Poster Presentation

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Liquid crystal lens with doping of rutile titanium dioxide nanoparticles

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Schematic diagram of a conventional LC lens with a circularly hole-patterned electrode

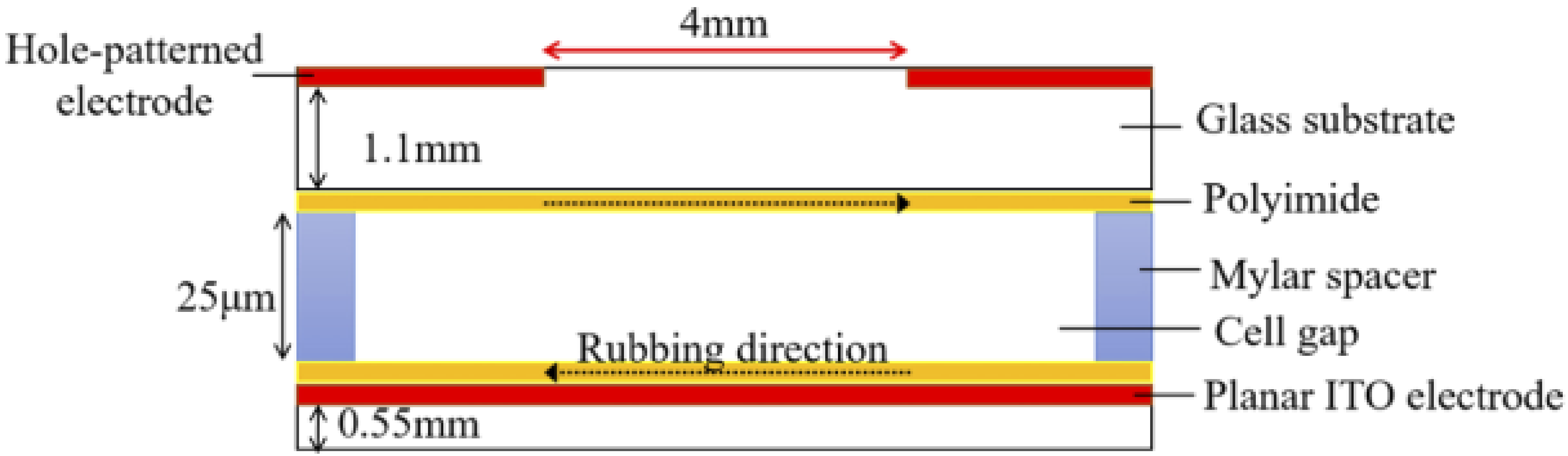
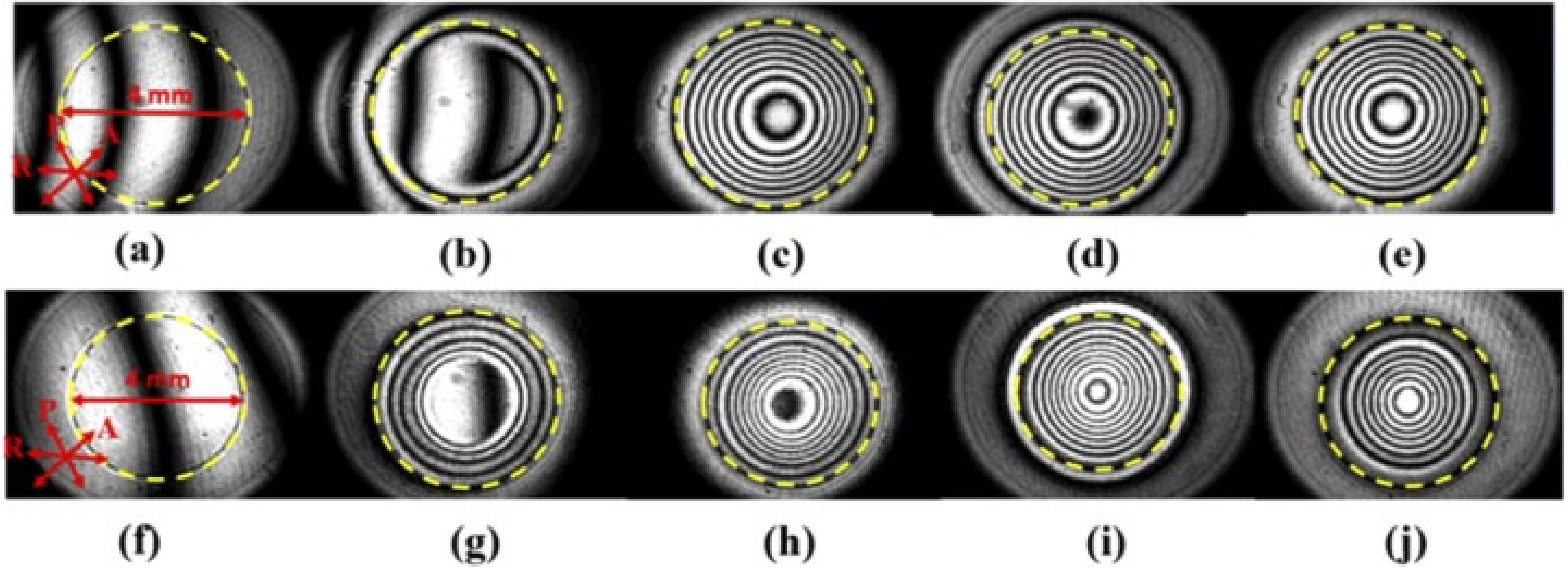


