Programmable Metasurfaces by Electrically Driven Transparent Micro-Heaters

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In the last decades, metasurfaces have attracted much attention because of their extraordinary light scattering properties. The metasurfaces inherent fix geometry is an obstacle to bring dynamic tunability in their optical behaviour. The thermo-optical effect has been recently exploited for tuning the optical properties of metasurfaces due to the ability to show significant and reversible modulation contrast in transmission [1, 2]. Here, we demonstrate for the first time the programmable tuning of dielectric inverse-designed metasurfaces made of hydrogenated amorphous silicon by electrically driven transparent micro-heaters (Figure 1a,b). Our work circumvents the shortcomings of the previous works, namely the switching speed and addressability.

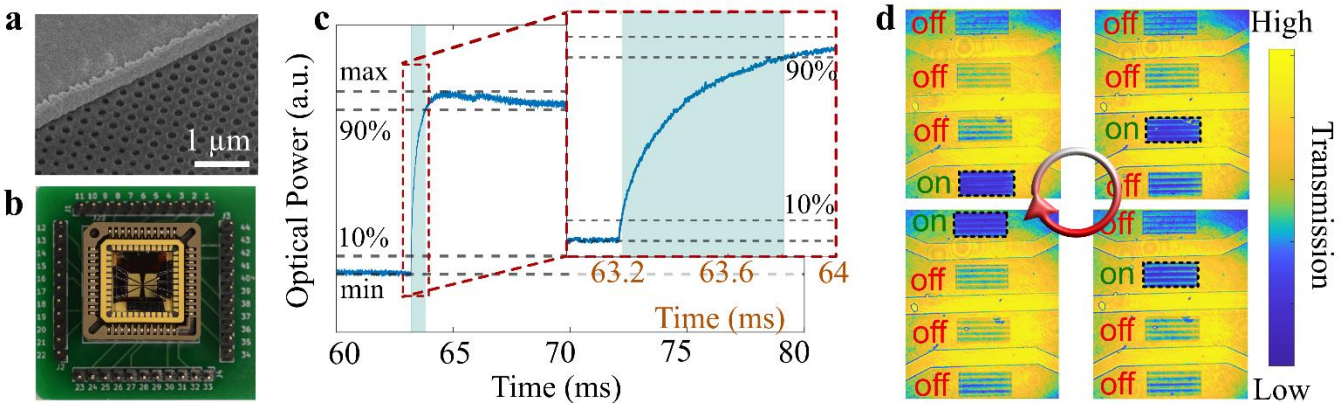

Figure 1: **a** SEM of the Si membrane metasurface embedded in ITO. **b** Picture of the PCB used for programing and electrically driving the metasurface. **c** Transmission intensity rise-time upon electrically biasing the system. **d** Addressable tuning of individual metasurfaces.

Driving the micro-heaters with consumer electronics compatible voltages (<5V) results in the metasurface exhibiting 9 folds increment in the transmission intensity output. Controlling the voltage profile helped us to achieve a sub-millisecond switching time (625 μs), which is over 20 folds faster than biasing the system by a step profile voltage (Figure 1c). Moreover, this method enables us to tune spatially selective metasurfaces on demand (Figure 1d). Such a performance makes our metasurface an ideal integrable element within cutting-edge technologies, where a fast, solid-state and transparent optical switch is required.

[1] M. Rahmani, L. Xu, *Adv. Funct. Mater.* **27**, 1700580 (2017).

[2] K. Zangeneh Kamali, L. Xu, et al., *Small* **15**, 1805142 (2019).