Supporting Information

Simultaneous enhancement of fluorescence intensity, thermometry sensitivity and SNR of upconversion thermometers via optical field localization

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Preparation of $NaGdF_4$,Yb,Er@$NaYF_4$ core shell UCNPs: Rare earth chloride aqueous solution was prepared by dissolving rare earth chlorides in deionized water. The prepared $LnCl_3$($LnCl_3$=80% Gd, 18% Yb, 2% Er) aqueous solution, 2 mL OA and 2 mL ODE were added to a 50 mL 2-necked flask with magnetic stirring, and then heated to 180°C. Under nitrogen protection, this solution was held for 80 min to turn the reaction system into a clear liquid. After the temperature cooled down to 60°C, the methanol solution of NaOH and NH_4F was added, keeping the reaction continuously stirred at 60°C for 30 min. The reaction temperature was raised to 300°C and maintained for 80 min under the protection of nitrogen. Finally, the reaction was cooled to room temperature and the product was collected by centrifugation, and washed with cyclohexane, ethanol and deionized water for several times, finally dispersed in methanol for later use.

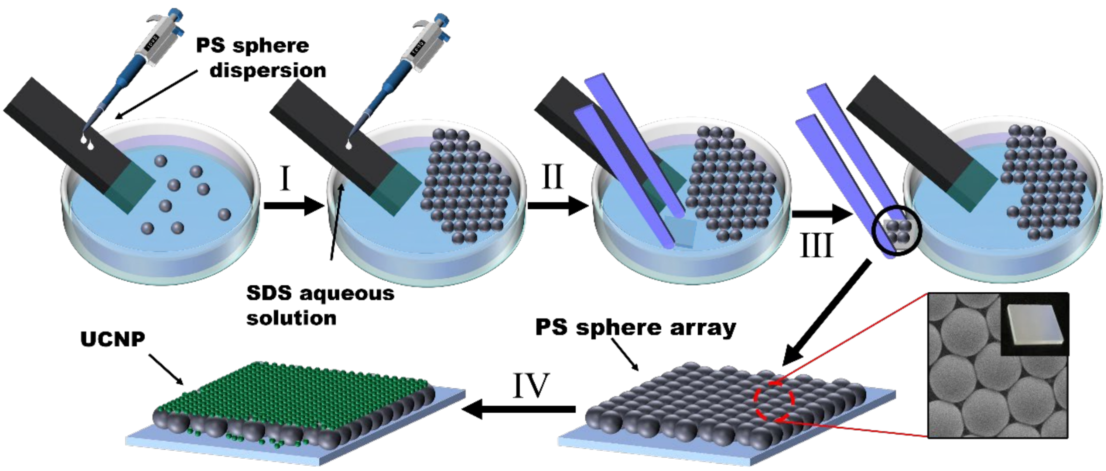


Fig. S1 Fabrication process of the photonic crystal. I: Formation process of the Monolayer Photonic Crystals at the air/water interface. II and III: Transfer Photonic Crystals to the glass sheet. The enlarged image is SEM image, and the top right inset is the photo of photonic crystal. IV: The attachment of UCNPs.

