Complete-basis-reprogrammable coding metasurface for generating dynamically-controlled holograms

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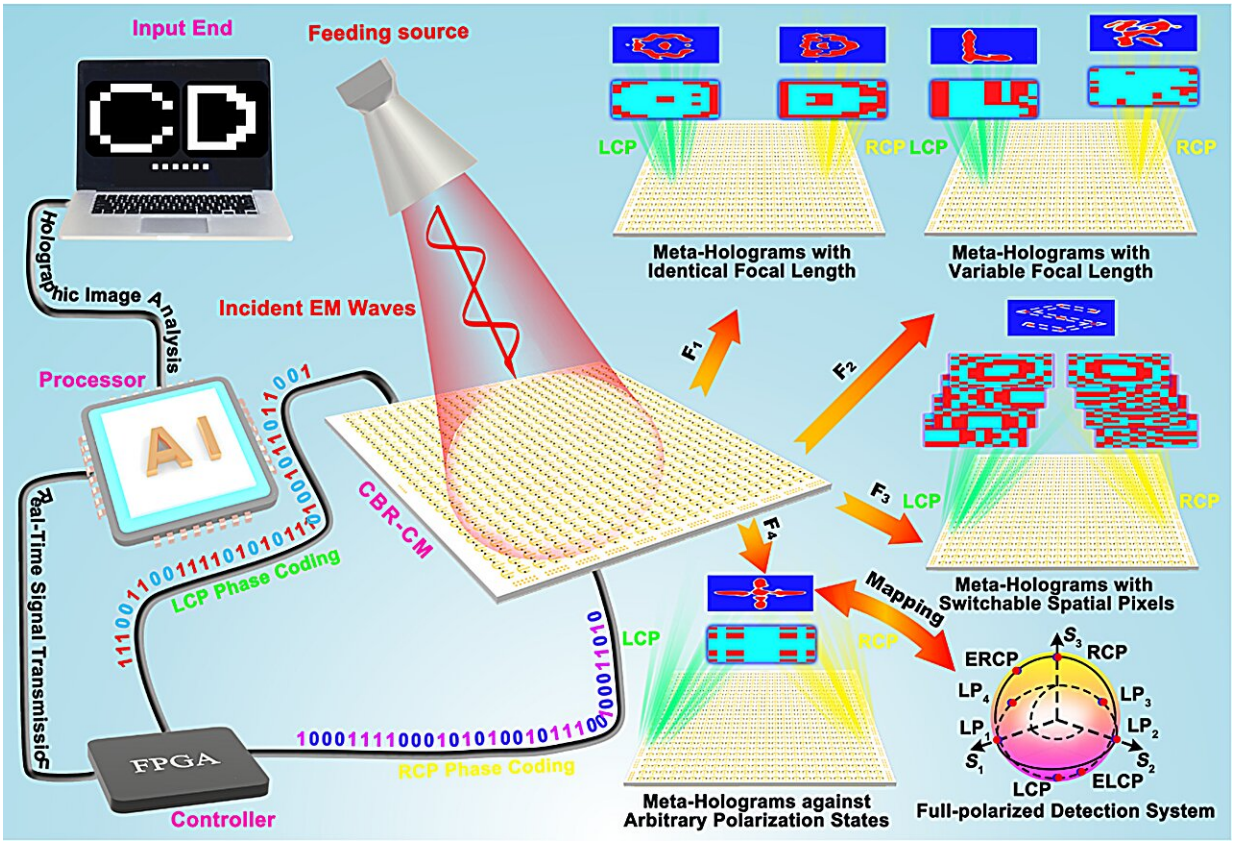

Working schematic illustration of the dynamic holograms based on complete-basis-reprogrammable coding metasurface. Credit: OEA

An article in *Opto-Electronic Advances*, discusses complete-basis-

reprogrammable coding metasurface for generating dynamically-controlled holograms under arbitrary polarization states.

This article proposes a dynamically-controlled holographic device based on complete-basis-reprogrammable coding metasurface. The orthogonal circular polarization components of the incident electromagnetic waves are utilized as a complete set of basis states, and the holographic image under arbitrarily polarized incident electromagnetic waves can be modulated and detected.

Given the merits of rapid response, simple integration, and high practicality, etc., the meta-device possesses great application potential in ultra-high capacity information storage, dynamic holographic display and detection, and multi-functional electromagnetic information processing.

Initially, the concept of digital and reprogrammable coding metasurfaces had been put forward to adopt binary codes to quantify physical parameters (e.g., amplitude, phase, and polarization). Compared with metasurfaces with continuously various parameters, they establish a sound foundation for controlling complex electromagnetic operations in real time while simplifying the design of the electromagnetic waves.

Among multitudinous studies of wavefronts shaping via reprogrammable coding metasurface, the most remarkable application is undoubtedly reprogrammable meta-holograms, on-demand recording, storage, and evocation of the targeted images, which meets the urgent needs of miniaturization, integration and tunability of photoelectric systems and holds great potential ranging from information encryption to intelligent detection.

It's easy to achieve independent control of multiple physical parameters under orthogonal linear polarization basis through reprogrammable

coding metasurface with birefringent characteristics and further realize high-quality dynamic imaging and detection under different modes. However, birefringent reprogrammable coding metasurface generically requires more active components and works in a relatively narrow bandwidth and is inconducive to actual application of fabricated products.

The spin-reprogrammable coding metasurface with high diffraction efficiency and wide operating bandwidth can reconstruct the electromagnetic characteristics under the orthogonal circular polarization basis via employing external excitations, which provides a novelty train of thought for the implementation of simple dynamic holographic modulation, display and detection with encryptability, high convenience and large capacity in microwave band.

The authors of this article propose a dynamically-controlled holographic device based on complete-basis-reprogrammable coding metasurface, in which the orthogonal circular polarization components of the incident electromagnetic waves are utilized as a complete set of basis states. According to the vectorial synthesis and decomposition theory of the electromagnetic field, the incident electromagnetic wave in any polarization state can be equivalent to the linear sum of this set of complete basis.

In this study, they achieved independent dynamic regulation over the co-polarized reflection phases while maintaining the same amplitude for left-handed circularly polarized waves and right-handed circularly polarized waves via umbrella-shaped metallic structure embedded with two symmetrical positive–intrinsic–negative diodes which can be controlled through different voltages input from the field-programmable gate array.

Correspondingly, combined with sequences calculated through iterative optimization algorithm, the target holographic image under arbitrarily

polarized waves can be generated based on the joint coding and modulation of this complete set of basis.

In both the simulations and experiments, they demonstrated four illustrative functionalities including spin-controlled meta-holograms with identical or variable focal length, coplanar dual-polarized pixel synthesis meta-holograms, and full-polarized detection system on Poincaré sphere, proving the independent spin-space-addressing-multiplexing capability and puissant arbitrary polarization state adaptability and high robustness in dynamic holograms.

Moreover, the entire meta-device possesses a compact structure, broadband bandwidth, and high scalability.

The complete-basis-reprogrammable coding metasurface is dominated via voltage-controllable active components, which carries rapid response, simple integration and high practicability. It can be further linked with signal modulation and demodulation devices to achieve the transmission relay of real images, and exhibits great application potential in ultra-high capacity information storage, dynamic holographic display and detection, and multi-functional electromagnetic information processing.

More information: Zuntian Chu et al, Complete-basis-reprogrammable coding metasurface for generating dynamically-controlled holograms under arbitrary polarization states, *Opto-Electronic Advances* (2024). DOI: 10.29026/oea.2024.240045

https://phys.org/news/2024-08-basis-reprogrammable-coding-metasurface-generating.html