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Electronic Supplementary Information

In-situ localized formation of cesium lead bromide nanocomposites for fluorescence micro-patterning technology achieved by organic solvent polymerization

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Experimental section

Chemicals. Cesium bromide (CsBr, 99.9%), lead bromide ($PbBr_2$, 99.999%), ethyl acetate (ACS, ≥ 99.5%) and γ-butyrolactone (GBL, AR) were purchased from Aladdin Industrial Corporation, China. All chemicals were directly used without further purification.

Preparation of precursor solution. CsBr (0.0213 g), $PbBr_2$ (0.0367g) and GBL (2 mL) were loaded into a 10 mL vial and stirred at 120 ℃ for 15 min. A turbid yellow solution was obtained and subsequently filtered using a polytetrafluoroethylene membrane filter (0.22 μm pore size). Finally, the obtained transparent white solution is used for subsequent femtosecond laser processing.

Sample preparation for femtosecond laser patterning. Prior to the precursor solution deposited on the glass substrate, all the substrates were successively washed in acetone, isopropanol and absolute alcohol for 15 minutes in an ultrasonic washer, and finally dried in a nitrogen flow. The single-sided adhesive polyimide tape with appropriate size was fixed on the central area of the clean glass substrate, and a square groove with the approximately size of 4 mm × 4 mm was obtained in the middle of the tape by using a scalpel. A small amount of precursor solution (5 μL) was dropped into the preformed square groove, and then a glass slide was capped over the precursor solution and fixed with polyimide tape. Finally, the resulting samples could be patterned by the 532 nm femtosecond laser setup.

Additionally, for the Au-coated samples, a thin gold film was formed on the glass/PET substrate by using an ion sputter coater (ISC 150, Supro Instruments) before dropping the precursor solution into the square groove. The working power of the ion sputter coater was 15 W and the sputtering time was 80 s.

After laser patterning, the residual precursor solution was cleaned out with ethyl acetate solution.

Femtosecond laser setup. All the experiments were carried out on the homemade nano/micro fabrication system with a 532 nm femtosecond laser (Fianium, repetition rate: 80 MHz, pulse width: 170 fs). An objective lens with a high numerical aperture (100×, NA = 1.4, Olympus) was used to focus light on to the

glass substrate. The diameter of the focus spot was about 232 nm. All designs including lines, dot arrays and patterns were obtained by moving the sample stage (563.3CD, Physik Instrumente) while keeping the laser beam steady. The desired patterns were defined by a program-controlled system. The morphologies of laser-induced nanocomposites were influenced by laser power, writing speed and exposure time.

Characterization. The morphologies of the resulting patterns fabricated by femtosecond laser pulses were observed by a high-resolution field-emission scanning electron microscope (NOVA NanoSEM 450, FEI). Transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM), high resolution transmission electron microscopy (HRTEM) images, energy dispersive spectrum (EDS), selected area electron diffraction (SAED) patterns and elemental mapping analysis were recorded by a Titan G^2 60-300 transmission electron microscope with an acceleration voltage of 300 kV. The photoluminescence (PL) images were taken by a camera (C4742-95-12EGR, hamamatsu) installed on a home-made imaging system with an excitation wavelength of 460 nm. The PL spectrum was also collected on this system with an Ocean optics (USB2000+UV-VIS) spectrometer. The absorption spectrum of the precursor solution was recorded by a Shimadzu UV-3600 spectrophotometer. All the tests were performed under ambient conditions at room temperature.

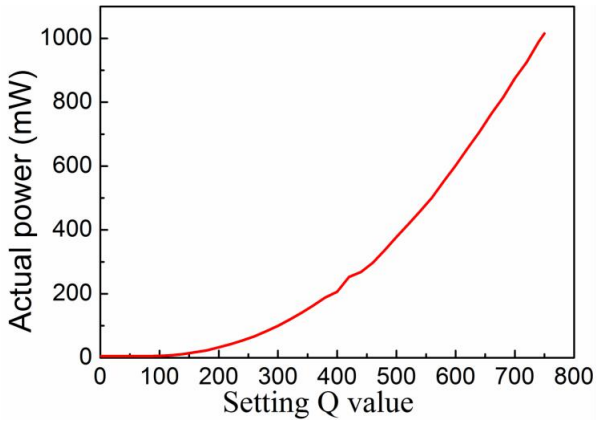

Figure S1. The dependence of the actual power of 532 nm femtosecond laser on the setting Q value entered into the computer control system.

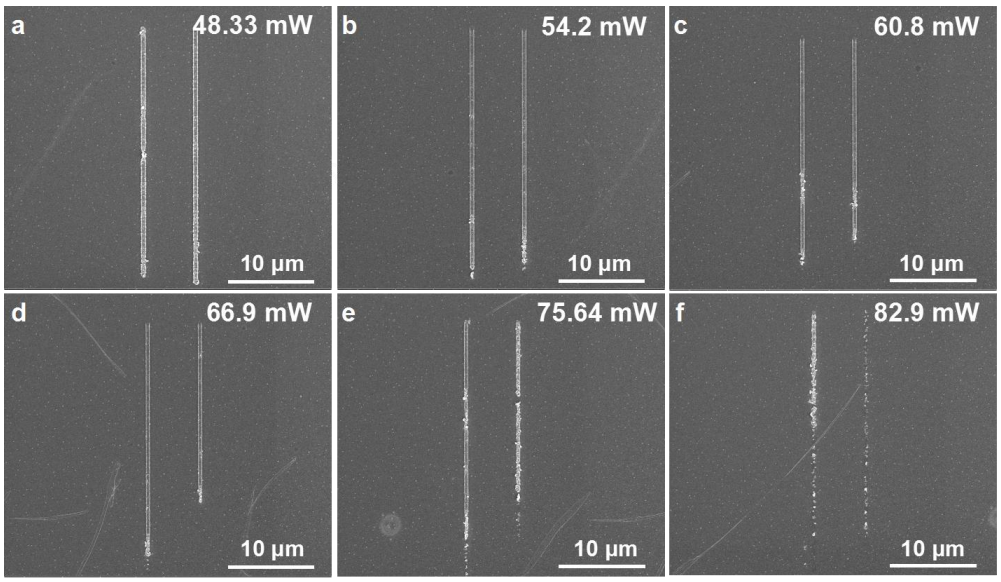

Figure S2. The SEM images of linear patterning based on GBL processed at different laser powers (fixed writing speed: 2 μm/s).

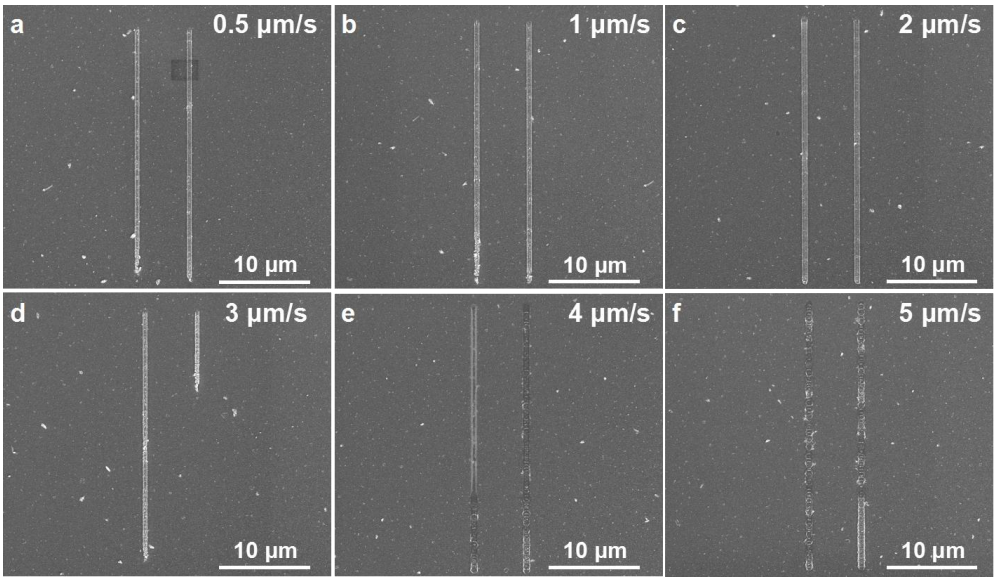

Figure S3. The SEM images of linear patterning based on GBL processed at different writing speeds (fixed laser power: 48.33 mW).