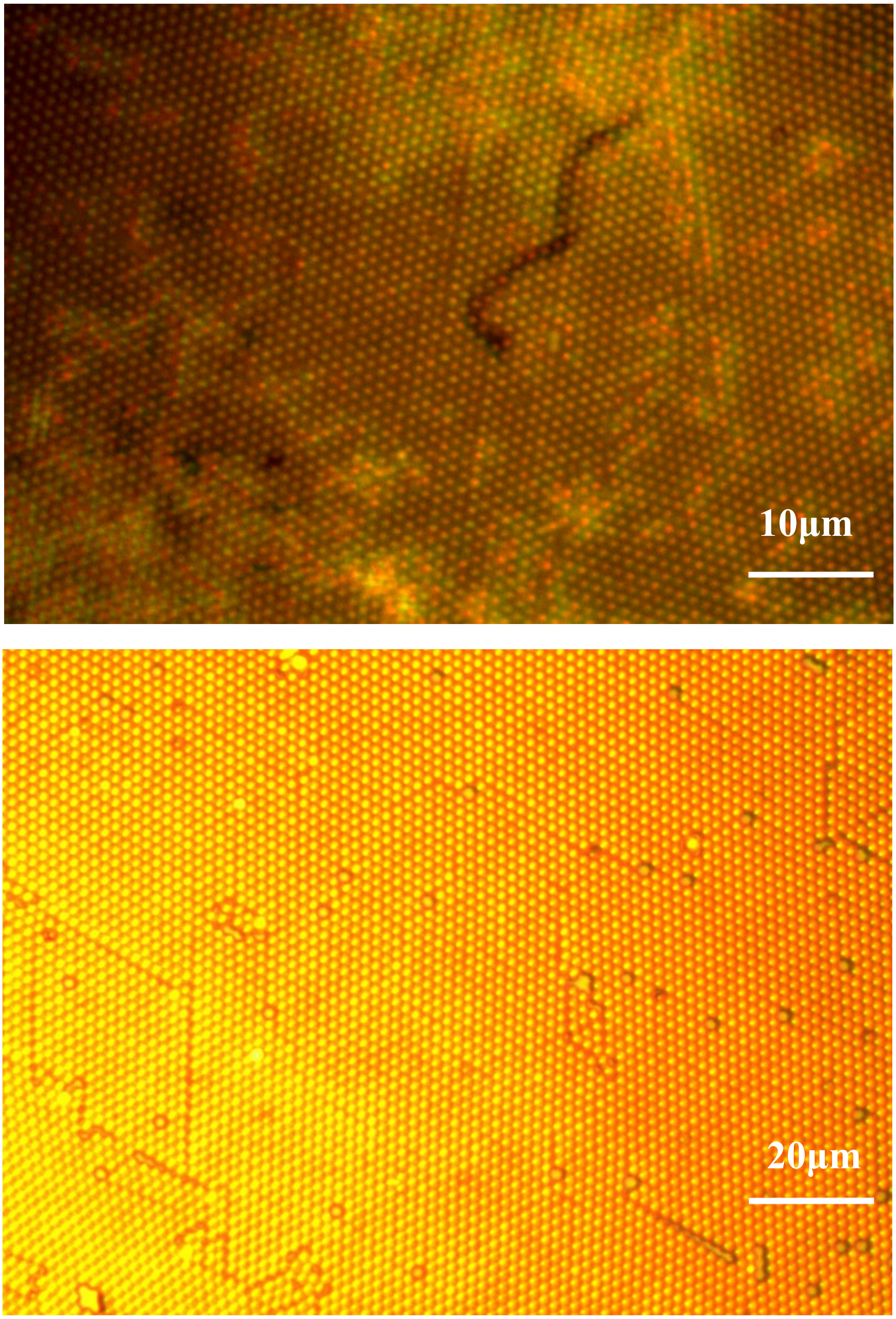


Fig. S2 The microscope photos of (a)1μm (1000 folds) and (b)2μm (400 folds).

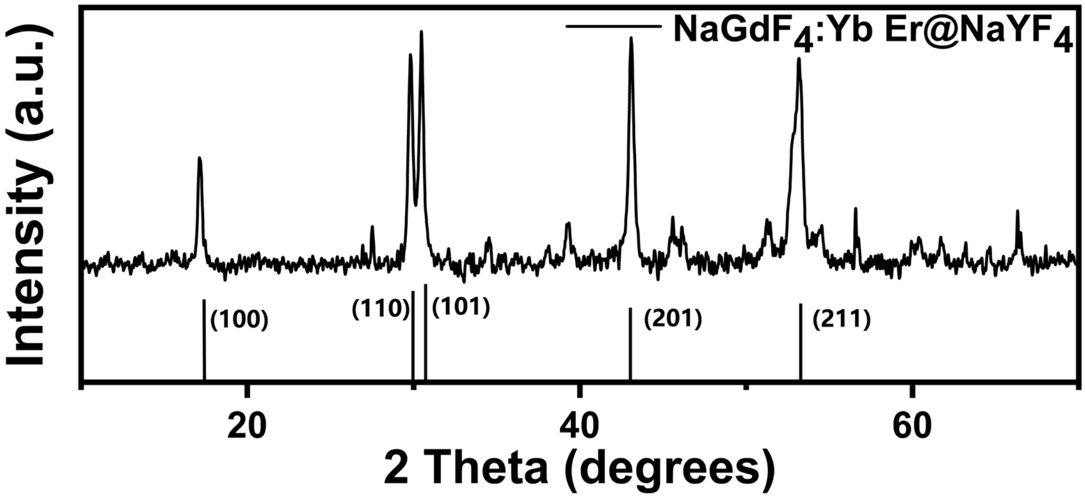


Fig. S3 The XRD spectra of the UCNPs.

