Supplementary Information (SI) for Nanoscale.
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Supporting Information

Fabricating 3A Optical Films via Transfer Printing from a Nickel Nanocone Array Template

Kun Gan,†[a,b] Shanlin Li,†[a] Haojie Zhu,[a] Weisheng Pan,[a] Rui Yao [a] and Cheng Yang*[a]

a. Institute of Materials Research, Tsinghua Shenzhen International Graduate School, Tsinghua, Shenzhen, China, 518055.
b. Sunroll Tech. Co. Ltd., Shenzhen, China, 518106
† These authors contributed equally: K. Gan, S. Li.

Experimental Section

Materials: hexahydrate nickel chloride ($NiCl_2·6H_2O$), ammonium chloride (NH_4Cl), boric acid (HBO_3), ammonia ($NH_3·H_2O$) and dilute hydrochloric acid (HCl) ware purchased from Aladdin Co. Ltd., All chemical reagents were of analytical reagent grade and used as received. Copper foil and nickel foam were purchased from Maoye Co. Ltd. PI tape was purchased from Xinli Co. Ltd. C8fr (PET) was purchased from Shinco Co. Ltd. U483 (PET) was purchased from TORAY Co. Ltd. J403 (PMMA) was purchased from Longhua Co. Ltd. P960RR (TAC) was purchased from Dahui Co. Ltd, and TA044 (SPF) was purchased from TOYOBO Co. Ltd. L-6907 UV resin was purchased from Lencolo Co. Ltd. Z-975-HO3C UV resin was purchased from Taier Co. Ltd. 1240 fluorocarbon UV resin 2150 fluorosilicone UV resin ware purchased from Siyezi Plastic Co. Ltd. C8fr was purchased from Shinkong Co. (PET, 125 μm). U483 was purchased from Toray Co. Ltd. (PET, 125 μm). PU-H403 was purchased from Longhua Co. Ltd. (PMMA, 60 μm). P960RR was purchased from TacBright Optronics Co. Ltd. (TAC film, 60 μm), and TA044 was purchased from Toyobo Co. Ltd. (SPF, 80 μm).

Preparation of Nickel Nanocone Array Template: (1) In 50 mL of deionized water, 10 g of hexahydrate nickel chloride, 10 g of ammonium chloride, and 1.5 g of boric acid were mixed together. The solution pH value was adjusted to 4, using ammonia and diluted hydrochloric acid. (2) In an electrolysis cell, nickel foam was used as anode and a copper sheet was used as the cathode for direct current electroplating. Prior to electroplating, cover the back of the copper sheet with PI tape to prevent deposition on the backside and to control the current density.

Preparation of 3A Optical Films via Nano-Imprinting: The candidate substrates for transfer print include C8fr (PET), U483 (PET), H403 (PMMA), P960RR (TAC), and TA044 (SPF). The imprint ink consists of 96wt.% fluorosilicone resin, 3% wt EL-9061 adhesion promoter, and 1wt.% initiator. The NCAs template obtained through electroplating was placed on a glass substrate to serve as the base, where the imprint ink and the substrate PET were covered onto the NCAs template with

pressure. (5) A UV lamp with an intensity of 320 mJ cm^{-2} was used to cure the resin ink. Then the cured optical film was released from the template to obtain the corresponding AGF. Then a scraper was used to apply a layer of AF resin with a wet-thickness of 5 μm on the surface of AGF. Different concentrations of AF resin were prepared by controlling the ratio of propylene glycol monomethyl ether (PGME) solvent to the F26C resin. Then the solvent was evaporated at 85°C for a drying time of 2 minutes. Finally, a UV lamp was employed to cure the film at an energy level of 320 mJ cm^{-2} to obtain the 3A optical film.

Characterizations: Reflectivity, Transmittance Measurement, Haze Measurement and Color Coordinates were conducted using benchtop spectroPhotograph meters (CAIPU CS-821N). Contact angle measurement was conducted using Contact Angle Goniometer (KRUSS DSA3). SEM analysis was conducted using Cold Field Emission Scanning Electron Microscopes (HITACHI SU8010).

