Electronic Supplementary Material (ESI) for Materials Horizons.

Supplementary Information

Inkless Multi-Color Writing and Copying of Laser-Programmable Photonic Crystals

*Yunlong Wang, Qilong Zhao, and Xuemin Du**

Institute of Biomedical & Health Engineering, Shenzhen Institutes of Advanced Technology (SIAT), Chinese Academy of Sciences (CAS), Shenzhen, 518035, China

*Corresponding author: E-mail: xm.du@siat.ac.cn

Experimental Section

Preparation of PC papers: Monodispersed silica particles were prepared using the Stöber method, washed using water and ethanol for 3 times, respectively, and then centrifuged to condense to a concentration of 20 w/v%. The dispersion was ultrasonicated for 2 hours and then assembled on a clean glass substrate using the drop-casting method. The precursor of SMP-based PC contains 4 mL St, 1 mL BA, 0.5 mL DVB (as crosslinker), and 0.1 mL diethoxyacetophenone (DEPH) (as initiator). 0.5 mL of precursor was sandwiched between the assembled particle layers and a piece of clean glass substrate, which was then polymerized using a UV curing system for 8 hours. The film was demolded and then immersed in 5% HF solution for 2 hours, subsequently washed for 3 times prior to completely drying in a vacuum oven, resulting in SMP-based PC papers with inverse opal structures.

Characterization: The scanning electron microscopy (SEM) images were taken using a field-emission scanning electron microscopy (Sigma, Carl Zeiss 300, Germany) to determine the morphologies of the silica colloidal crystals and the inverse opal films. Samples for SEM characterizations were coated with a thin layer of gold before the measurement. Digital photos were taken with a SLR camera (Canon EOS 7D Mark I). Reflectance spectra of the inverse opal films were measured by an Ocean Optics HR 2000+ spectrometer. Microscopic images of SMP-PC paper during the of NIR-thermal recovery process and microscopic photo of PC papers with written or copied patterns were taken by an optical microscope (Nikon Ni-U, Japan).

Thermal recovery of PC papers: The SMP-based PC paper was cut into a square with a size of 1×1 cm^2 and compressed to completely colorless state by using a tablet machine. The color of the paper heated in an oven (80 °C) for different time was captured by the SLR camera. Additionally, the colors of the PC paper at the colorless state covered on printed pattern with different gray scales upon NIR irradiation were also recorded. A piece of clean cover glass was

pressed above to keep the sample closely in touch with the printed patterns. An NIR laser was used to irradiate samples for different time at given heights. Then spectra were taken using an Ocean 2000+ spectrometer. The infrared thermal imaging pictures of the PC papers upon NIR irradiation were recorded using an infrared thermometer (R300SR, NEC).

NIR-writing and information transfer on PC papers: A piece of SMP-based PC paper with a large area (40 mm × 60 mm) was firstly compressed to completely colorless state using a roller and then covered on a black paper or printed patterns. An 808 nm NIR laser (5 W, 6 mm spot diameter, Nanjing Laichuang Laser Technology Co., Ltd.) is used to write on the PC papers or to scan the printed patterns for copying purpose.

Supporting Materials

Table S1. Comparison of the bandgap wavelengths of experimental results (λ_{max} measured) and theoretical values (λ_{max} calculated) via heating at 80 °C (> T_g) for different time, for example, 2 min, 4 min and 6 min, and 8 min, respectively.

sample	d (nm)	λ_{max} measured (nm)	λ_{max} calculated (nm)
2 min	178	469	415
4 min	210	556	489
6 min	251	585	586
8 min	256	612	599
Original	265	613	618

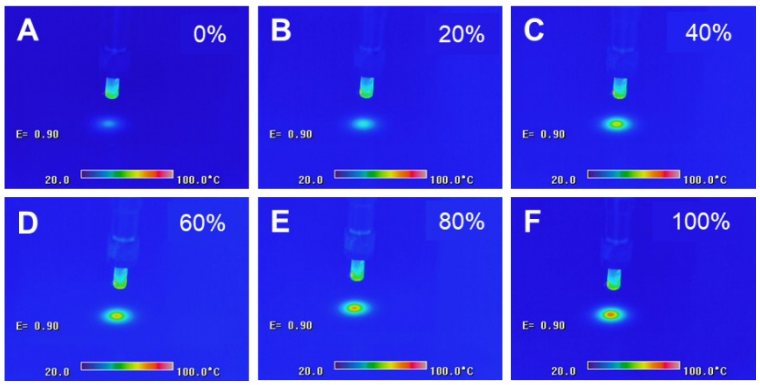

Figure S1. IR thermal-imaging images papers after recovery under NIR irradiation, the gray scales of contacting during photo-thermal process is 0% (A), 20 % (B), 40% (C), 60% (D), 80% (E), 100% (F).