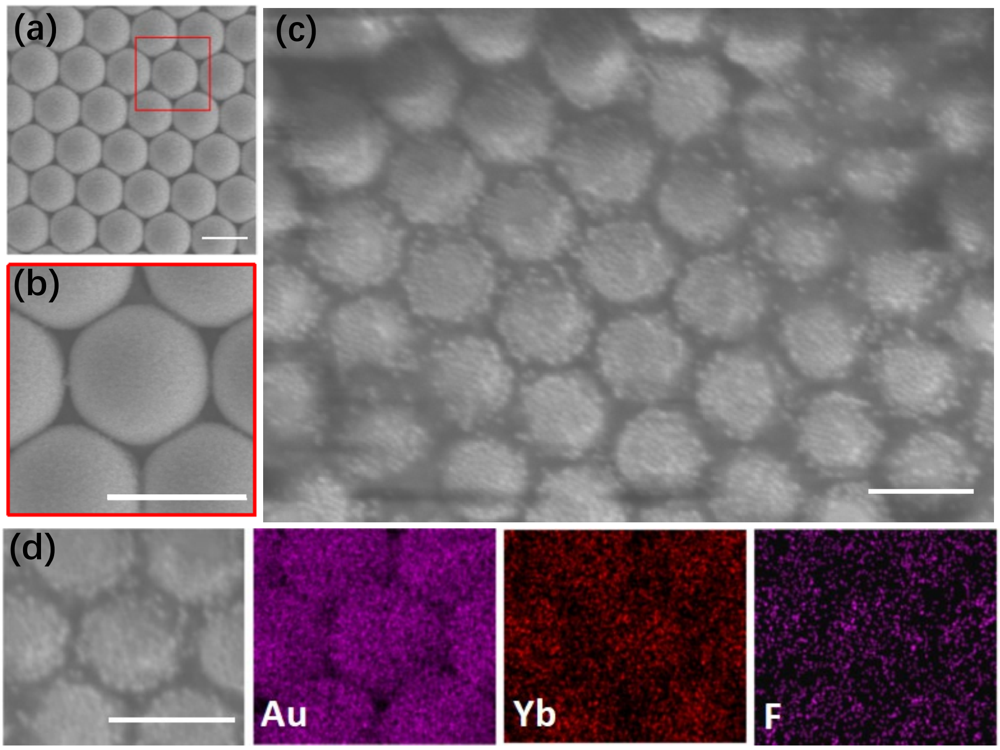


Fig. S4 (a) and (b) are the SEM image of the 2D PC@Au film structure. (c) The SEM image of the 2D PC@Au film@UCNPs structure. (d) The EDS analysis picture the of Au, Yb and F. The scale bar is 1μm.

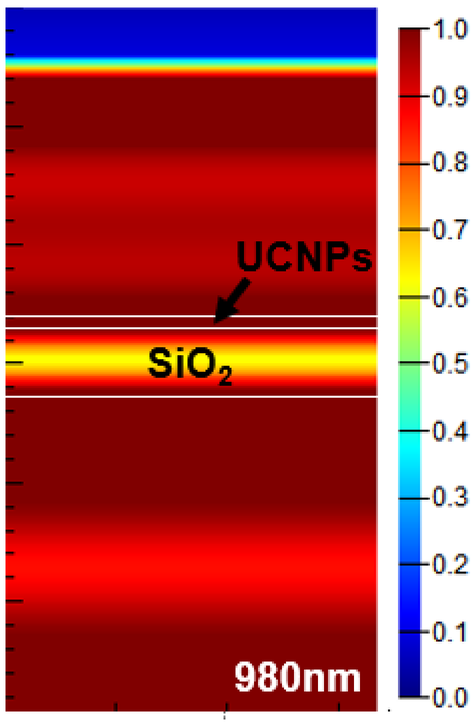
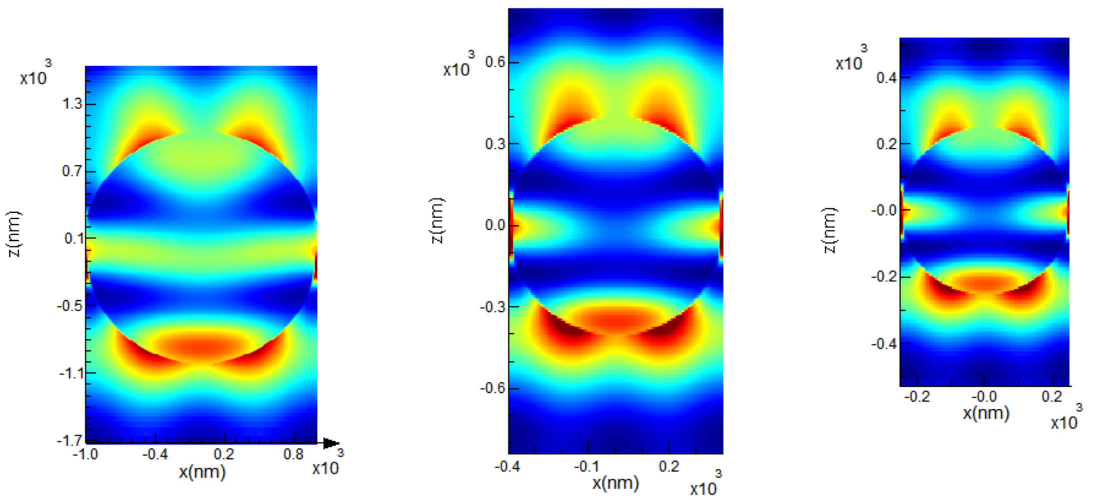


Fig. S5 FDTD simulation of the Electrical field distribution $|E/E_0|$ of 980 nm NIR for the reference group.



λ=2005nm **λ=808nm** **λ=507nm**

d=2000nm **d=800nm** **d=500nm**

Fig. S6 FDTD simulation of the Electrical field distribution $|E/E_0|$ of 2005nm, 808nm and 505nm incident light on the PS spheres with diameters of 500nm, 800nm and 2000nm, respectively.