Supplementary Figures

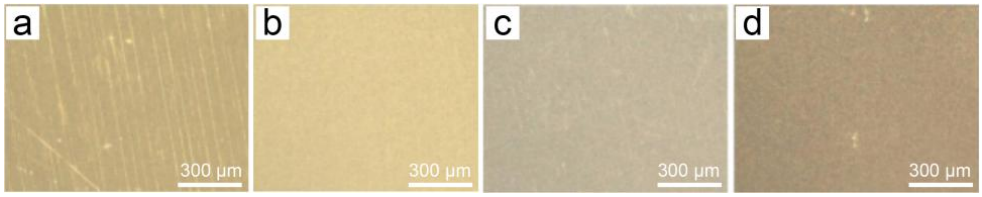

Figure S1. Optical micrographs of samples with different electrochemical deposition times (a) 5 min (b) 10 min (c) 15 min (d) 20 min.

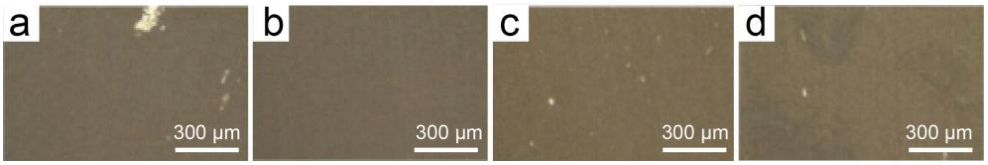

Figure S2. Optical micrographs of samples with different electrochemical deposition temperatures (a) 55℃ (b) 60℃ (c) 65℃ (d) 70℃.

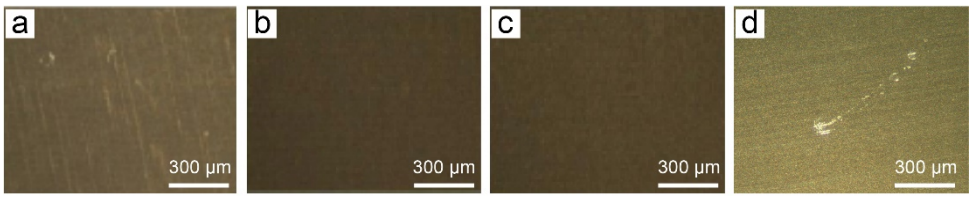

Figure S3. Optical microscopy images of samples with different electrochemical deposition current densities (a) 10 $mAcm^{-2}$ (b) 12 mA cm^{-2} (c) 14 m Acm^{-2} (d) 18 $mAcm^{-2}$.

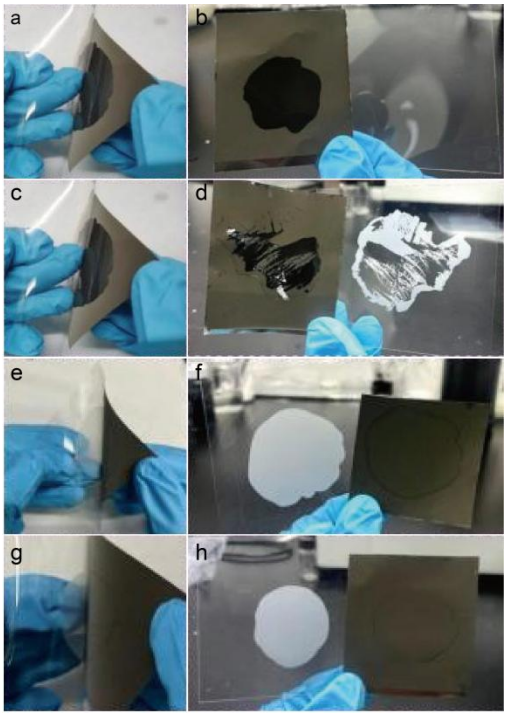

Figure S4. Releasing the transfer printed samples with different resins (a, b) L-6907 UV resin (c, d) Z-975-H03C UV resin (e, f) 1240 fluorocarbon UV resin and (g, h) 2150 fluorosilicone UV resin.

