Supplementary Information

Tailoring high-refractive-index nanocomposites for the manufacturing of ultraviolet metasurfaces

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Supplementary Note 1. Jones matrix analysis

To achieve the Pancharatnam-Berry (PB) phase, anisotropic meta-atoms are used. These meta-atoms are represented using a Jones matrix **J**, which can be expressed as follows:

$$\mathbf{J} = \begin{bmatrix} t_{xx} & 0 \\ 0 & t_{yy} \end{bmatrix},$$

where t_{xx} and t_{yy} represent its complex transmission coefficients for longer and shorter axes of the rectangular nanorod, respectively. The Jones matrix **T** for a rectangular nanorod, rotated at an angle θ, can be determined using a rotation matrix **R**(θ) as

$$\mathbf{T} = \mathbf{R}(-\theta)\,\mathbf{J}\,\mathbf{R}(\theta).$$

This matrix can be expressed as

$$\boldsymbol{E_t} = \frac{t_{xx}+t_{yy}}{2}\begin{bmatrix} 1 & 0 \\ 0 & \pm i \end{bmatrix} + \frac{t_{xx}-t_{yy}}{2} e^{i2\theta} \begin{bmatrix} 1 & 0 \\ 0 & \mp i \end{bmatrix}.$$

Supplementary Note 2. Measured ellipsometry results

The refractive indices of the ZrO_2 nanocomposite film according to NP concentrations were measured using ellipsometry. The measured amplitude ratio (Ψ) and phase difference (Δ) of ZrO_2 nanocomposite films were fitted using Tauc-Lorentz model.

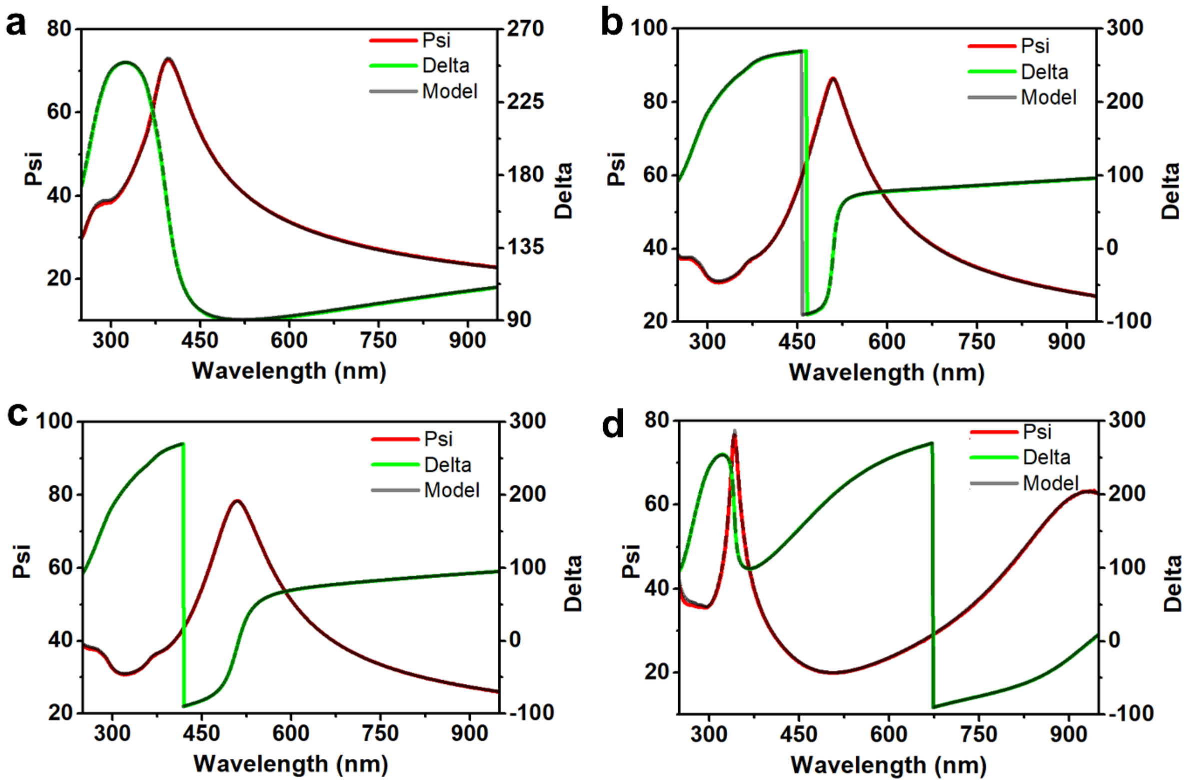

Fig. S1 Measured amplitude ratio (Ψ) and phase difference (Δ) of the zirconium dioxide (ZrO_2) nanocomposite film according to NP concentrations: **(a)** 20 wt%; **(b)** 50 wt%; **(c)** 80 wt%; **(d)** 90 wt%.