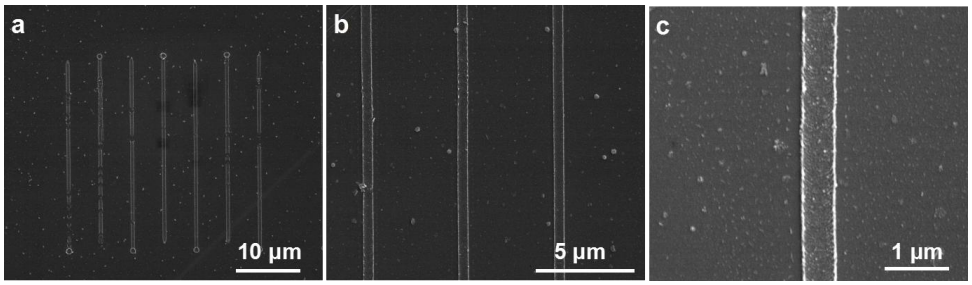

Figure S4. The SEM images of polymer line arrays based on GBL measured in different magnifications.

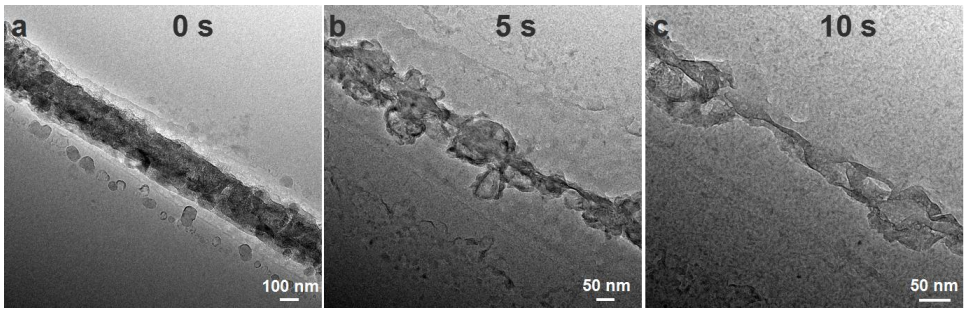

Figure S5. The TEM images of a GBL-based polymer line fabricated by femtosecond laser measured for different times. a) 0 s. b) 5 s. c) 10 s.

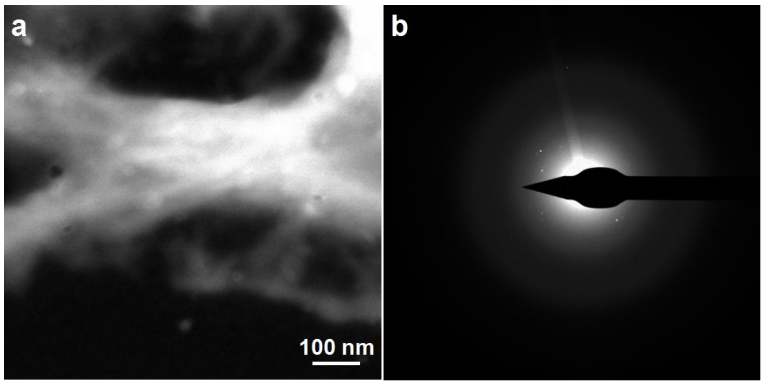

Figure S6. a) The typical STEM image of GBL-based polymer line. b) The corresponding SAED pattern.

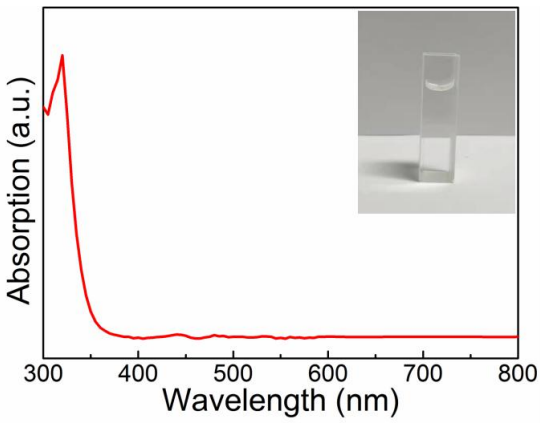

Figure S7. The absorption spectrum of Cs-Pb-Br precursor solution, inset: the photographs of the precursor solution.

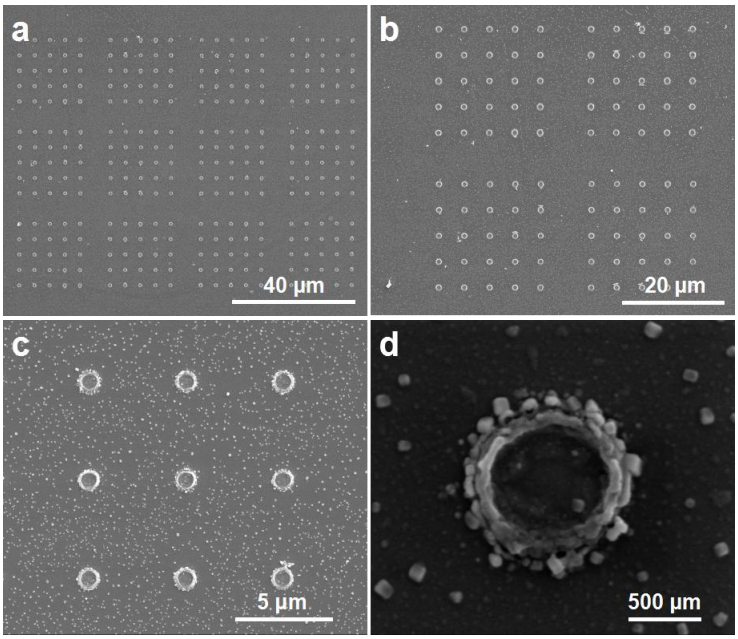

Figure S8. The SEM images of dot arrays fabricated using Cs-Pb-Br precursor solution measured in different magnifications.