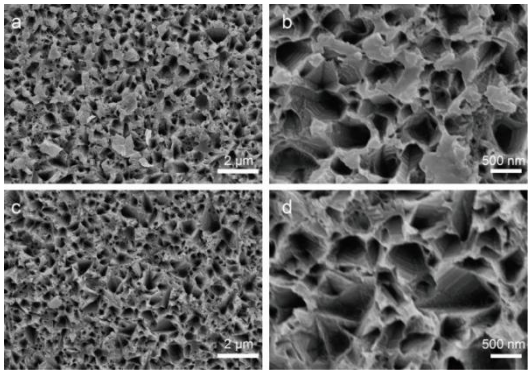

Figure S5. SEM images of (a, b) 1240 fluorocarbon UV resin and (c, d) 2150 fluorosilicone UV resin after transfer.

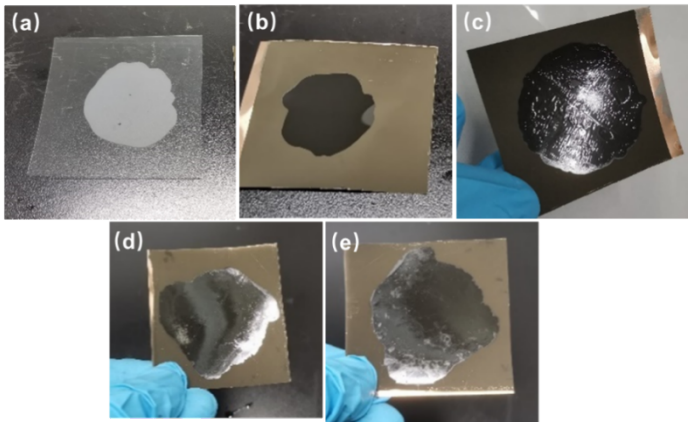

Figure S6. Transfer printing samples of different substrates (a) C8fr (PET) (b) U483 (PET) (c) H403 (PMMA) (d) P960RR (TAC) (e) TA044 (SPF).

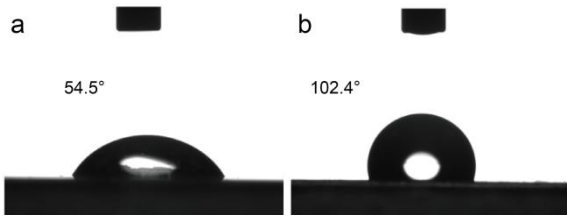

Figure S7. Contact angle of (a) Smooth PET substrate and (b) Smooth PET substrate coated with a layer of AF ink.

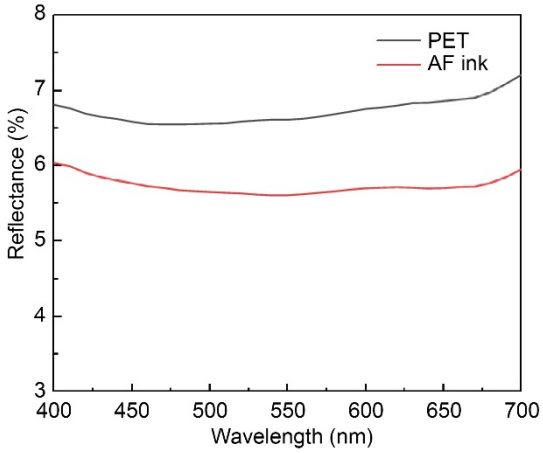

Figure S8. Optical reflectances of the smooth PET substrate and the one coated with a layer of AF ink.