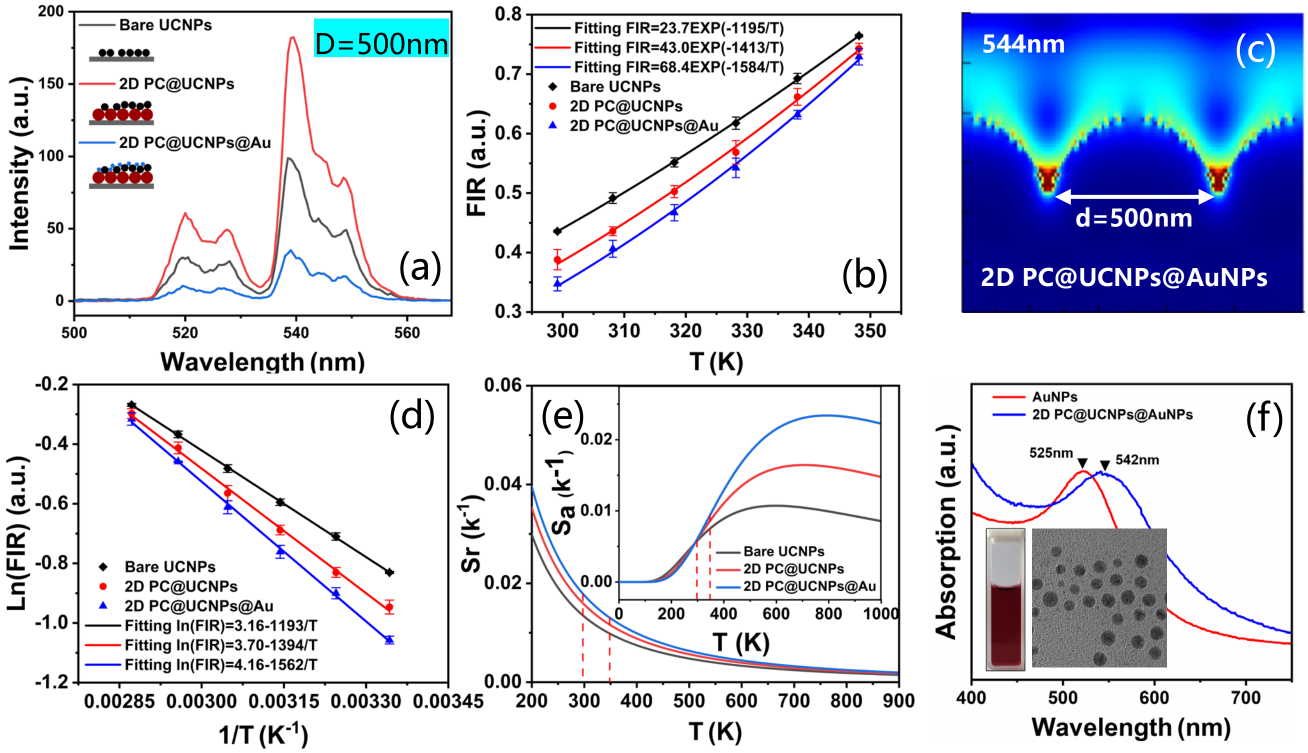


Fig. S7 Temperature sensing performance of the 500nm PC@UCNPs composite. (a) Fluorescence intensity of the three structures. (b) FIR520/540 and (d) Ln(FIR) temperature dependent experimental data points and fitted curves. (c) Simulated electrical field distribution of 544 nm in the composite structure. (e) Absolute and relative sensitivity of the three structures. (f) Absorption spectra of bare AuNPs and 2D PC@UCNPs@AuNPs.

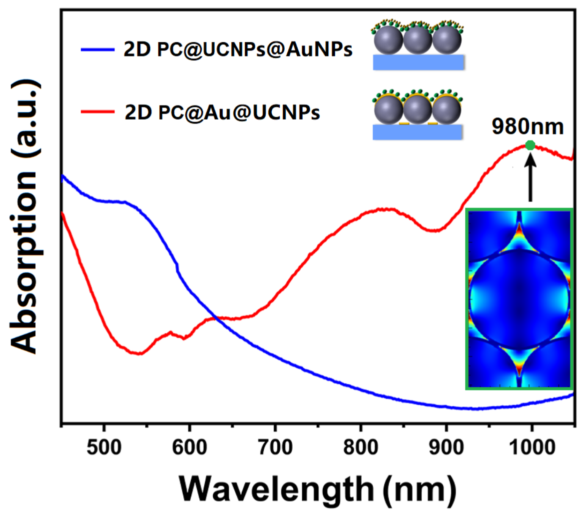


Fig. S8 Absorption spectrum of 1μm composite structure. The inset is a simulation of the field distribution of the 980 nm incident light.

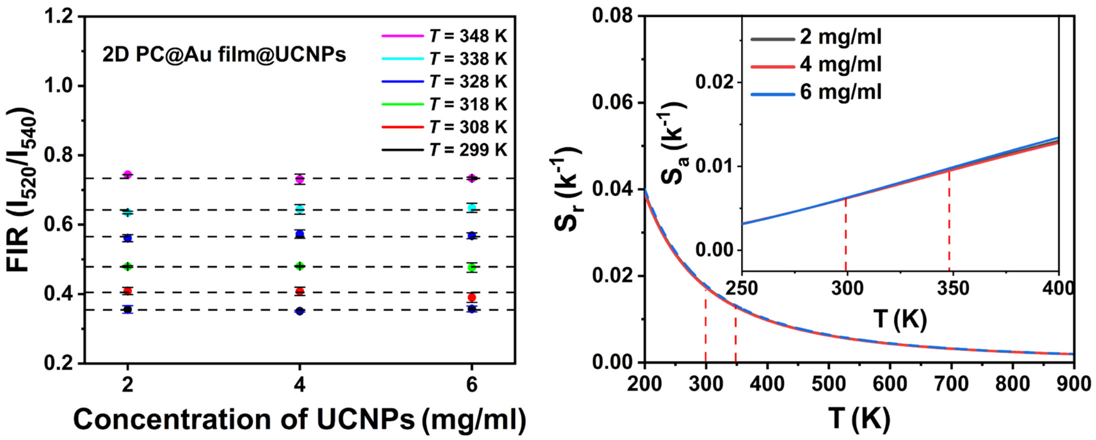


Fig. S9 The measurement intensity ratio FIR(I_{520}/I_{540}) at different UCNPs concentration in structure of 2D PC@Au film@UCNPs.