Fig. 1. Schematic of the hole-patterned LC lenses.



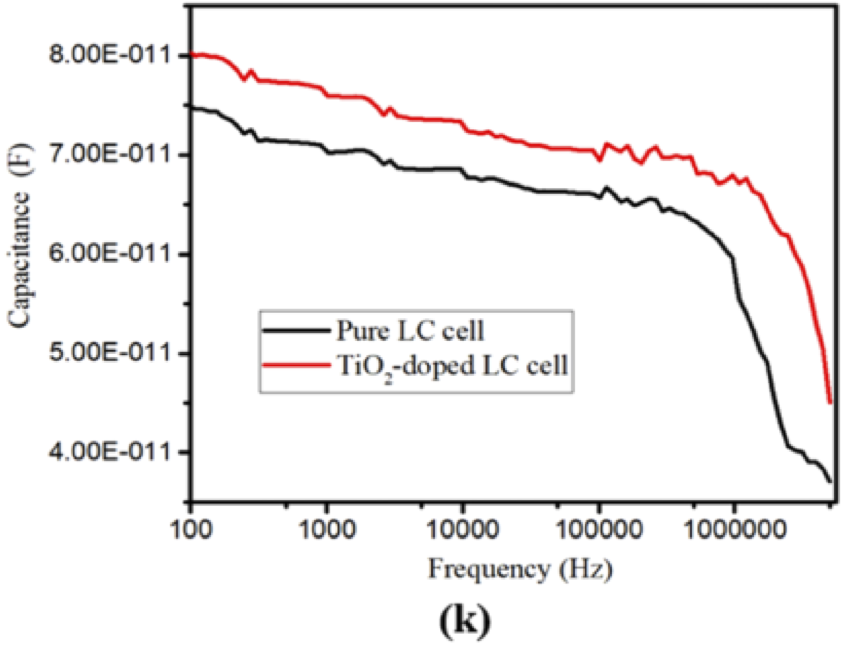


Fig. 2. Interference patterns of the pure LC lens at (a) 0 V, (b) 30 V, (c) 90 V, (d) 100 V, (e) 140 V; interference patterns of the TiO_2 NP-doped LC lens at (f) 0 V, (g) 30 V, (h) 50 V, (i) 80 V, (j) 140 V. The yellow dash-lines indicate the AH area of LC lens. (k) frequency-dependent capacitances of the pure and TiO_2 NP-doped LC lenses.