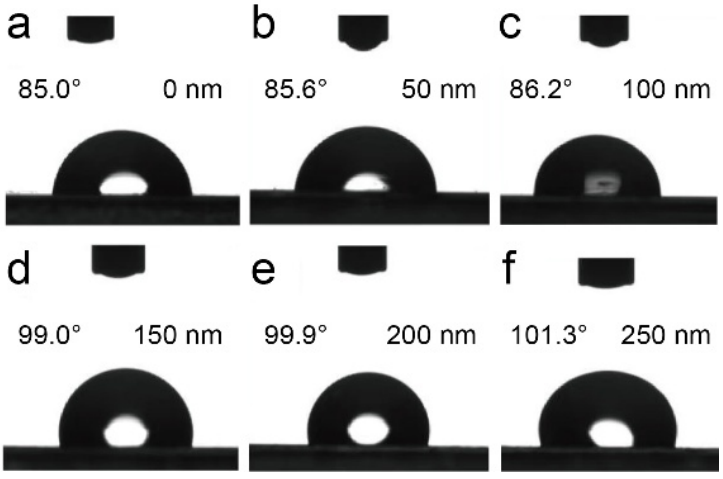

Figure S9. (a-f) Contact angle measurements of films with coatings thickness from 50 nm to 250 nm;

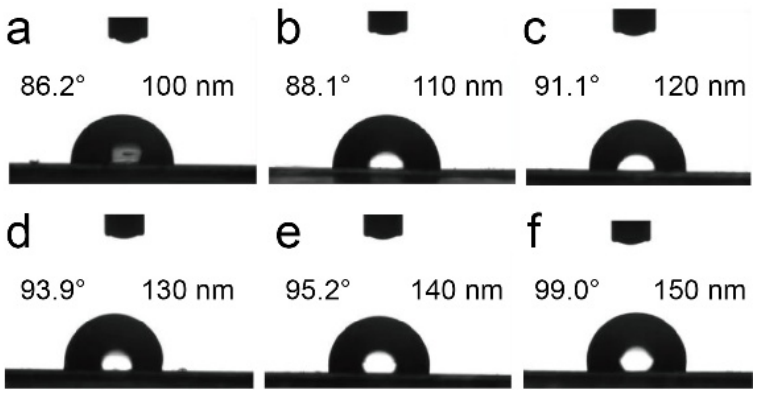

Figure S10. (a-f) Contact angle measurements of films with coatings thickness from 100 nm to 150 nm;

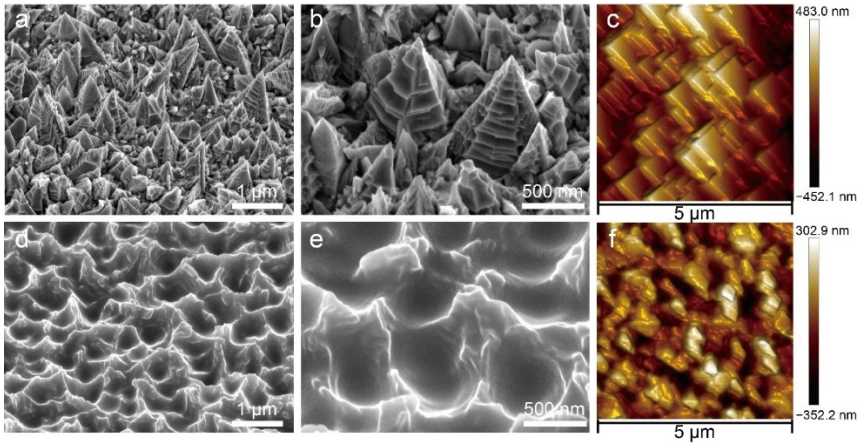

Figure S11. (a, b) SEM and (c) AFM images of the nanocone array template. (d, e) SEM and (f) AFM images of the 3A optical film.