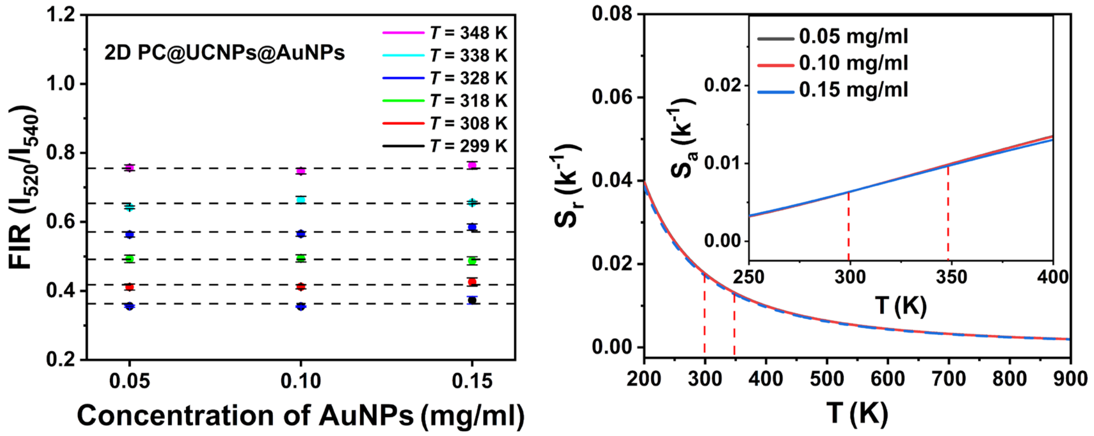


Fig. S10 The measurement intensity ratio FIR(I_{520}/I_{540}) at different AuNPs concentration in structure of 2D PC@UCNPs@AuNPs.

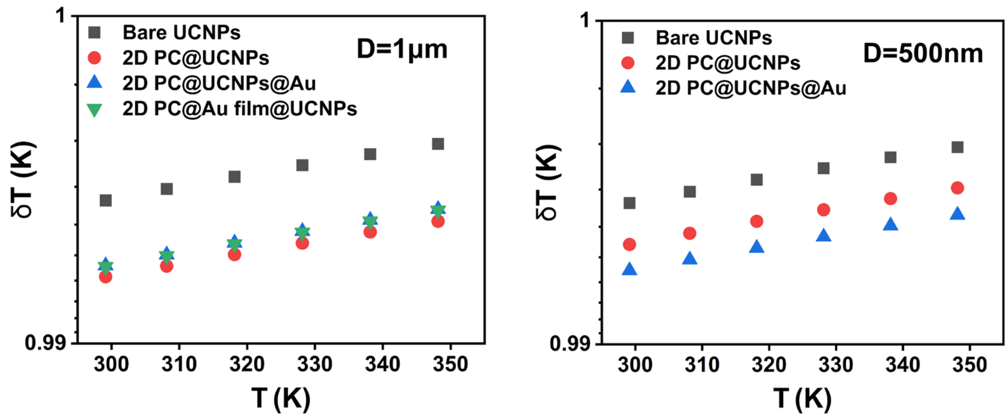


Fig. S11 The thermal resolution (δT) of the proposed UCNPs-based thermometers with various PS sphere diameters.