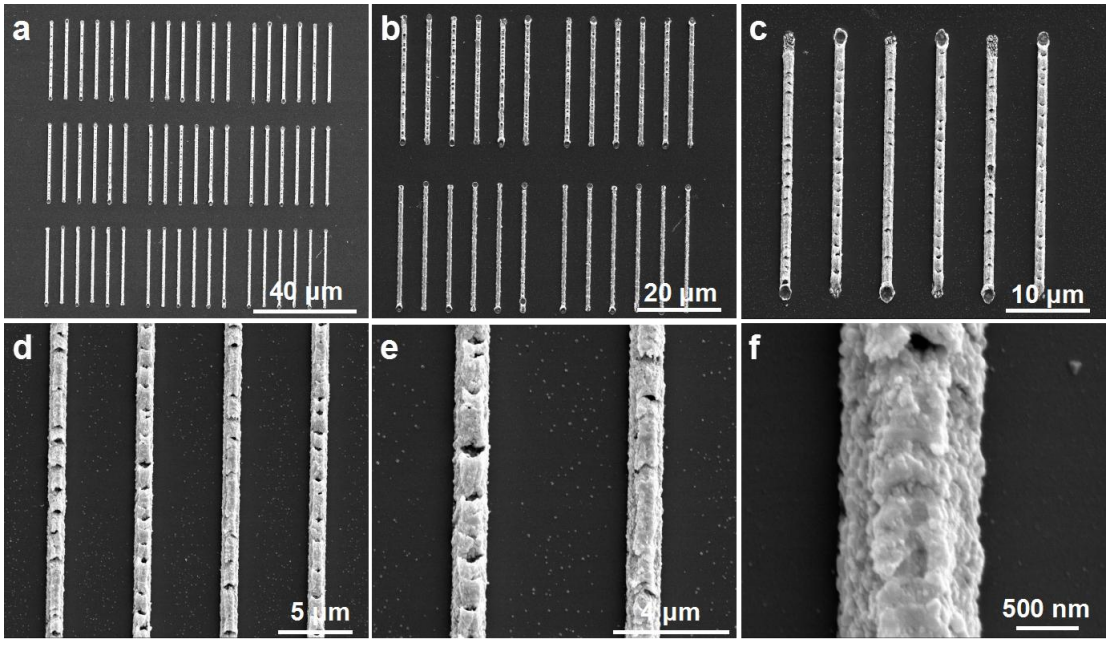

Figure S9. The SEM images of line arrays based on Cs-Pb-Br nanocomposites measured in different magnifications.

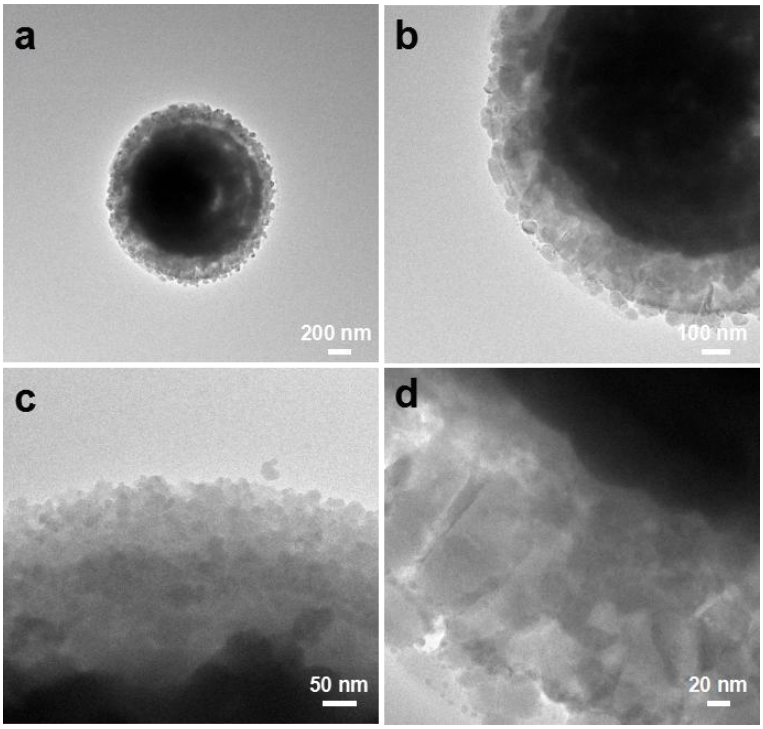

Figure S10. The TEM images of a typical dot based on Cs-Pb-Br nanocomposites measured in different magnifications.

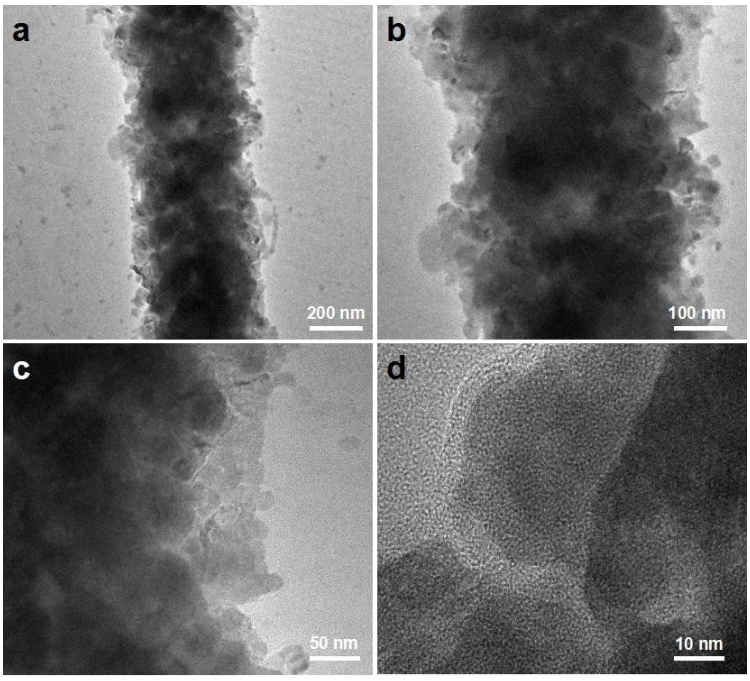

Figure S11. The TEM images of a laser-processed line based on Cs-Pb-Br nanocomposites measured in different magnifications.

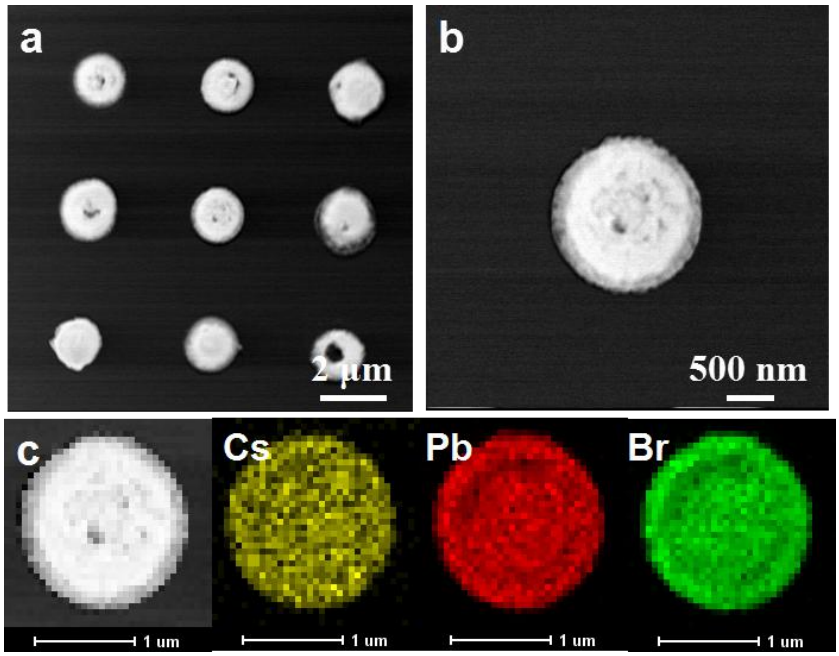

Figure S12. a,b) The STEM images of dot arrays based on Cs-Pb-Br nanocomposites measured in different magnifications. c) Elemental mapping images of a laser-processed dot for Cs, Pb, and Br.

