Supporting Information

Room Temperature Two Photon Pumped Random Lasers in FAPbBr3/Polyethylene Oxide (PEO) Composite Perovskite Thin Film

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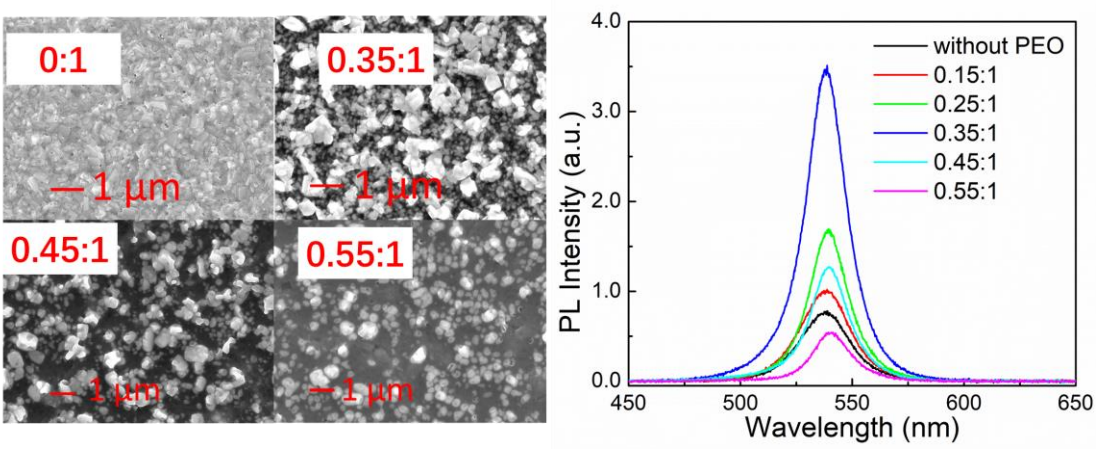
Materials 1. Samples mixed with different ratio of PEOs were prepared, the SEM images of them were scanned, as seen in the Fig.S1 below. The arrangement of the perovskite nanoparticles in the film is tightly arranged before mixing the PEO molecules. But when mixing with the PEO molecules, the perovskite nanoparticles in the film are aggregated onto a series of independent islands and covered by PEO molecules. As the increase of the PEO molecules, the distance between separate islands gradually increased. In this structural change, the fluorescence intensity of the material showed a tendency to first increase and then decrease, which was the strongest in the 0.35:1 sample. The laser threshold of the sample and the PL show an inverse relationship, the specimen with the ratio of 0.35:1 demonstrated the best laser behavior, as exhibited in the manuscript.



(a) **(b)**

Fig. S1 (a) Surface appearance image of $FAPbBr_3$ perovskite thin films mixed with different ratio of PEOs taken by scanning electron microscope; (b) photoluminescence spectra of $FAPbBr_3$ and $FAPbBr_3$/PEO composition perovskite thin films

Materials 2. Two photon pumped random laser emission spectra in $FAPbBr_3$ perovskite thin films mixed with different ratio of PEOs.

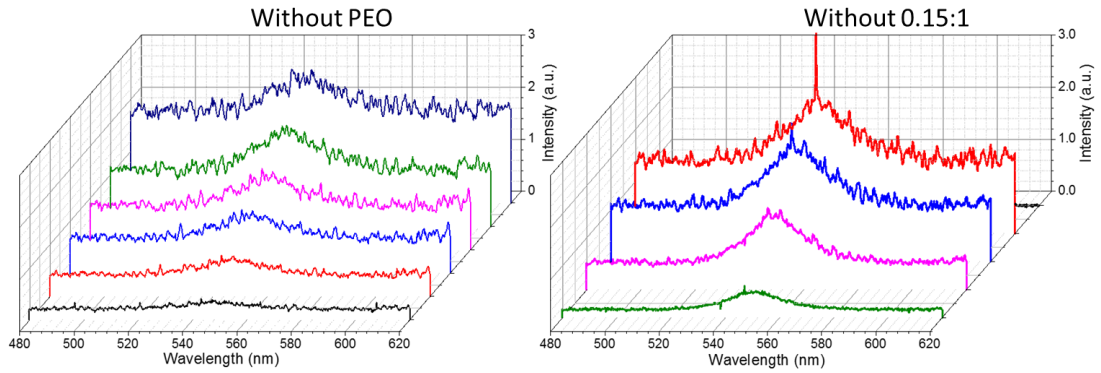


Fig. S2. Two photon pumped random laser emission spectra in $FAPbBr_3$ perovskite thin films mixed with different ratio of PEOs.