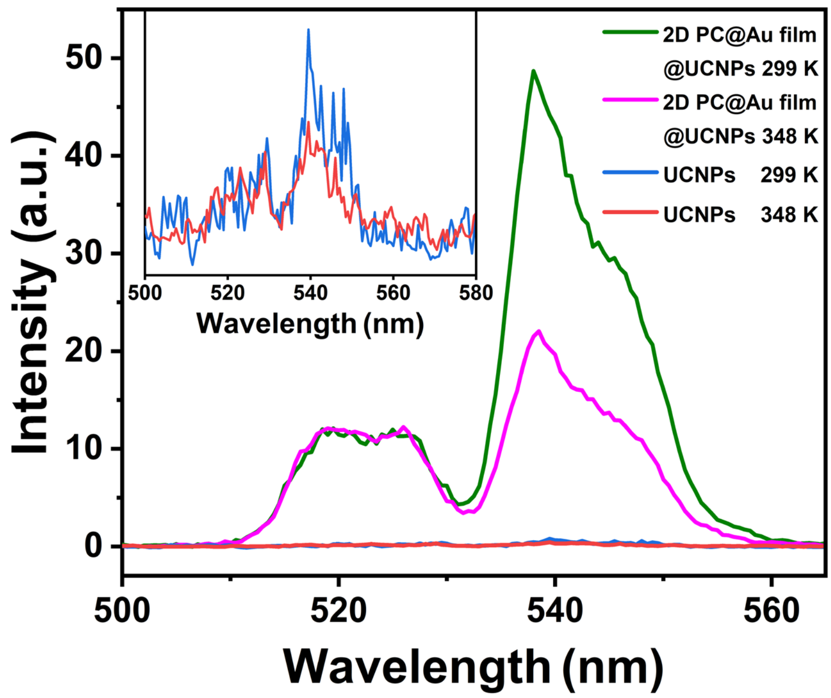


Fig. S12 The PL spectra of bare UCNPs and 2D@Au film@UCNPs under the weak 980nm NIR excitation power of 50mW.

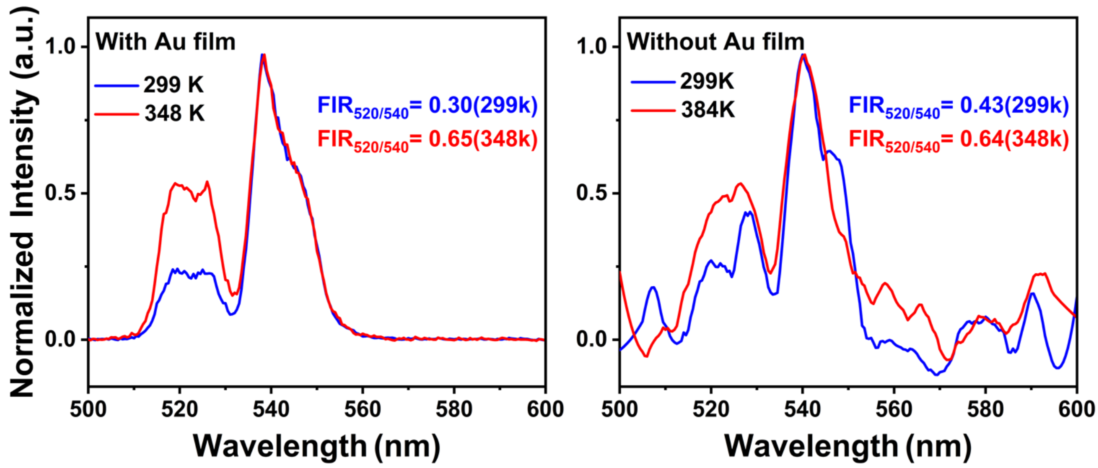


Fig. S13 Normalized spectra collected at the same temperatures (299 K and 348 K) for sensing system with and without Au.