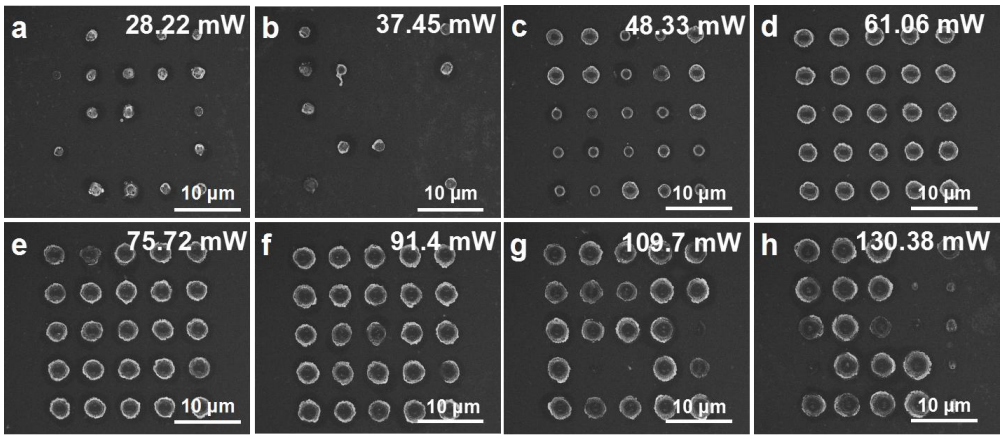

Figure S13. The SEM images of dot arrays based on Cs-Pb-Br nanocomposites processed at different laser powers (fixed exposure time: 800 ms).

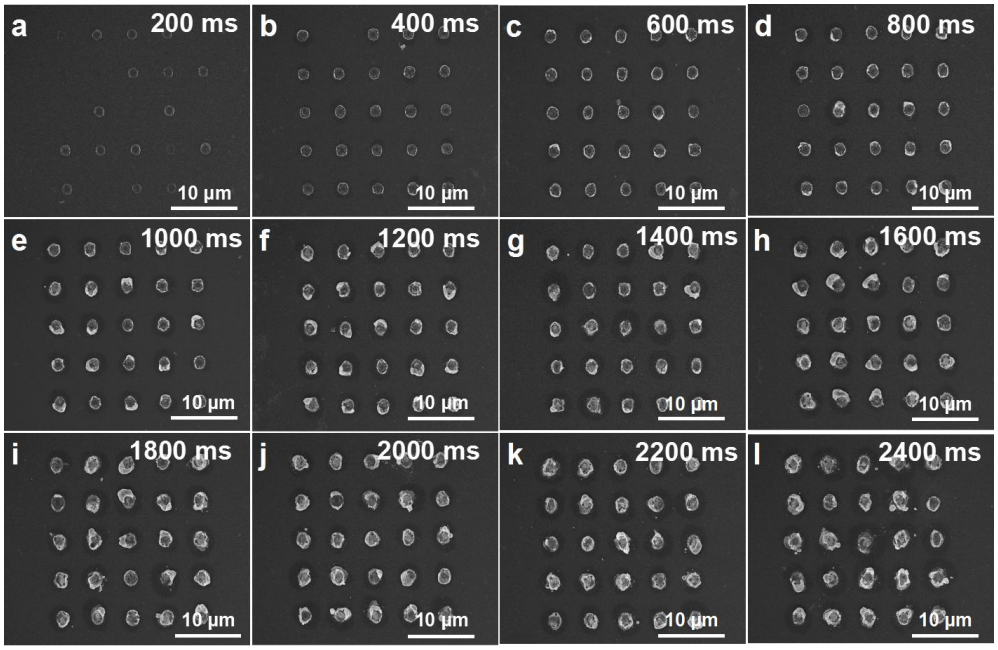

Figure S14. The SEM images of dot arrays based on Cs-Pb-Br nanocomposites processed at different exposure times (fixed laser power: 48.33 mW).

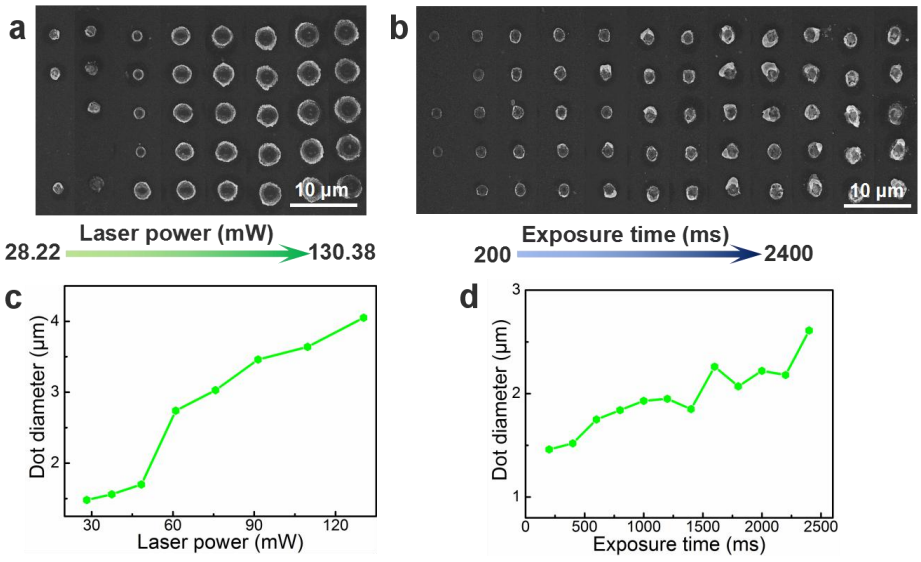

Figure S15. The SEM images of laser-processed dots obtained on the glass substrates under different a) laser powers and b) exposure times. c,d) The corresponding variations in dot diameter of a,b).

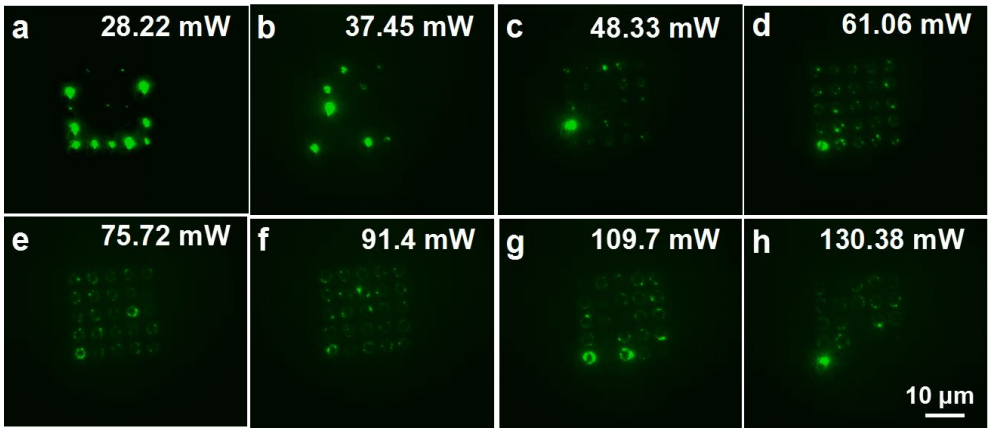

Figure S16. The fluorescent images of dot arrays based on Cs-Pb-Br nanocomposites processed at different laser powers (fixed exposure time: 800 ms).

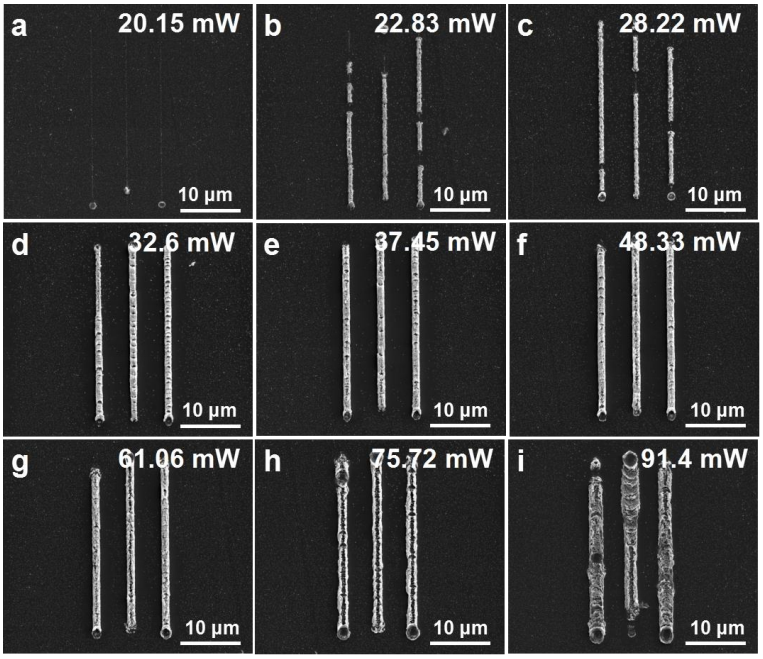

Figure S17. The SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed at different laser powers (fixed writing speed: 2 μm/s).