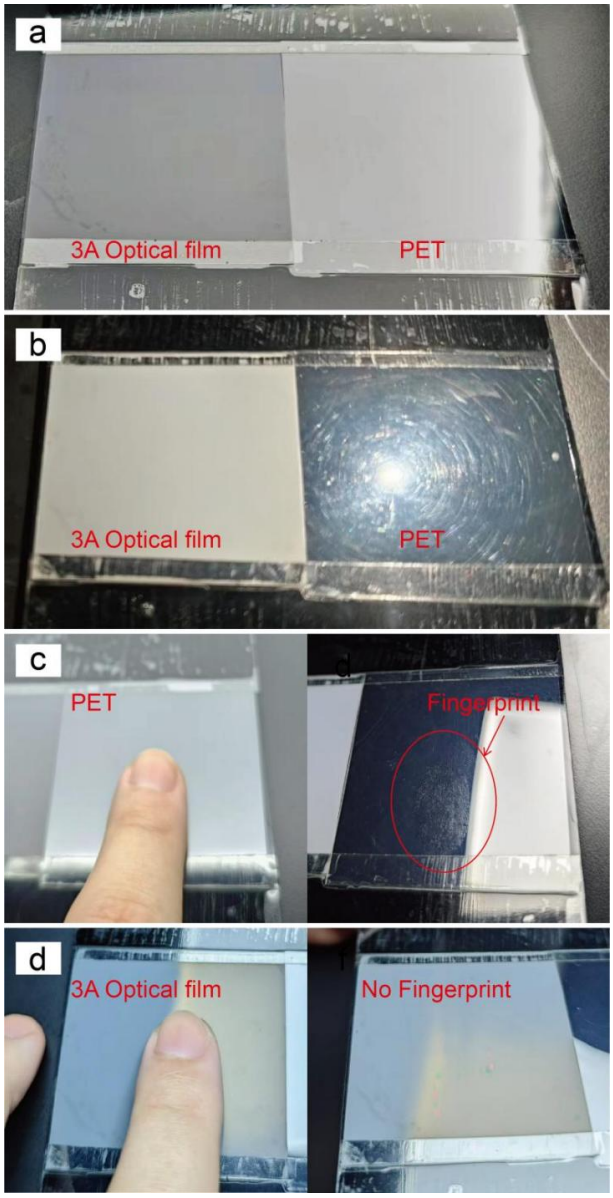

Figure S12. (a) Photograph of 3A optical film and the corresponding PET substrate. (b) Photograph of the anti-glare effect of 3A optical film and its PET substrate. (c) Fingerprints can be remained on the substrate PET film. (d) Fingerprints cannot be remained on a 3A optical film.

Supplementary Table

Table S1. The total transmittance, haze and color coordinates of PET substrate, AF ink and 3A optical film.

Sample	Total transmittance (%)	Haze (%)	Lightness (L*)	Green-red coordinate (a*)	Blue-yellow coordinate (b*)
PET substrate	89.82	1.47	95.92	−0.06	0.37
PET substrate + AF ink	91.26	1.33	96.52	−0.09	0.42
3A optical film	90.09	56.71	96.01	0.09	1.14

Table S2. Transmittance, haze, and color coordinates of the smooth PET substrate coated with different thickness levels of the AF resin (corresponding to ink concentration).

Sample	Total transmittance (%)	Haze (%)	Lightness (L*)	Green-red coordinate (a*)	Blue-yellow coordinate (b*)
0 nm	90.09	56.71	96.01	0.09	1.14
50 nm	88.42	56.09	95.01	0.04	1.56
100 nm	88.65	52.84	95.18	0.06	1.62
150 nm	90.83	8.35	96.15	−0.06	0.19
200 nm	91.41	5.15	96.31	−0.08	0.51
250 nm	92.4	3.45	96.95	−0.11	0.62

Table S3. Transmittance, haze, and color coordinates of the 3A optical films with different thickness levels of the AF resin (corresponding to ink concentration).

Sample	Total transmittance (%)	Haze (%)	Lightness (L*)	Green-red coordinate (a*)	Blue-yellow coordinate (b*)
100 nm	88.65	52.84	95.18	0.06	1.62
110 nm	88.62	44.08	95.67	0.14	1.26
120 nm	89.29	30.42	95.58	0.10	1.16
130 nm	90.41	25.19	95.98	−0.03	0.54
140 nm	90.87	10.74	96.19	−0.01	0.62
150 nm	90.83	8.35	96.15	−0.06	0.19