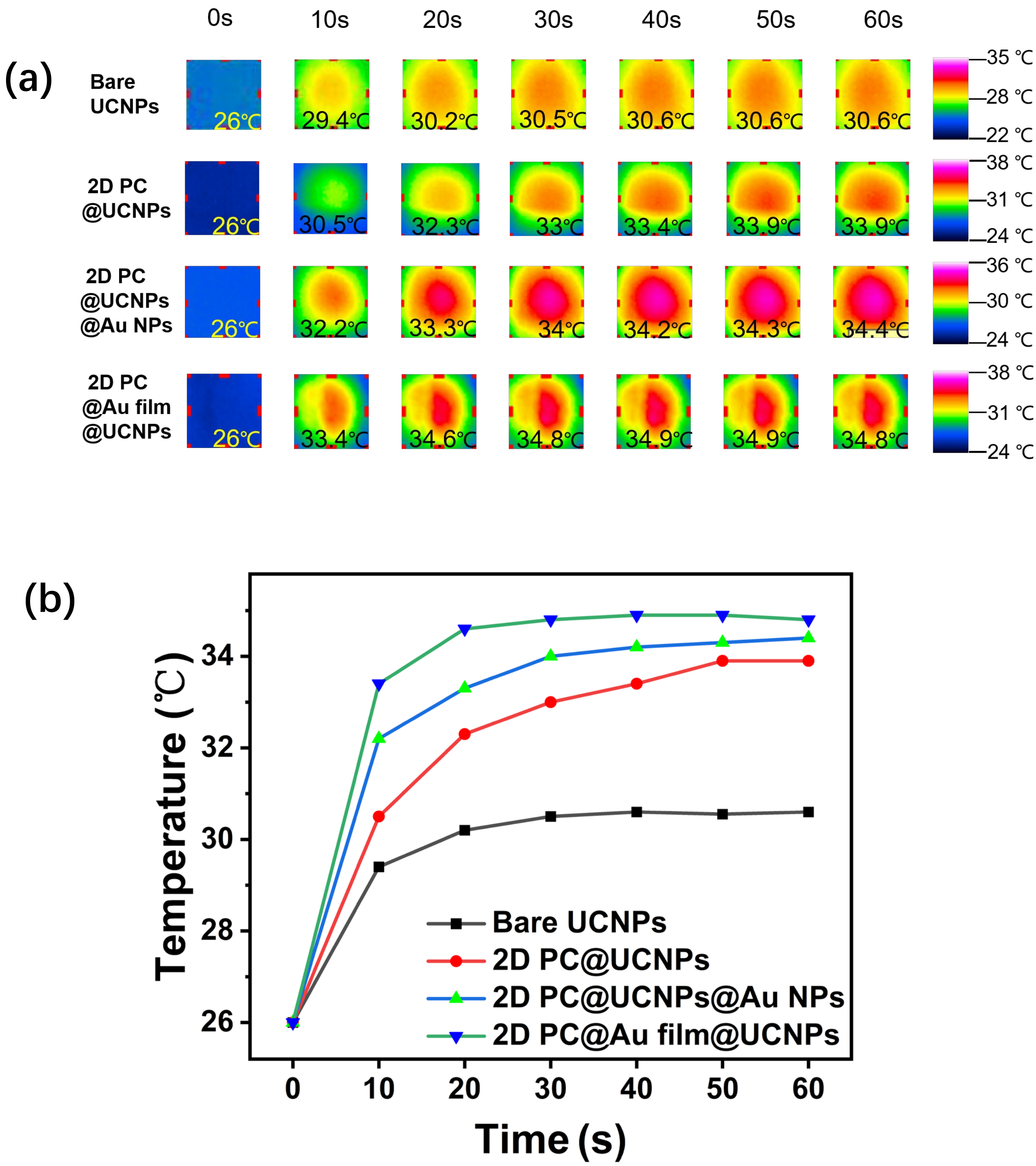


Fig. S14 (a) Infrared thermal imagery of four structures based on 1μm microspheres under 980 nm laser irradiation with time. (b) Point diagram of maximum temperature change with time.

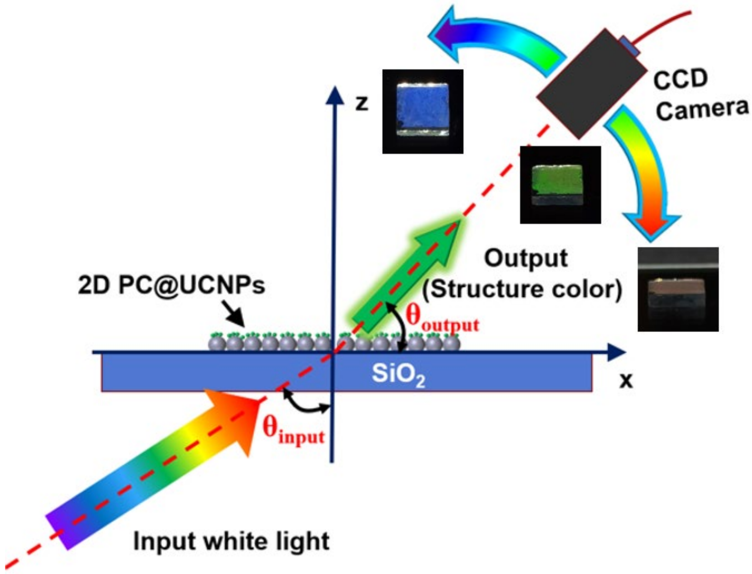


Fig. S15 Schematic diagram of the structural color measurement.

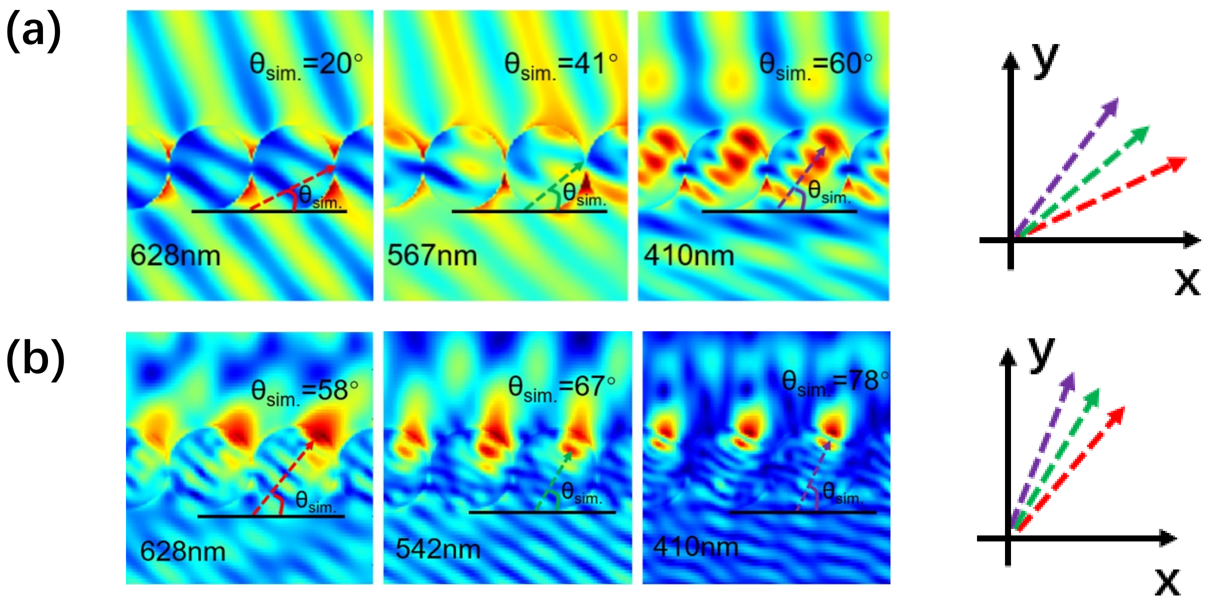


Fig. S16 Structural color simulation diagrams of PS arrays with (a) 500 nm and (b) 1μm diameters.