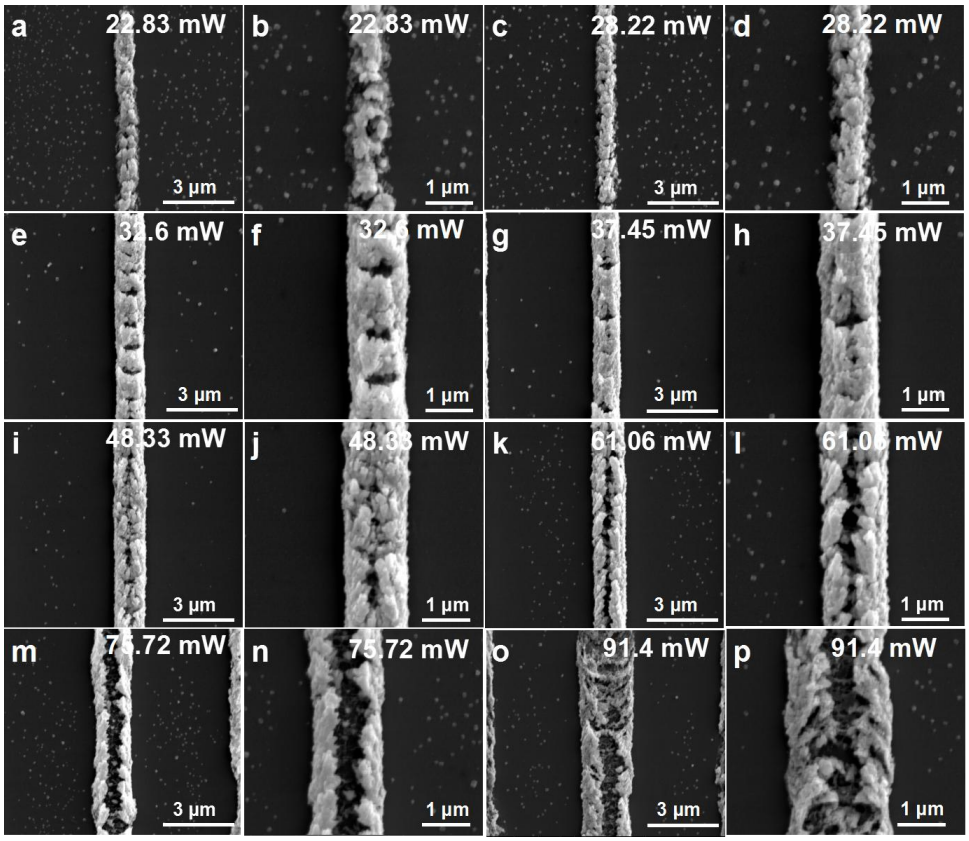

Figure S18. The enlarged SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed at different laser powers (fixed writing speed: 2 μm/s).

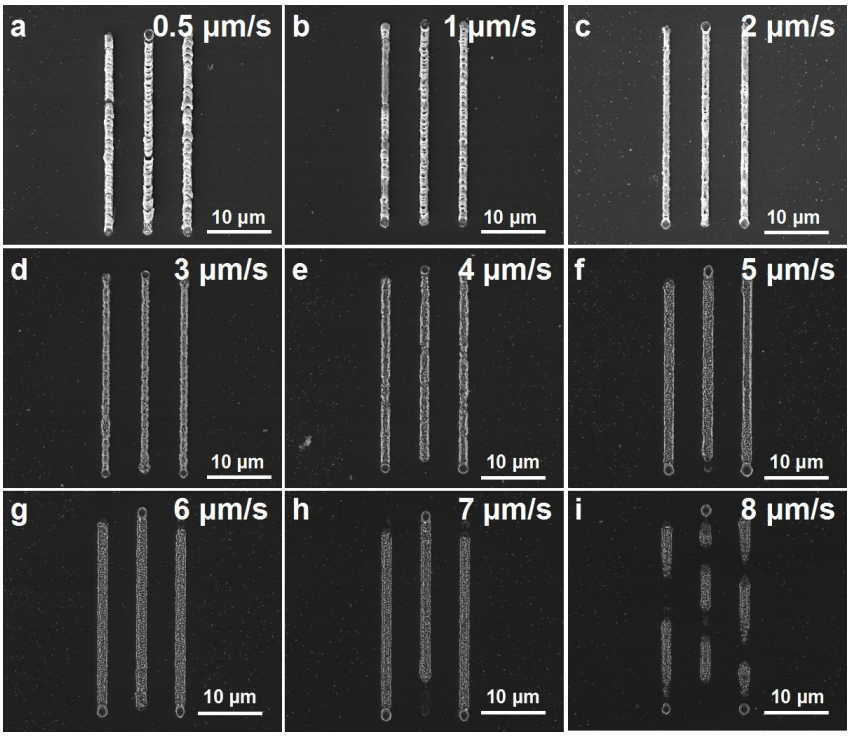

Figure S19. The SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed at different writing speeds (fixed laser power: 37.45 mW).

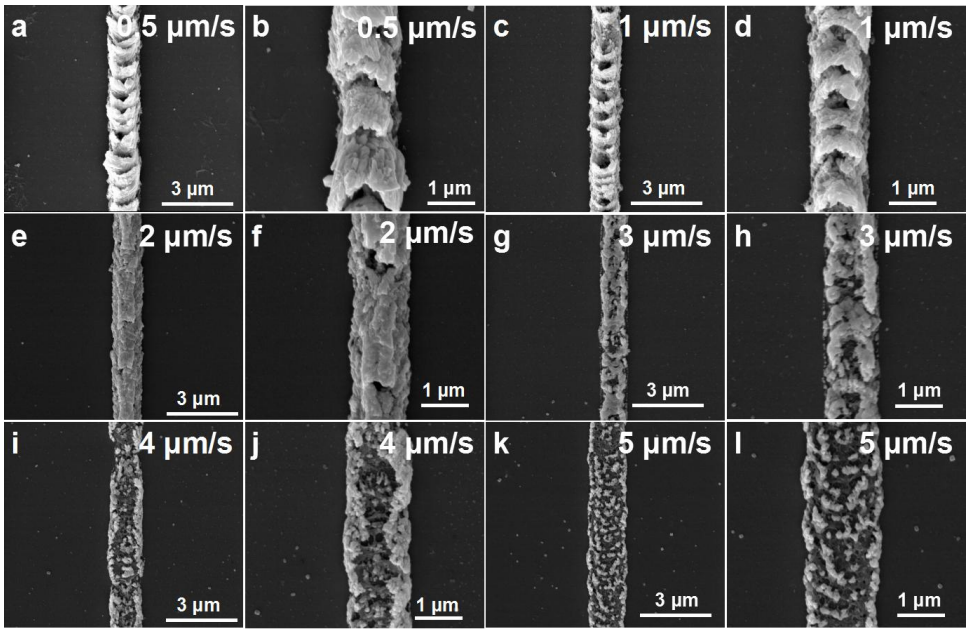

Figure S20. The enlarged SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed at different writing speeds of 0.5-5 μm/s (fixed laser power: 37.45 mW).

