

# Terahertz Metasurface for Manipulation of Surface Waves

Yu He<sup>1,3†</sup>, Xiangyu Jin<sup>2,3†</sup>, Shulin Sun<sup>2,3\*</sup>, Zhuo Wang<sup>2,3\*</sup>, Lei Zhou<sup>1,3\*</sup>

<sup>1</sup> State Key Laboratory of Surface Physics and Key Laboratory of Micro and Nano Photonic Structures (Ministry of Education), Department of Physics, Fudan University, Shanghai 200433, China

<sup>2</sup> Department of Optical Science and Engineering, School of Information Science and Technology, Fudan University, Shanghai 200433, China

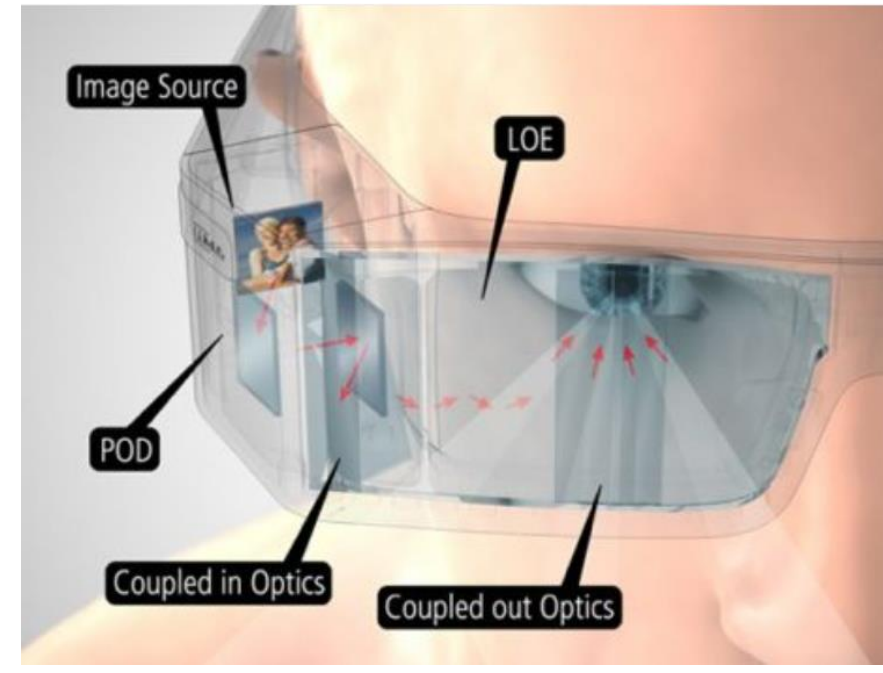
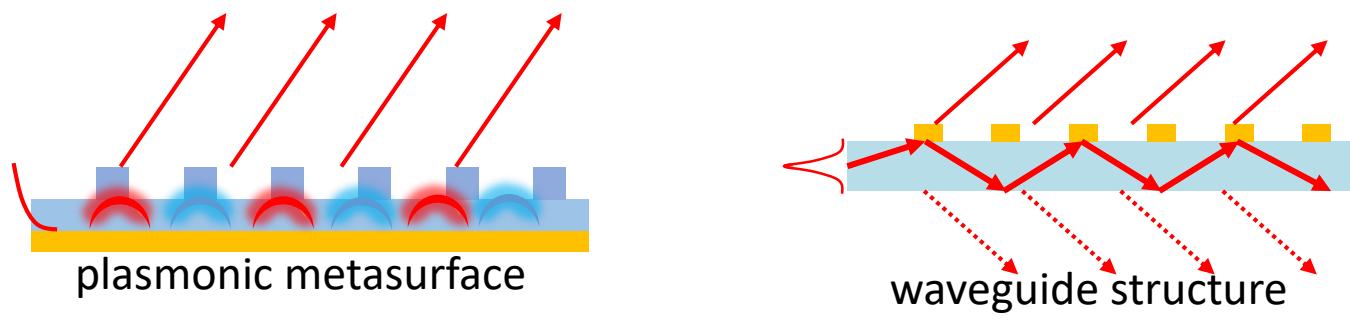
<sup>3</sup> Shanghai Key Laboratory of Metasurfaces for Light Manipulation, 200433 Shanghai, China