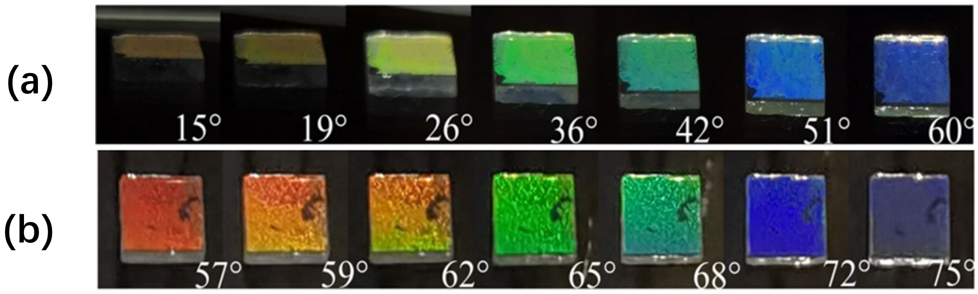


Fig. S17 Structural colors of PS spheres arrays of different diameter (a)500nm (b)1μm, after coating with UCNPs.

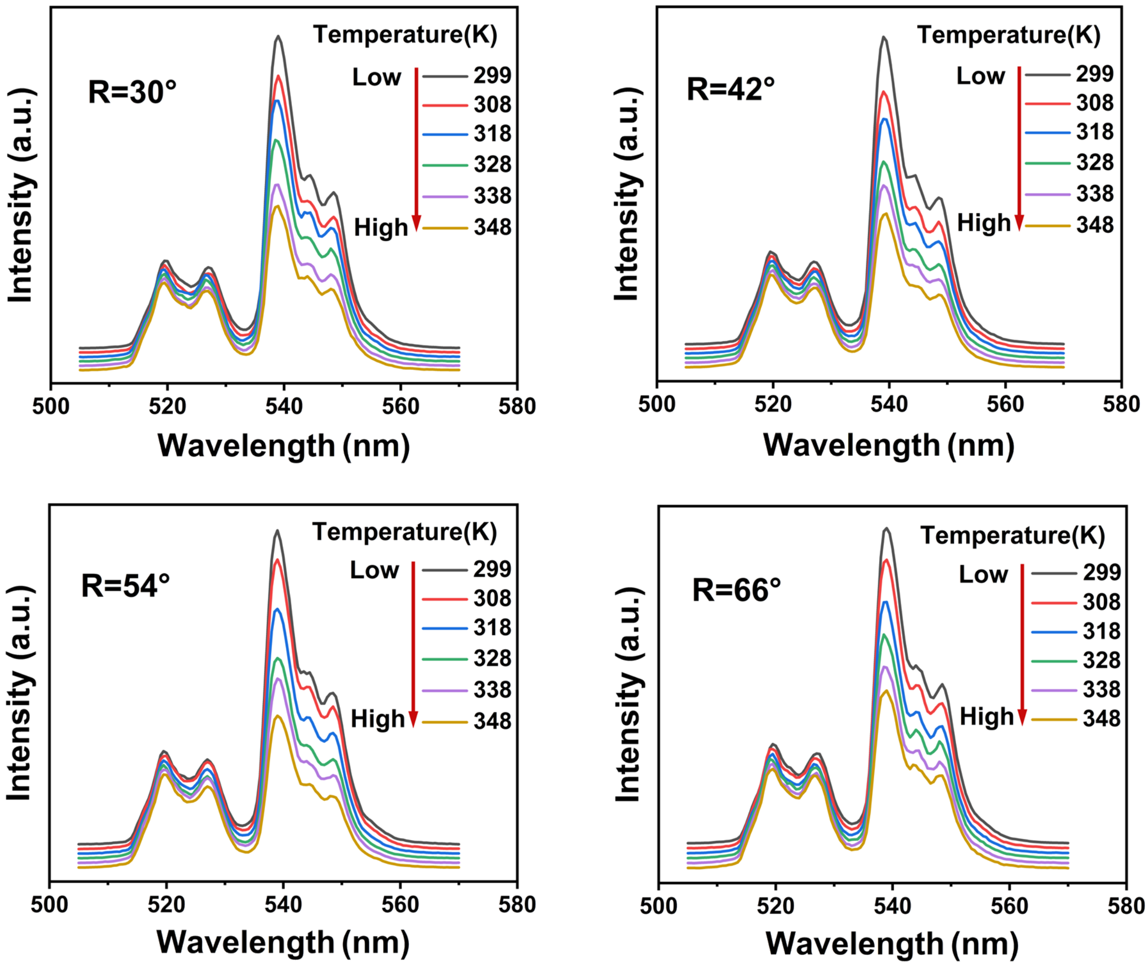


Fig. S18 The thermal sensing performance of 2D PC@Au film@UCNPs(d=1μm), under 980nm excitation at various angel R=30°, 42°,54° and 66°.