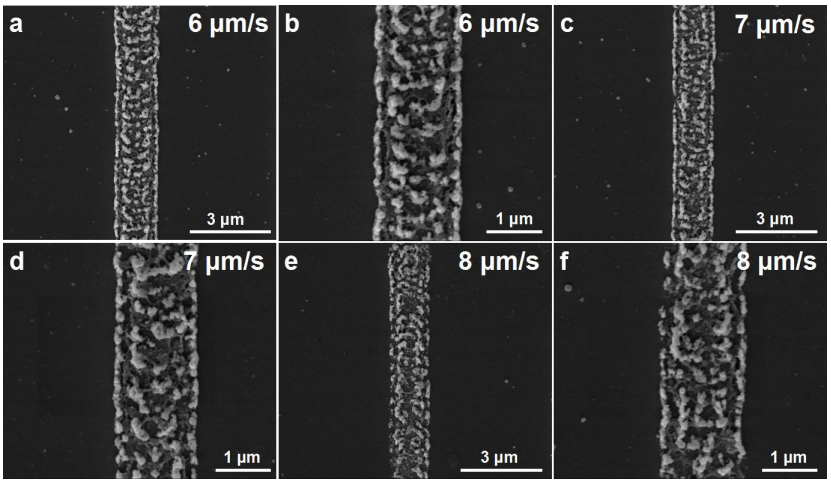

Figure S21. The enlarged SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed at different writing speeds of 6-8 μm/s (fixed laser power: 37.45 mW).

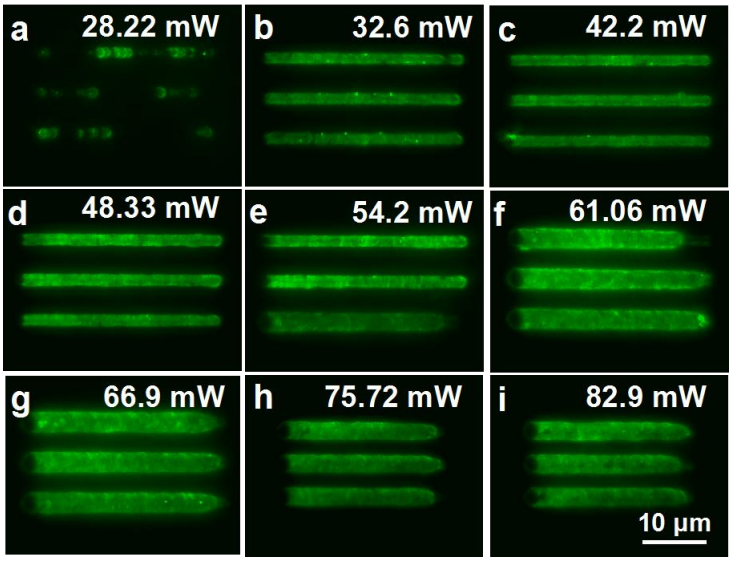

Figure S22. The fluorescent images of linear patterning based on Cs-Pb-Br nanocomposites processed at different laser powers (fixed writing speed: 2 μm/s).

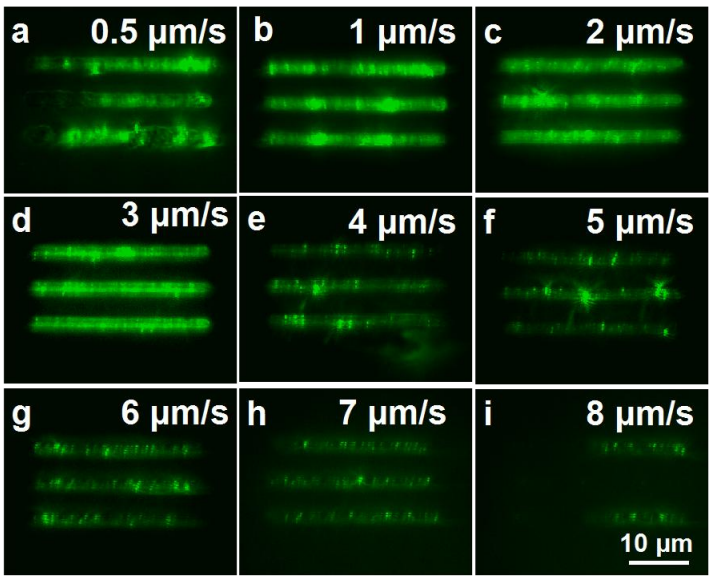

Figure S23. The fluorescent images of linear patterning based on Cs-Pb-Br nanocomposites processed at different writing speeds (fixed laser power: 37.45 mW).

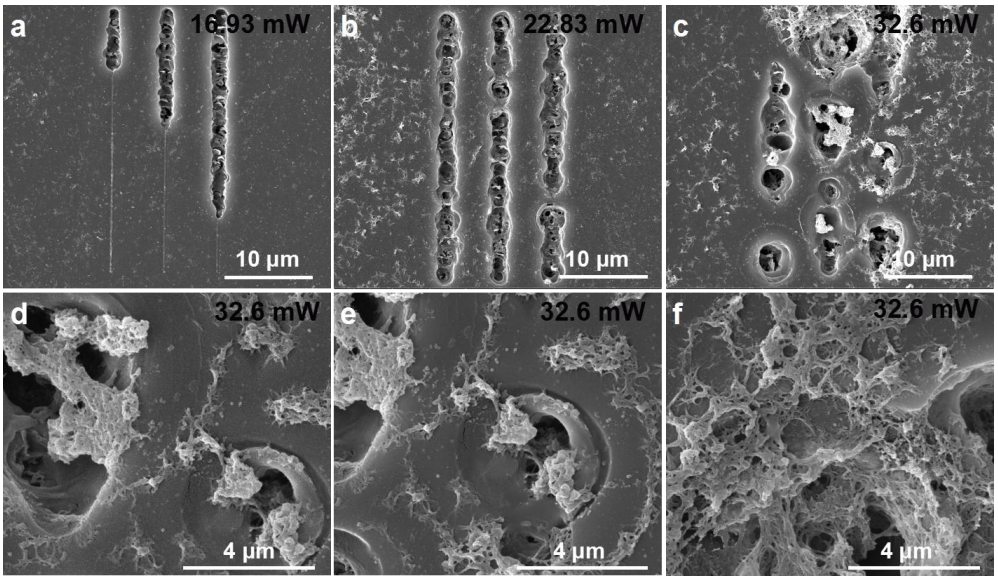

Figure S24. a,b,c) The SEM images of linear patterning based on Cs-Pb-Br precursor solution processed on the PET flexible substrates at different laser powers (fixed writing speed: 4 μm/s). d,e,f) The enlarged SEM images of (c).

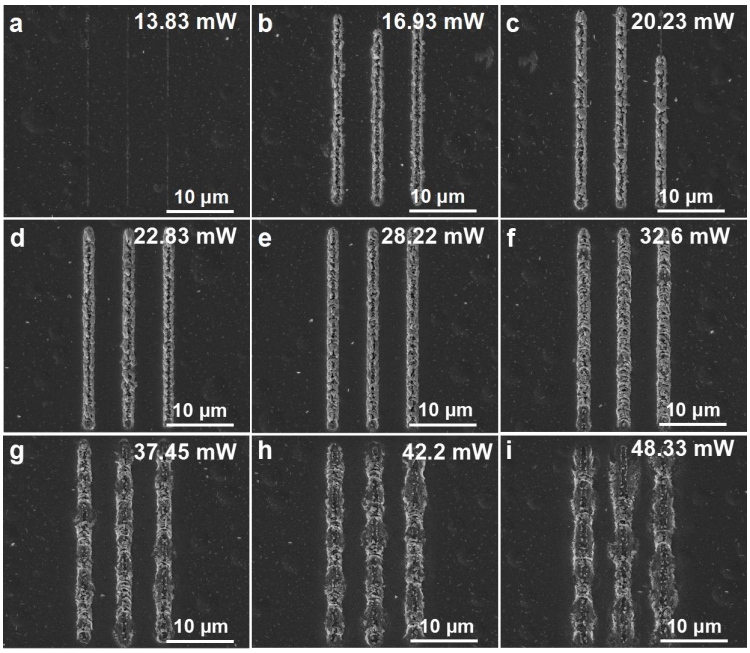

Figure S25. The SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed on the Au-covered glass substrates at different laser powers (fixed writing speed: 4 μm/s).