Focal length of HPELC lens

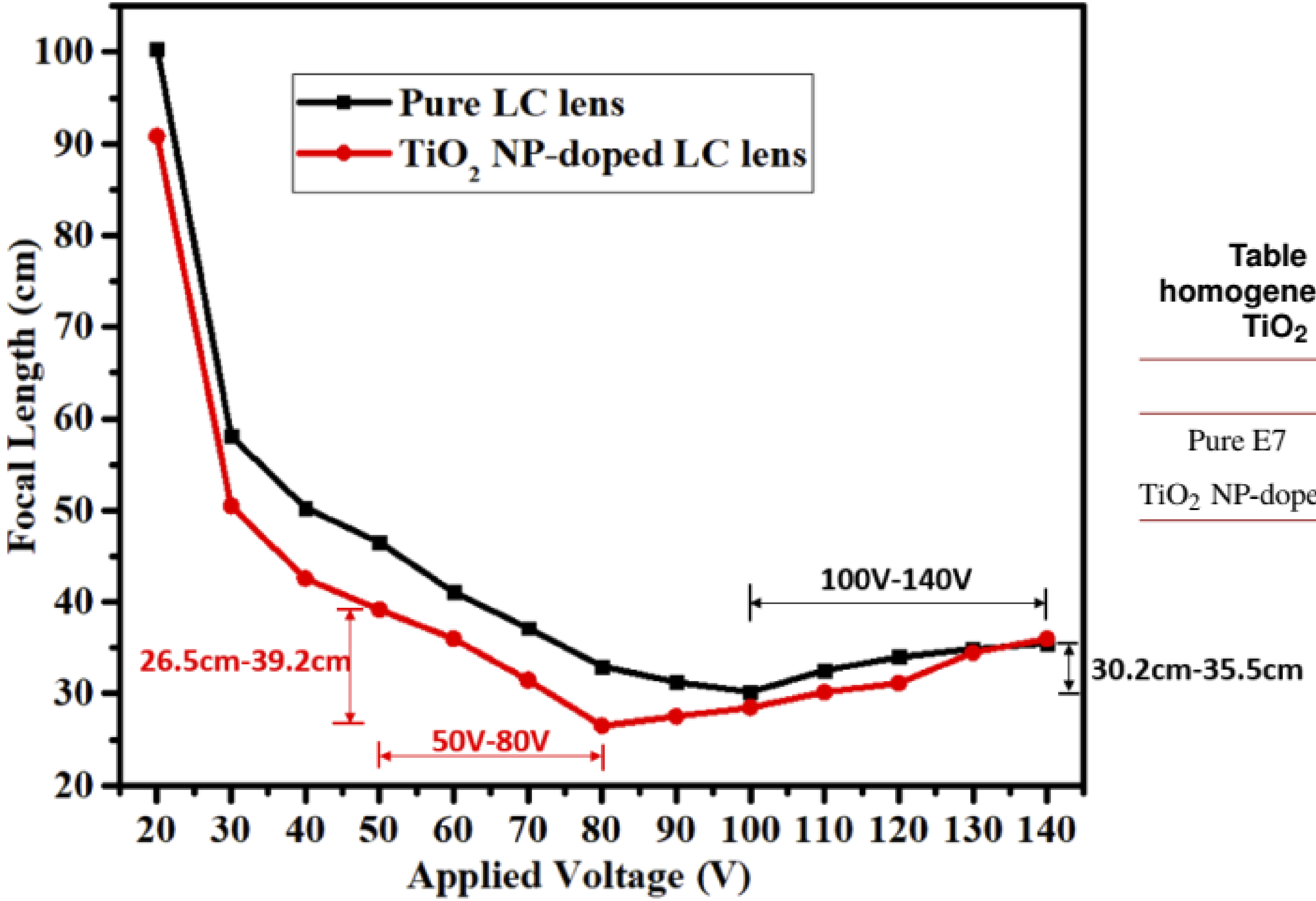


Table 1. T_{NI} and Δn of the homogeneous pure E7 and 0.5 wt% TiO_2 NP-doped LC cells.

	T_{NI} (°C)	Δn
Pure E7	61.5	0.21
TiO_2 NP-doped	63.5	0.25

Fig. 3. Voltage-dependent focal lengths of the pure and TiO_2 NP-doped LC lenses.

