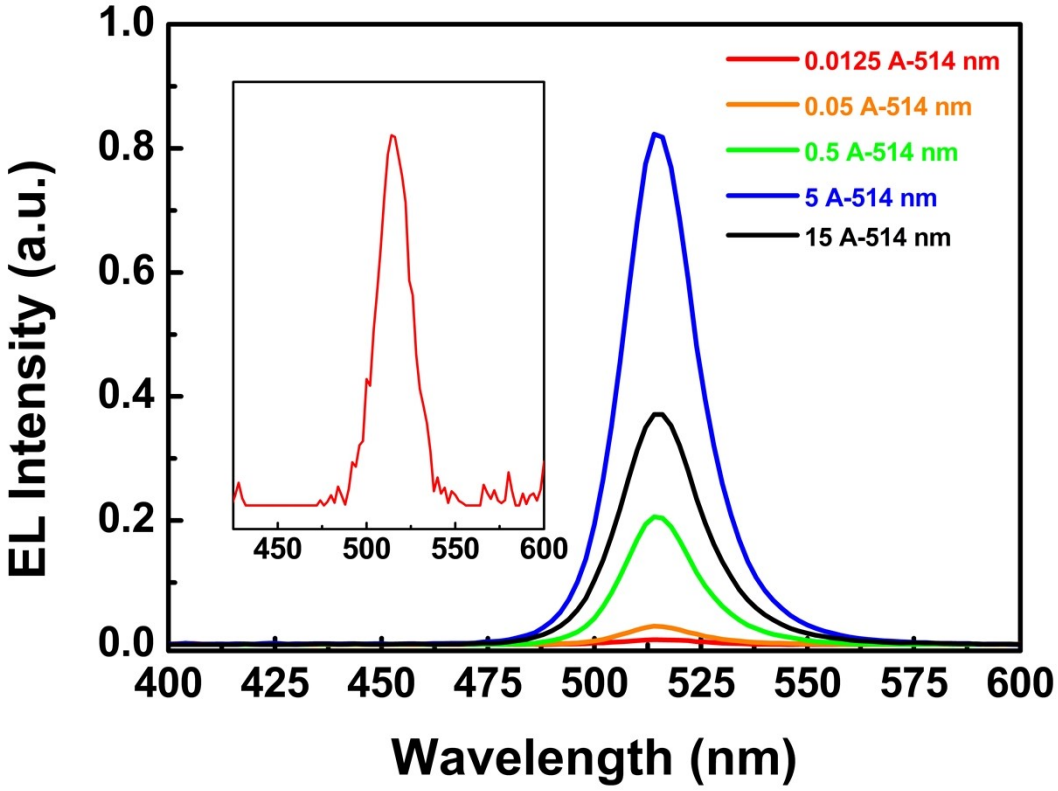

Fig. S16. PCL@AgNPs-P of PeLEDs EL spectrum trend under variable current operation.

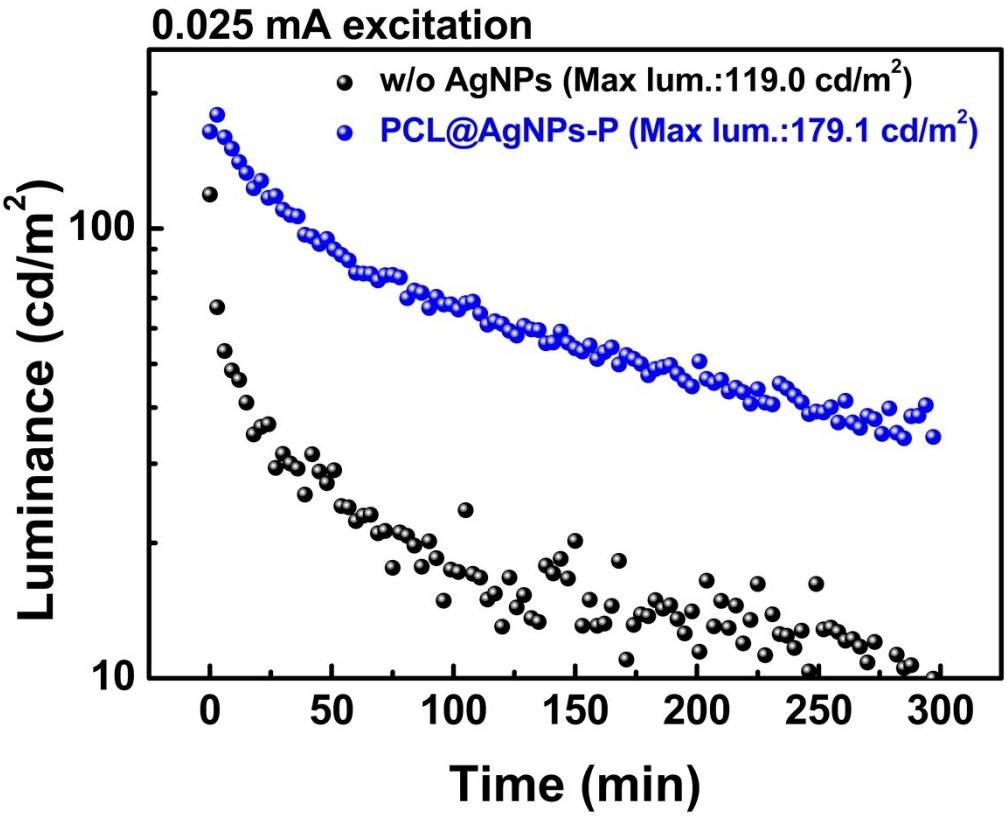

Fig. S17. Comparison of luminance lifetime of PeLEDs in w/o AgNPs and PCL@AgNPs-P case under 0.025 mA excitation.

Table S1 The zeta potential results of DMF@AgNPs, PCL@AgNPs-O and PCL@AgNPs-P.

	Zeta Potential (mV)	Mobility (cm^2/Vs)	Conductivity (mS/cm)	Doppler shift (Hz)	Base Frequency (Hz)	Conversion Equation
DMF@AgNPs	7.61	1.789e-005	0.1440	1.41	123.1	Huckel
PCL@AgNPs-O	2.78	6.544e-006	0.1397	0.52	122.8	Huckel
PCL@AgNPs-P	15.01	3.529e-005	0.1532	2.78	123.0	Huckel