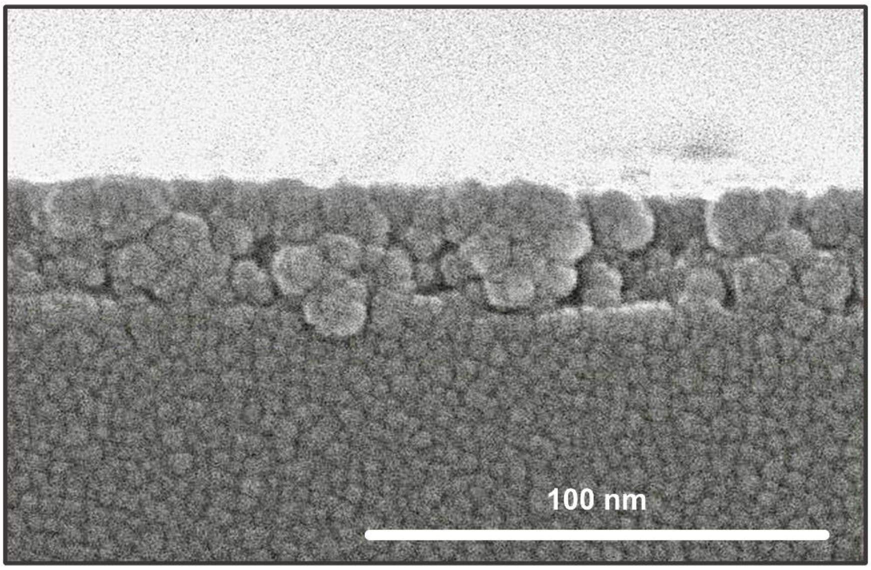

Fig. S2 A scanning electron microscope (SEM) image of a spin-coated 80wt% ZrO_2 nanocomposite film on a glass substrate.

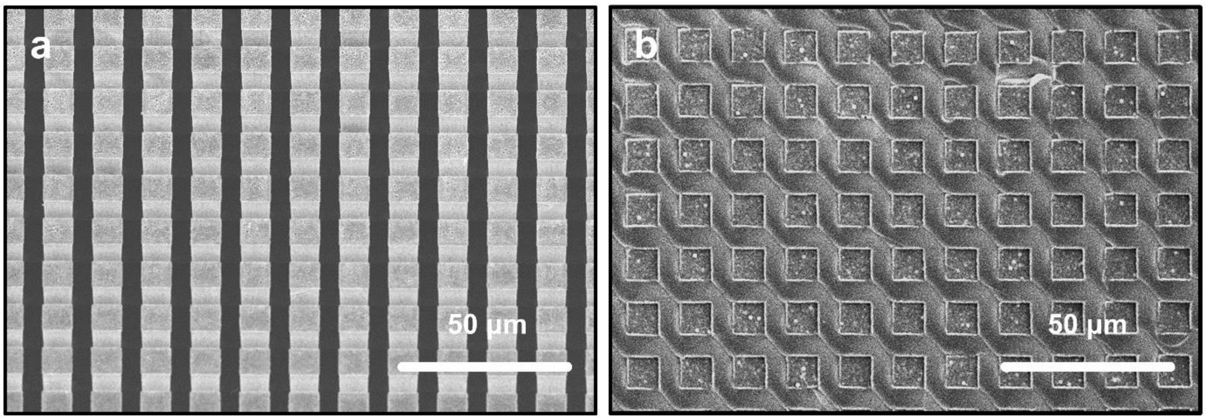

Fig. S3 SEM images of microscale **(a)** master mold and **(b)** soft mold.