FWHM of HPELC lens

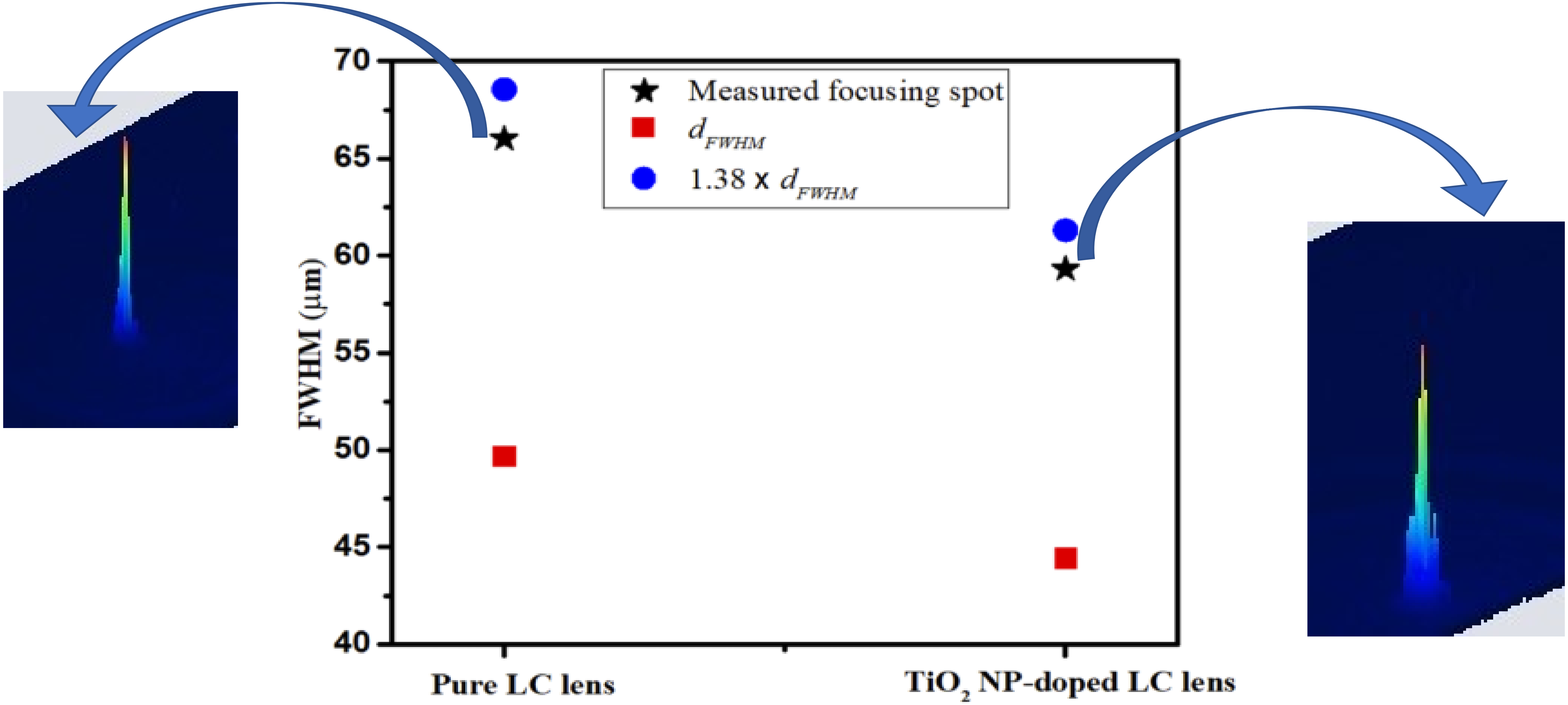


Fig. 4. Measured FWHM of the focusing spots and calculated *d_{FWHM}* for the pure and TiO_2 NP-doped LC lenses addressed with minimum focal length. Insets indicate the measured focusing profiles.

Lensing Properties Analysis of HPELC lens

Table 2. RMS errors of the pure and TiO_2 NP-doped LC lenses at operation voltages.

TiO_2 NP-doped LC lens					
Voltage (V)	50	60	70	80	
RMS error (λ)	0.072	0.073	0.064	0.062	
Pure LC lens					
Voltage (V)	100	110	120	130	140
RMS error (λ)	0.071	0.070	0.063	0.060	0.078

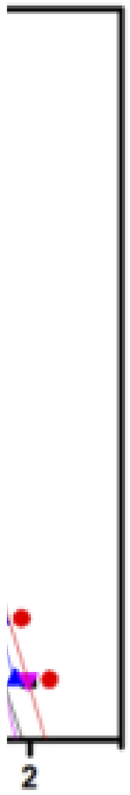


Fig. 5. Phase retardations and RMS errors of the (a) pure and (b) TiO2 NP-doped LC lenses at various voltages. The symbols and solid lines represent the measured data and quadratic-fitting curve, respectively.