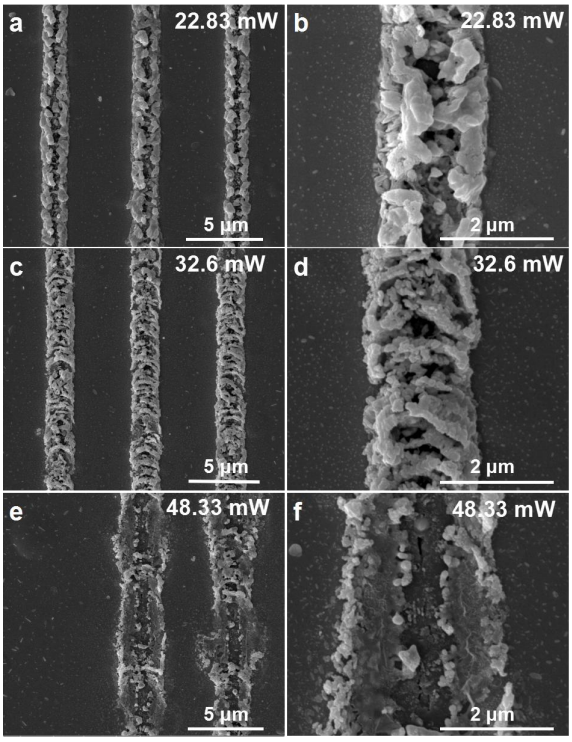

Figure S26. The enlarged SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed on the Au-covered glass substrates at different laser powers (fixed writing speed: 4 μm/s).

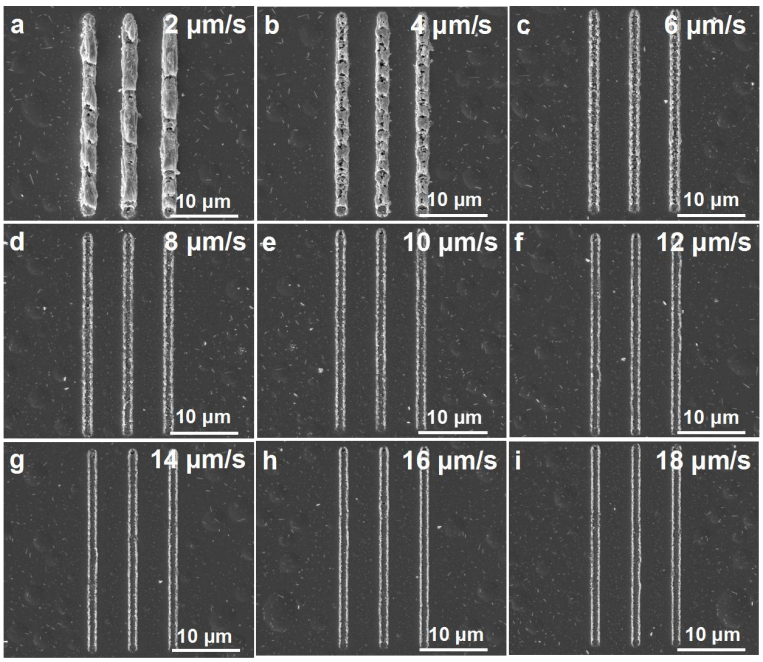

Figure S27. The SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed on the Au-covered glass substrates at different writing speeds (fixed laser power: 22.83 mW).

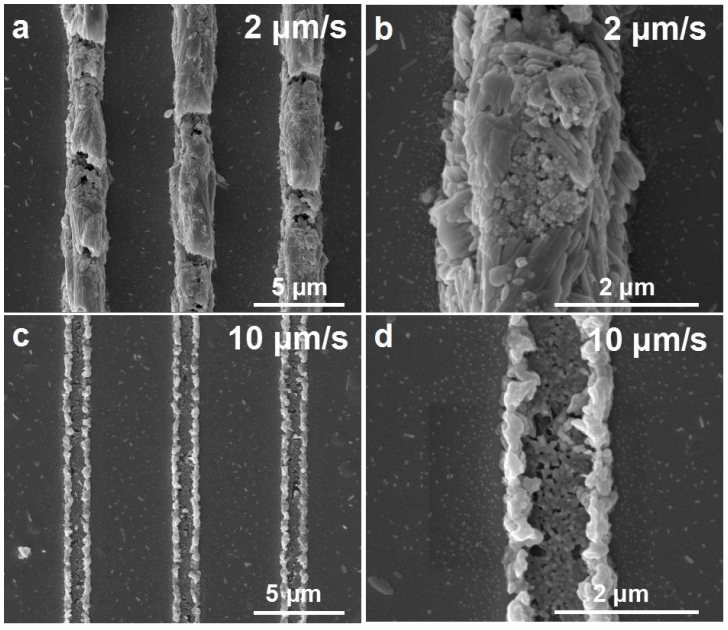

Figure S28. The SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed on the Au-covered glass substrates at different writing speeds (fixed laser power: 22.83 mW).

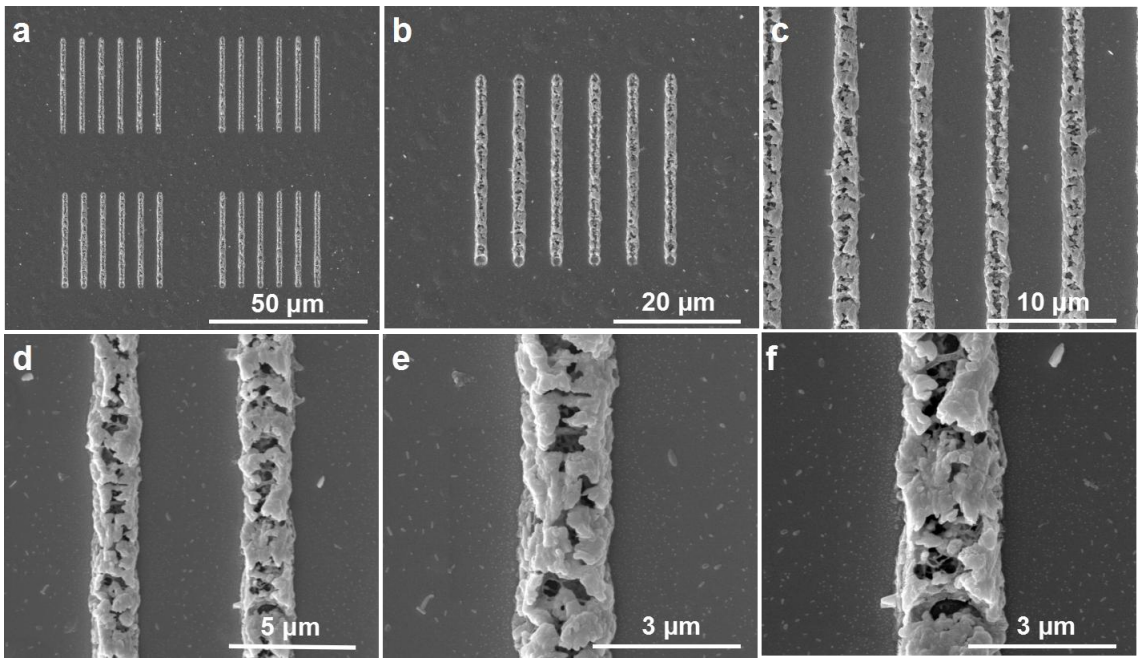

Figure S29. The SEM images of line arrays based on Cs-Pb-Br nanocomposites processed on the Au-covered glass substrates measured in different magnifications.