<sup>†</sup>These authors contributed equally to this work. Email: [21110190006@m.fudan.edu.cn](mailto:21110190006@m.fudan.edu.cn)

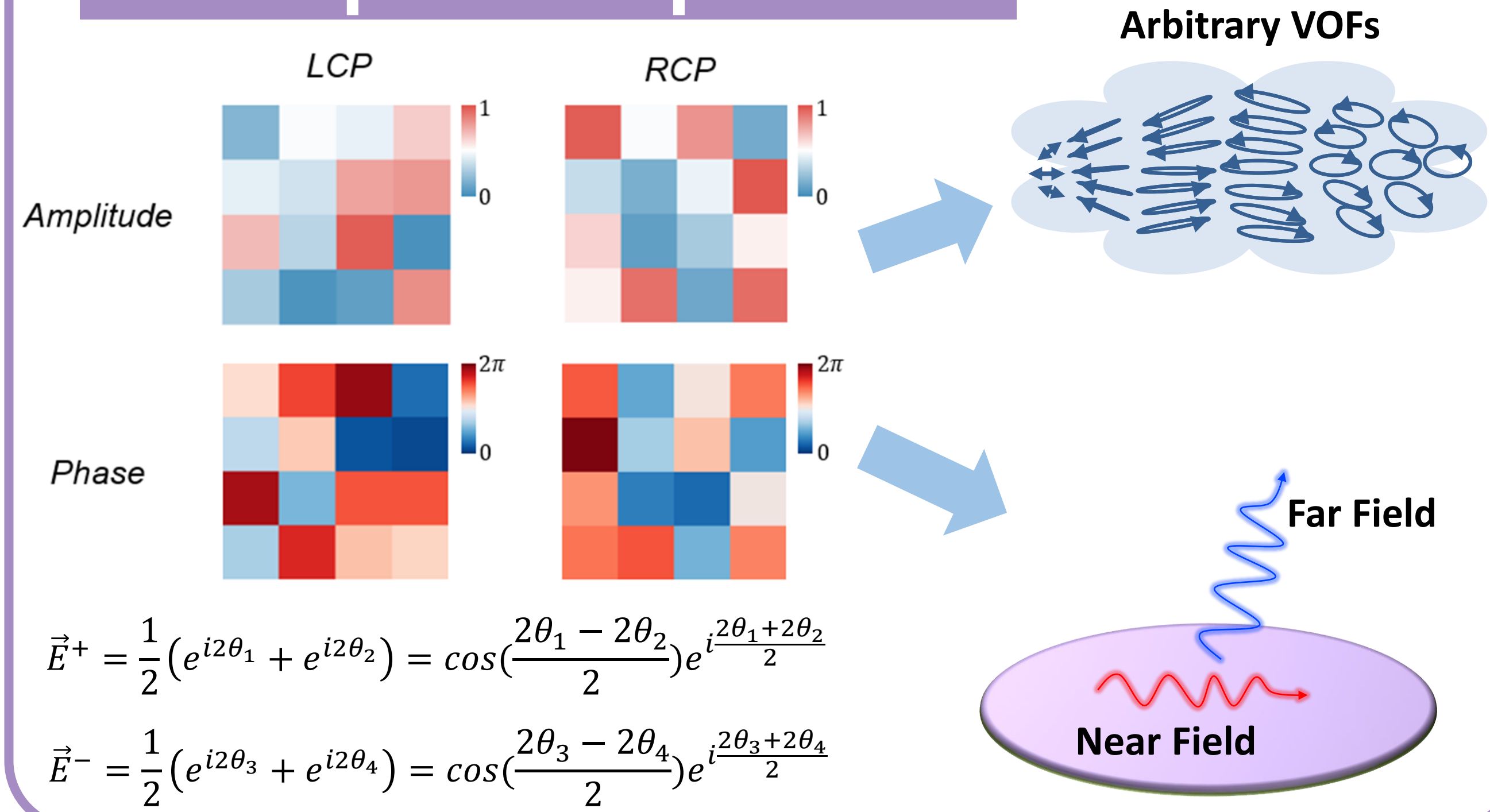
## Introduction

☒ In VR glasses applications, the waveguide structure can cause **backscattering** and exhibits **low efficiency** in optical field modulation