Response time of HPELC lens

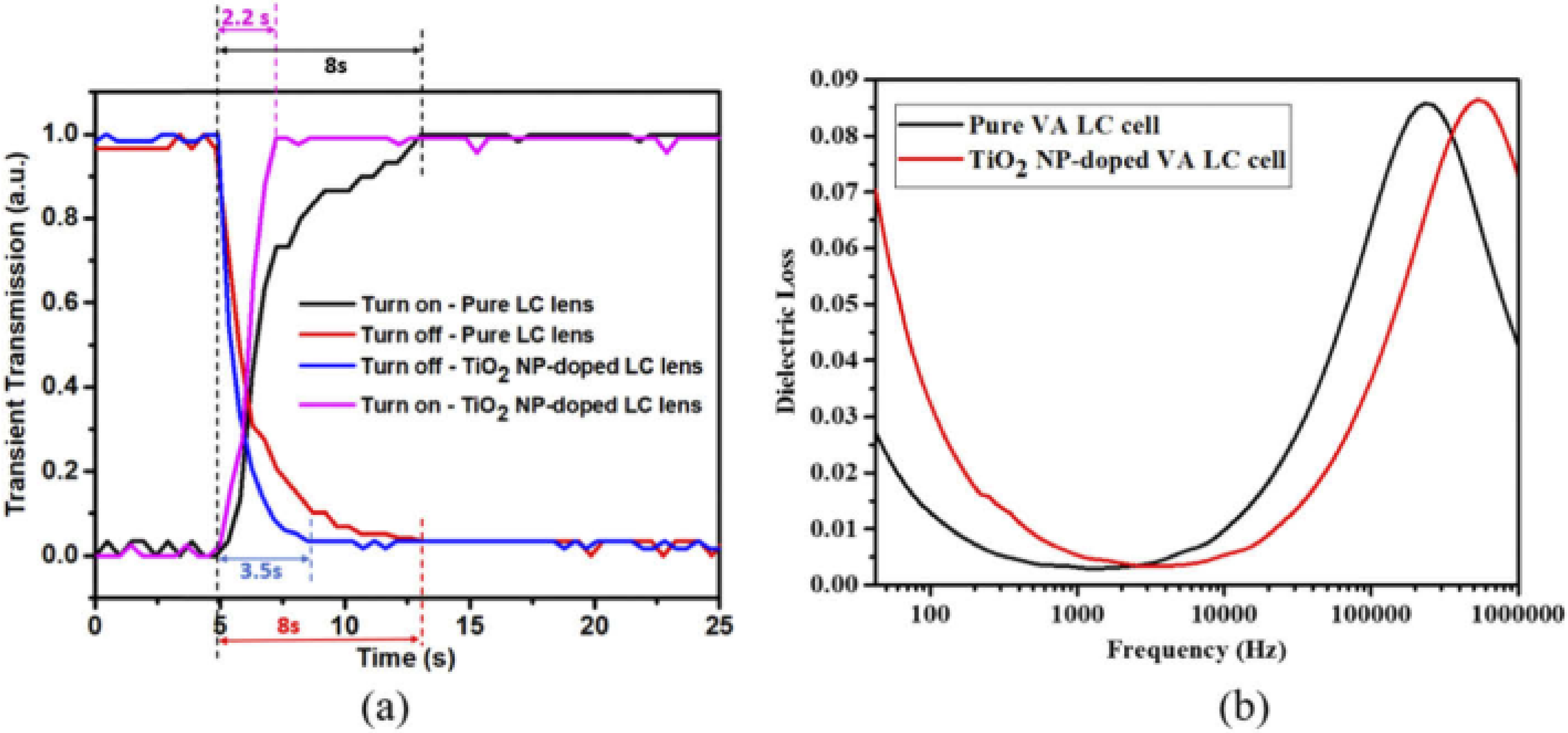


Fig. 6. (a) Turn-on and -off times of the pure and TiO2 NP-doped LC lenses. (b) frequency-dependent dielectric losses of the pure and TiO2 NP-doped VA LC cells.