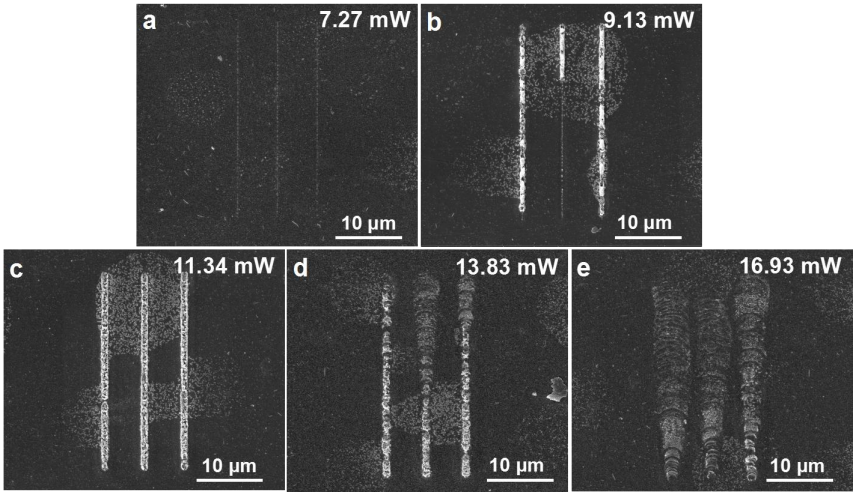

Figure S30. The SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed on the Au-covered PET flexible substrates at different laser powers (fixed writing speed: 4 μm/s).

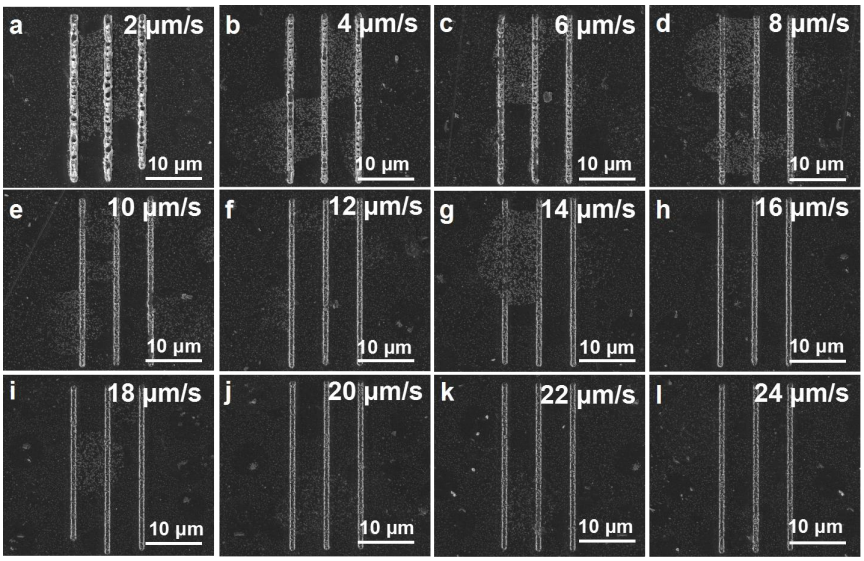

Figure S31. The SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed on the Au-covered PET flexible substrates at different writing speeds (fixed laser power: 11.34 mW).

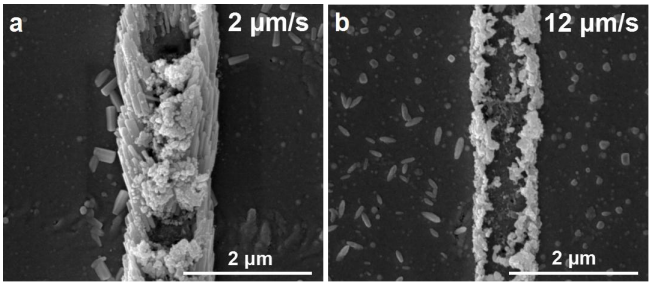

Figure S32. The enlarged SEM images of linear patterning based on Cs-Pb-Br nanocomposites processed on the Au-covered PET flexible substrates at different writing speeds (fixed laser power: 11.34 mW).

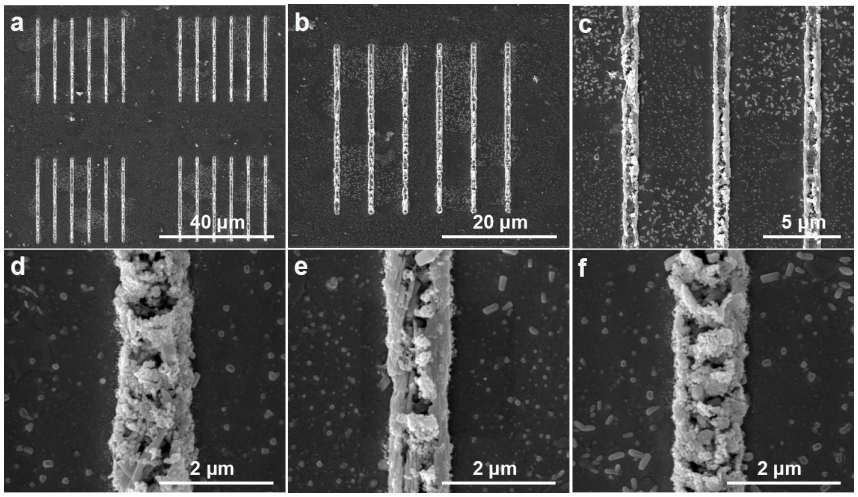

Figure S33. The SEM images of line arrays based on Cs-Pb-Br nanocomposites processed on the Au-covered PET flexible substrates measured in different magnifications.

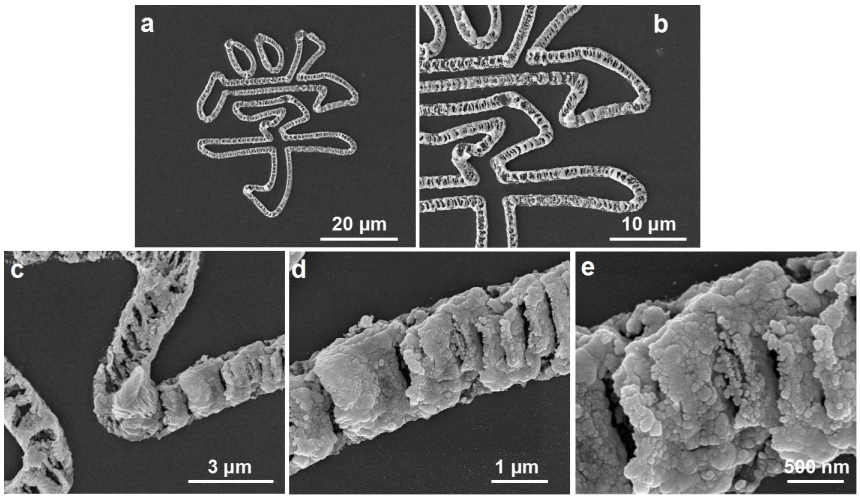

Figure S34. The SEM images of Chinese character “Xue” based on Cs-Pb-Br nanocomposites measured in different magnifications.