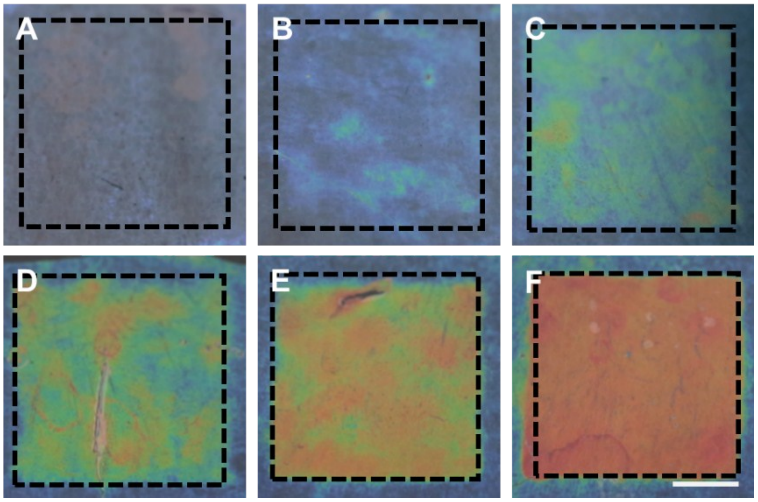

Figure S2. Color tuning of PC papers through contacting printed patterns with different gray scale during photo-thermal recovery. Digital images of papers after recovery under NIR irradiation, the gray scales of contacting during photo-thermal process is 0% (A), 20 % (B), 40% (C), 60% (D), 80% (E), 100% (F). Scale bar: 2 mm.

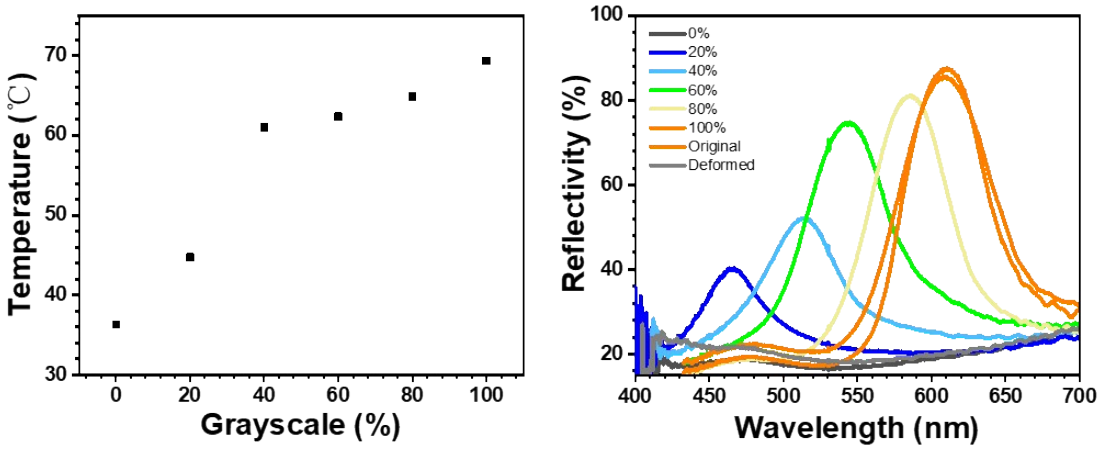

Figure S3. (A) Temperature of PC papers contacting printed pattern with diffrent color scale irradiated by NIR laser for 10 s. (B) Spectra of original, deformed PC papers contacting black printed pattern with diffrent color scale.

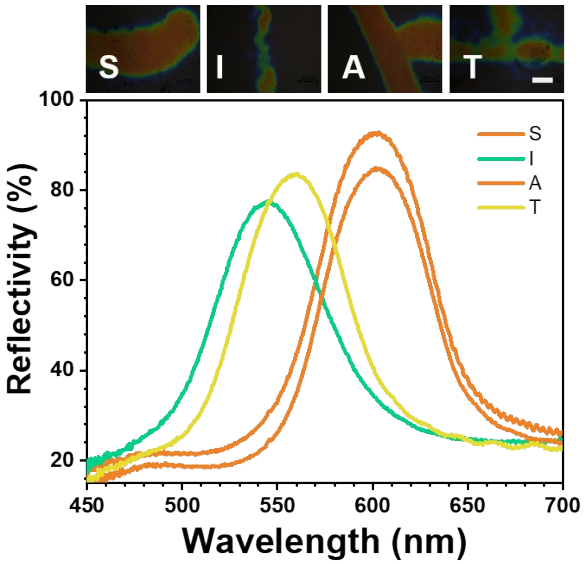

Figure S4. Microscopic images and spectra of NIR-laser written characters of SIAT on deformed SMP-based PC paper. Scale bar: 500 μm.