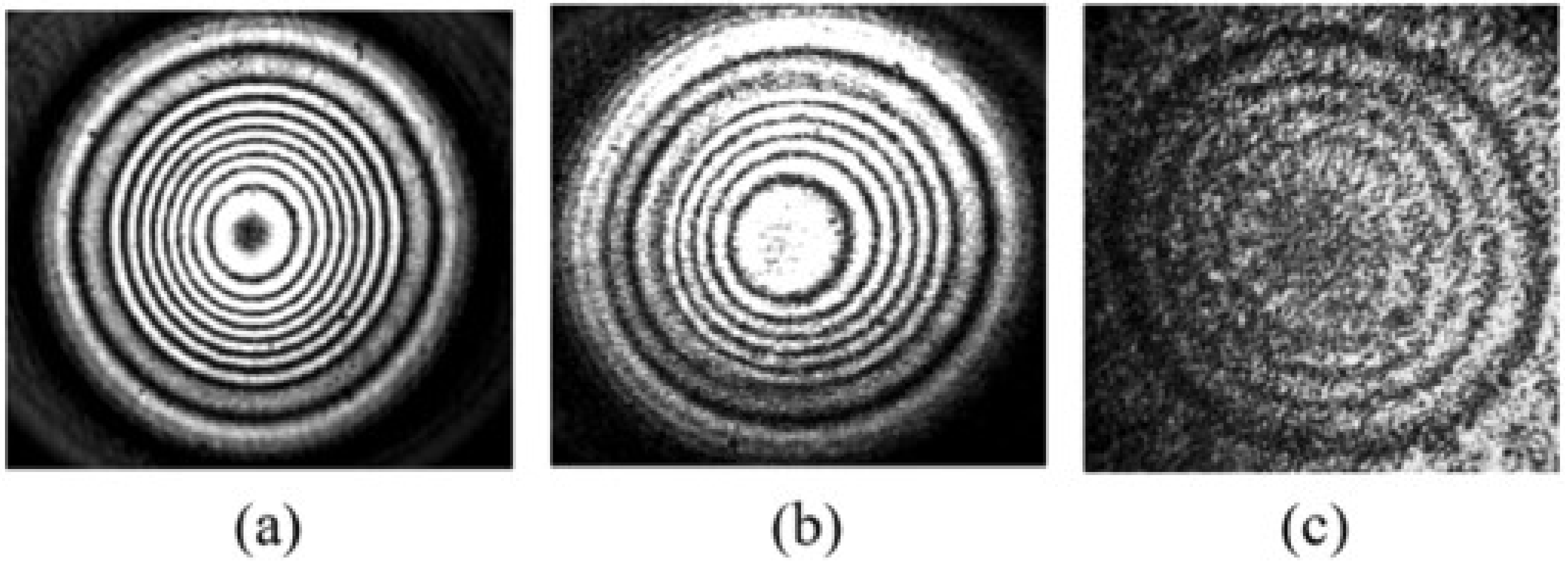


Fig. 7. Interference fringes of (a) 0.5 wt%, (b) 0.7 wt%, and (c) 1 wt% TiO_2 NP-doped LC lenses addressed at 80 V.

Table 3. Response times of 0.5 wt%, 0.7 wt%, and 1 wt% TiO_2 NP-doped LC lenses.

	0.5 wt% TiO_2 NP-doped LC lens	0.7 wt% TiO_2 NP-doped LC lens	1 wt% TiO_2 NP-doped LC lens
Turn-on time (s)	2.2	2.2	1.8
Turn-off time (s)	3.5	3.1	2.2