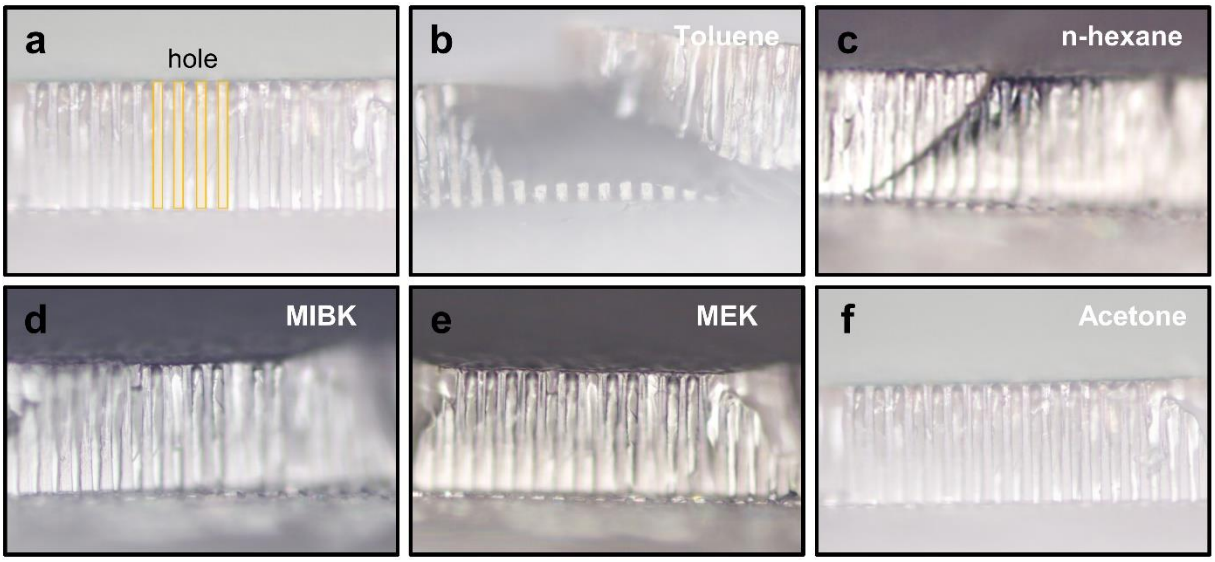

Fig. S4 Optical microscope (OM) images of the cross-section microscale soft mold **(a)** before coming into contact with the solvents, and after coming into contact with **(b)** toluene, **(c)** n-hexane, **(d)** methyl isobutyl ketone (MIBK), **(e)** methyl ethyl ketone (MEK), and **(f)** acetone.

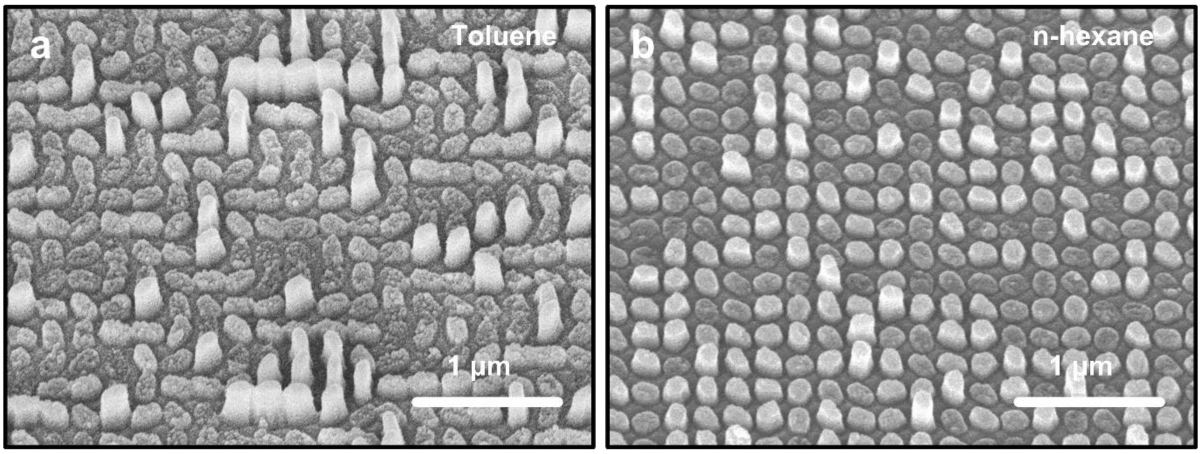

Fig. S5 Replicated ultraviolet (UV) metaholograms using the ZrO_2 nanocomposite with solvents of **(a)** toluene and **(b)** n-hexane.

Supplementary Note 3. PDMS-solvent interaction

Polydimethylsiloxane (PDMS), a component of the soft mold used in nanoimprint lithography, is a non-polar polymer composed mainly of silicon and oxygen atoms. Due to its non-polar nature and the relatively high force of polymerization during its formation, the PDMS surface exhibits low interaction with polar substances, such as water, while displaying higher interaction with gaseous substances, organic solvents, or other non-polar substances. As a result, the swelling ratio of PDMS decreases as the polarity index of the solvent increases.

Table S1. Calculation of the swelling ratio for different solvents.

Solvent type	Dry PDMS weight (g)	Swollen PDMS weight (g)	Swelling ratio
MIBK	1.503	1.732	1.152
Acetone	1.508	1.618	1.073
MEK	1.342	1.489	1.11
Toluene	1.344	1.843	1.371
n-hexane	1.502	2.073	1.38

Table S2. Polarity index of solvents

Solvent	Acetone	MIBK	MEK	Toluene	n-hexane
Polarity index	5.1	4.2	4.7	2.4	0.0

Table S3. Calculation of the measured conversion efficiency

Solvent type	**Reference (μW)**	**Converted beam (μW)**	**Conversion efficiency (%)**
MIBK	3.2	2.14	66.9
Acetone	3.9	2.4	61.5
MEK	3.6	1.85	51.4