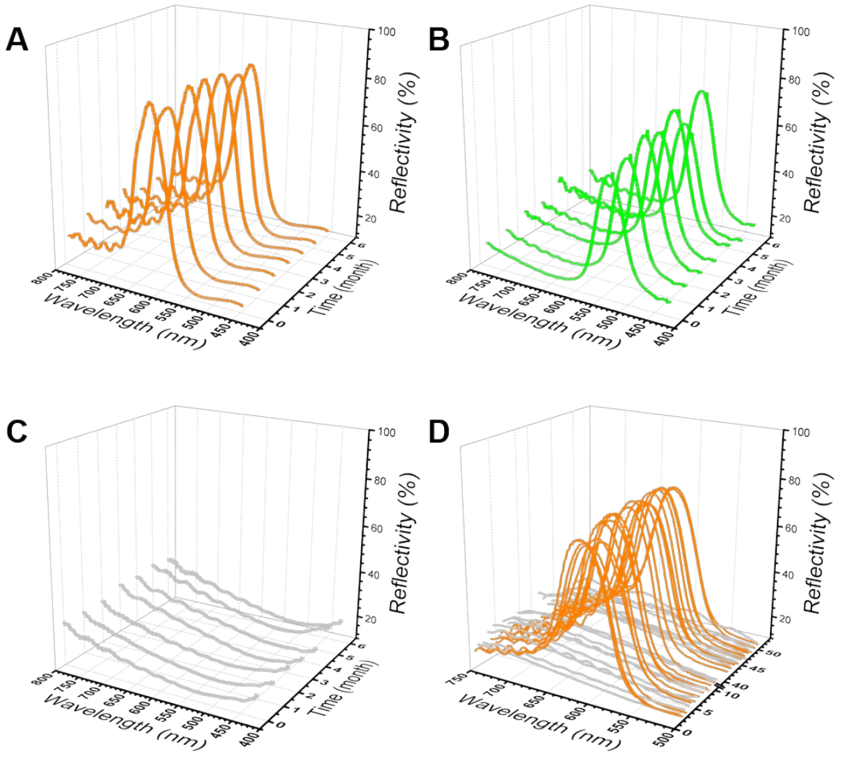

Figure S5. (A) Spectra of fully-recovered SMP-based PC papers stored at room temperature for diffrent time. (B) Spectra of half-recovered SMP-based PC papers stored at room temperature for diffrent time. (C) Spectra of deformed SMP-based PC papers stored at room temperature for diffrent time. (D) Spectra of SMP-based PC papers during deforming/recovery cycles for 50 times.

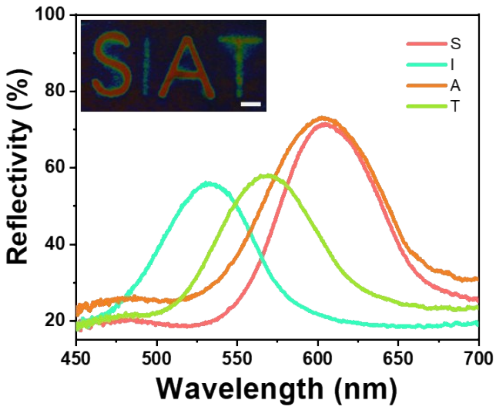

Figure S6. Optical image and spectra of NIR-thermal copied characters of SIAT on deformed SMP-based PC paper. Scale bar: 500 μm.

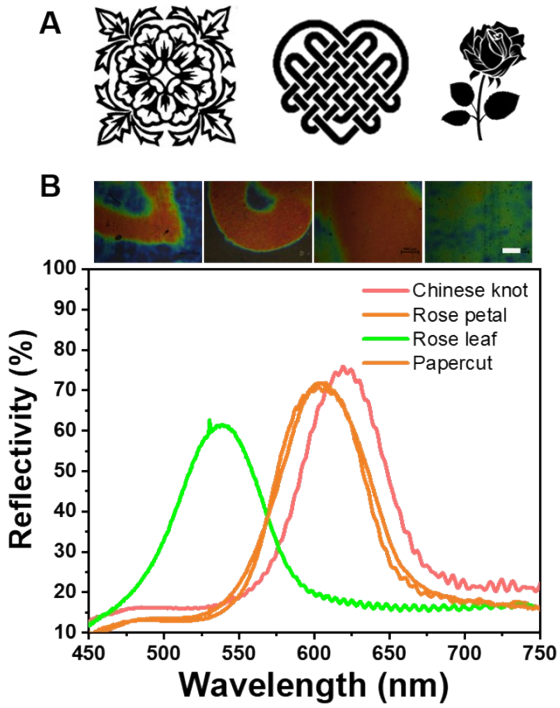

Figure S7. (A) Printed images on an A4 paper for NIR-thermal copy. (B) Microscopic images and spectra of the NIR-thermal copied paper-cut art, chinese knot, and diffrent part of rose. Scale bar: 500 μm.

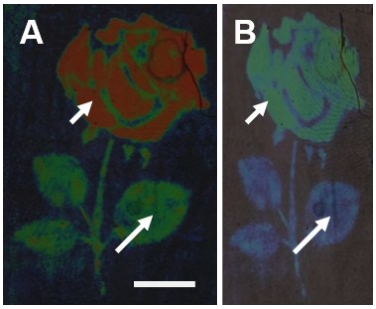

Figure S8. (A) The orange-red petals with recovered structures and the green leaves with deformed structures simultaneously change their colors into green and blue, respectively (B), via changing the viewing angle from 0° to 60°. The scale bar is 1 cm.