Image Performance of HPELC lens

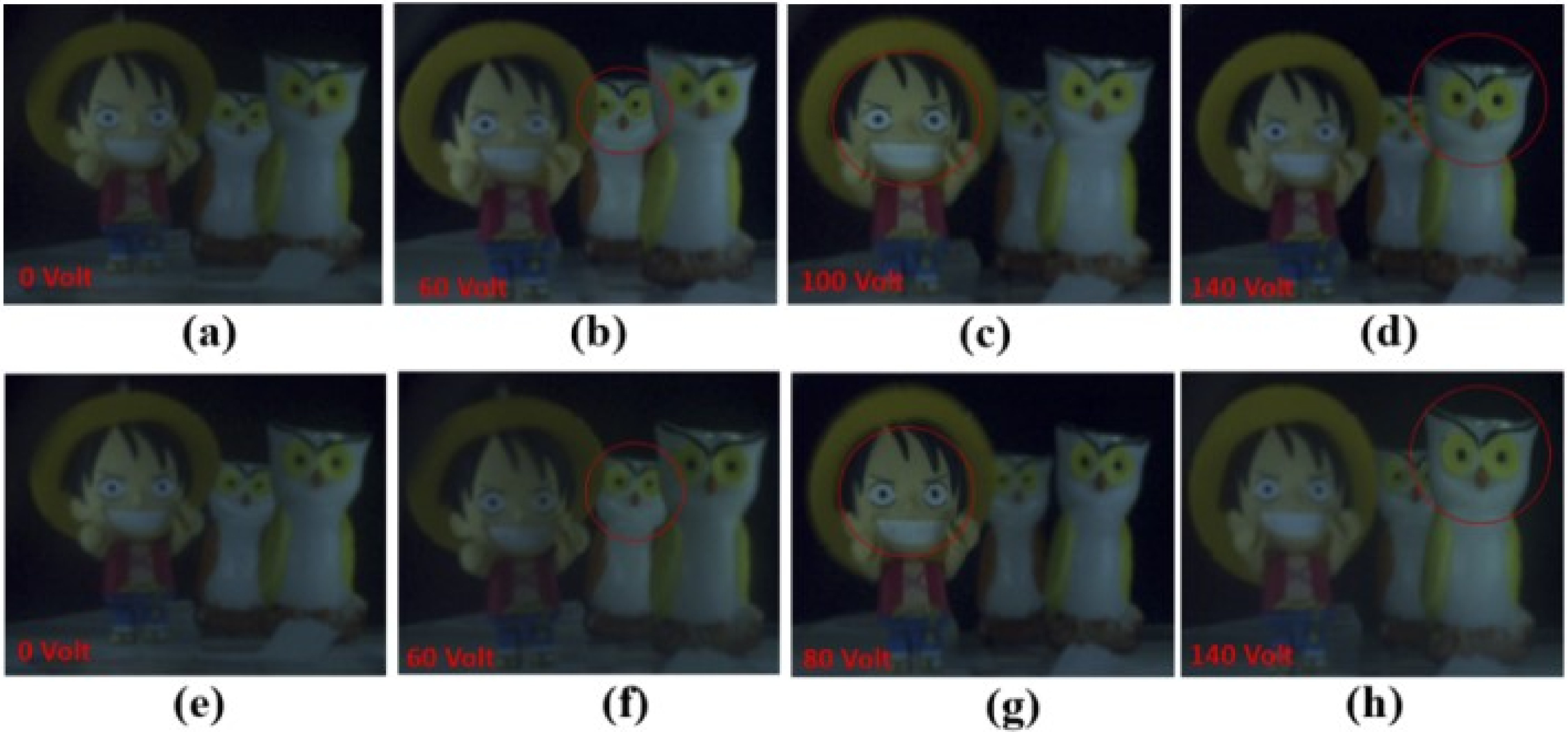


Fig. 8. Imaging performances of the pure LC lens at (a) 0 V, (b) 60 V, (c) 100 V, and (d) 140 V; those of the TiO_2 NP-doped LC lens at (e) 0 V, (f) 60 V (g) 80 V, and (h) 140 V.

Conclusions

- The doping of rutile TiO_2 NPs is used to fabricate the hole-patterned LC lens for the first time.
- TiO_2 NP dopants increase T_{NI} and Δn of the LC mixture and the lens power of the LC lens.
- In comparison with pure LC lens, TiO_2 NP-doped lens has approximately 50% lower operation voltage because of the strengthened electric field around the NPs and around 2.8 times faster response time because of the decreased rotational viscosity of the LC mixture and the increased interaction between the LC molecules by the NP dopants.
- TiO_2 NP-doped LC lens has a significantly lower V_{add}, wider tunable focal length range within narrower operation voltages, and faster response time than pure one.
- It also has relatively stable RMS errors within the operation voltages.
- The TiO_2 NP dopants preserve the acceptable focusing quality of LC lens.
- The pure and TiO_2 NP-doped LC lenses demonstrate similar imaging performance.
- The doping of rutile TiO_2 NPs provides a promising option to realize a superior LC lens.

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