Materials 3. To further investigate the effect of polymers on perovskite luminescence, we also used PMMA as a coagulant for similar experiments. When mixing with the PMMA molecules, the size of the perovskite crystals becomes smaller and the distance becomes more compact, as seen in Fig. S2. The fluorescence intensity of the sample was also significantly enhanced, which was the strongest in the 0.15:1 sample. The most important factor was the enhancement of UV absorption. However, since the surface of the sample is still flat, the scattering intensity of the sample is not as large as that of the PEO-doped sample, so the laser behavior is not achieved.

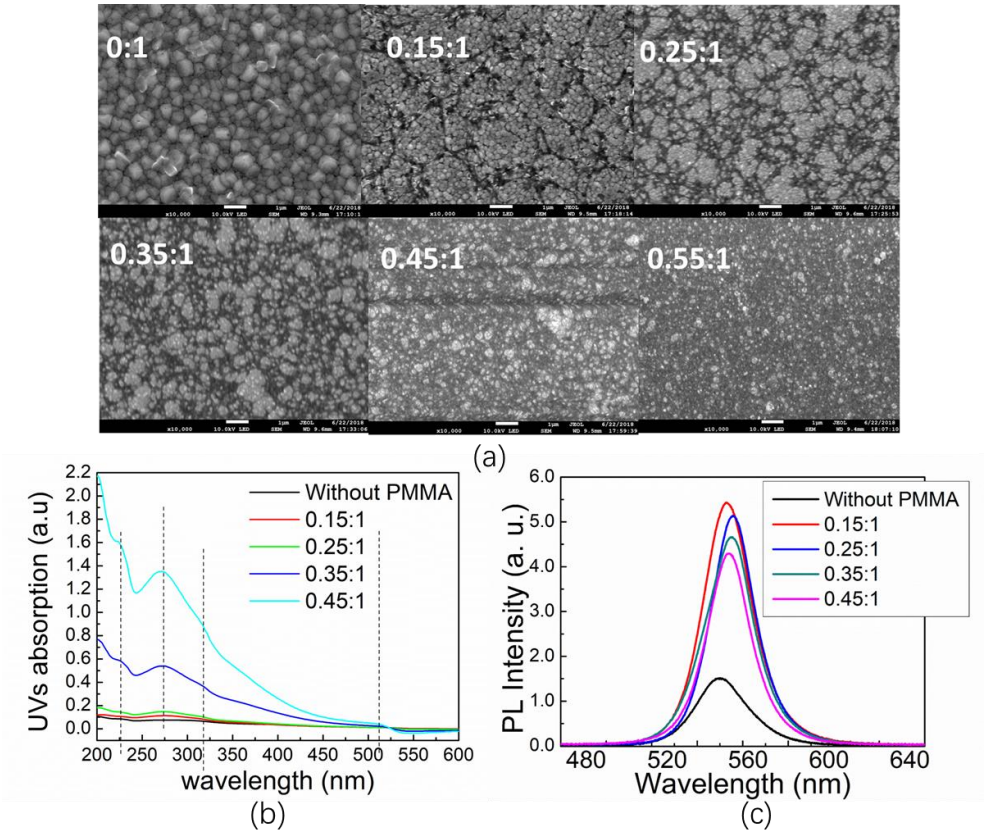


Fig. S3 (a) Surface appearance image of $FAPbBr_3$ perovskite thin films mixed with different

ratio of PMMAs taken by scanning electron microscope; (b) absorption and (c) photoluminescence spectra of $FAPbBr_3$ and $FAPbBr_3$/PEO composition perovskite thin films