☑ As an on-chip device, plasmonic metasurfaces offer **tunable scattering efficiency** and **eliminate backscattering**, making them excellent candidates to replace waveguide structures.

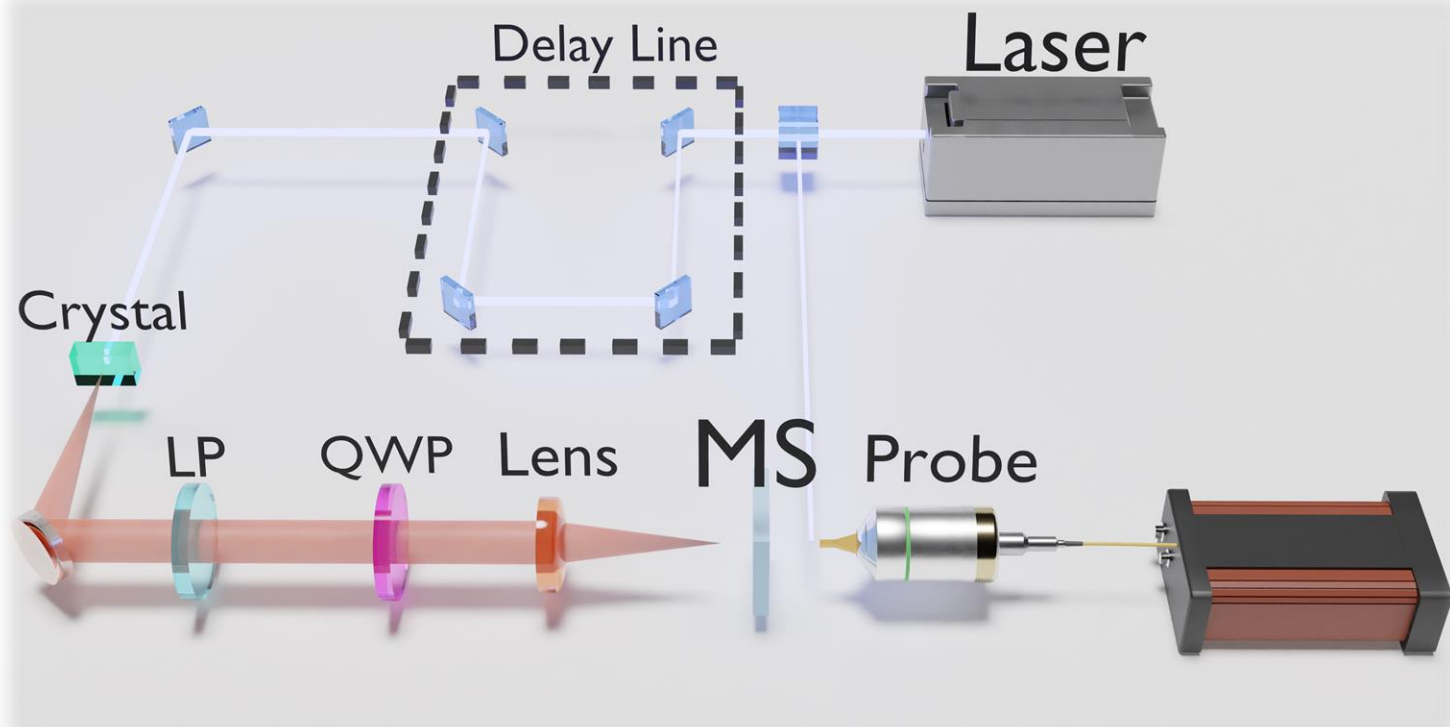


## Complex Amplitude



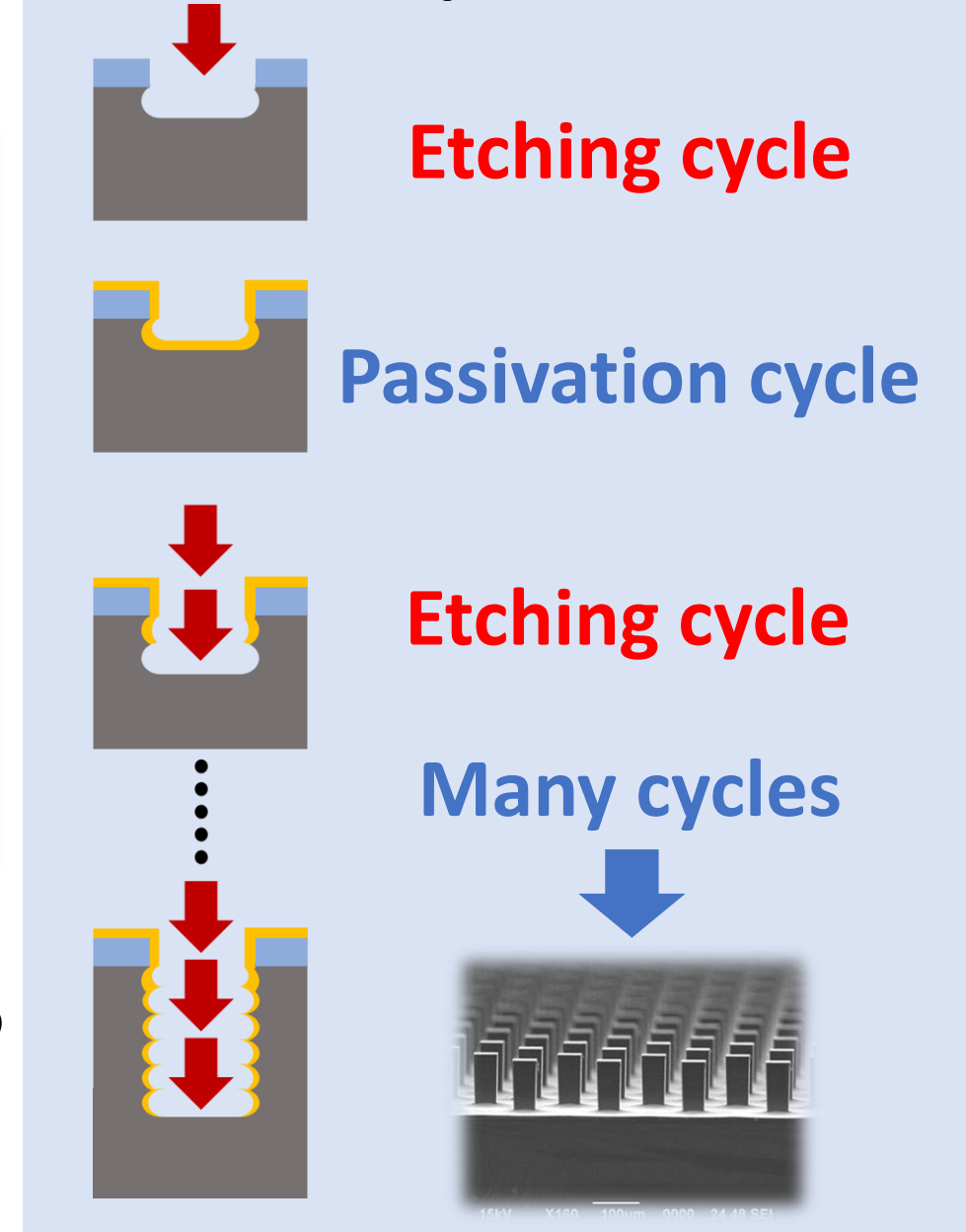
## Methods

Terahertz near-field probing technology

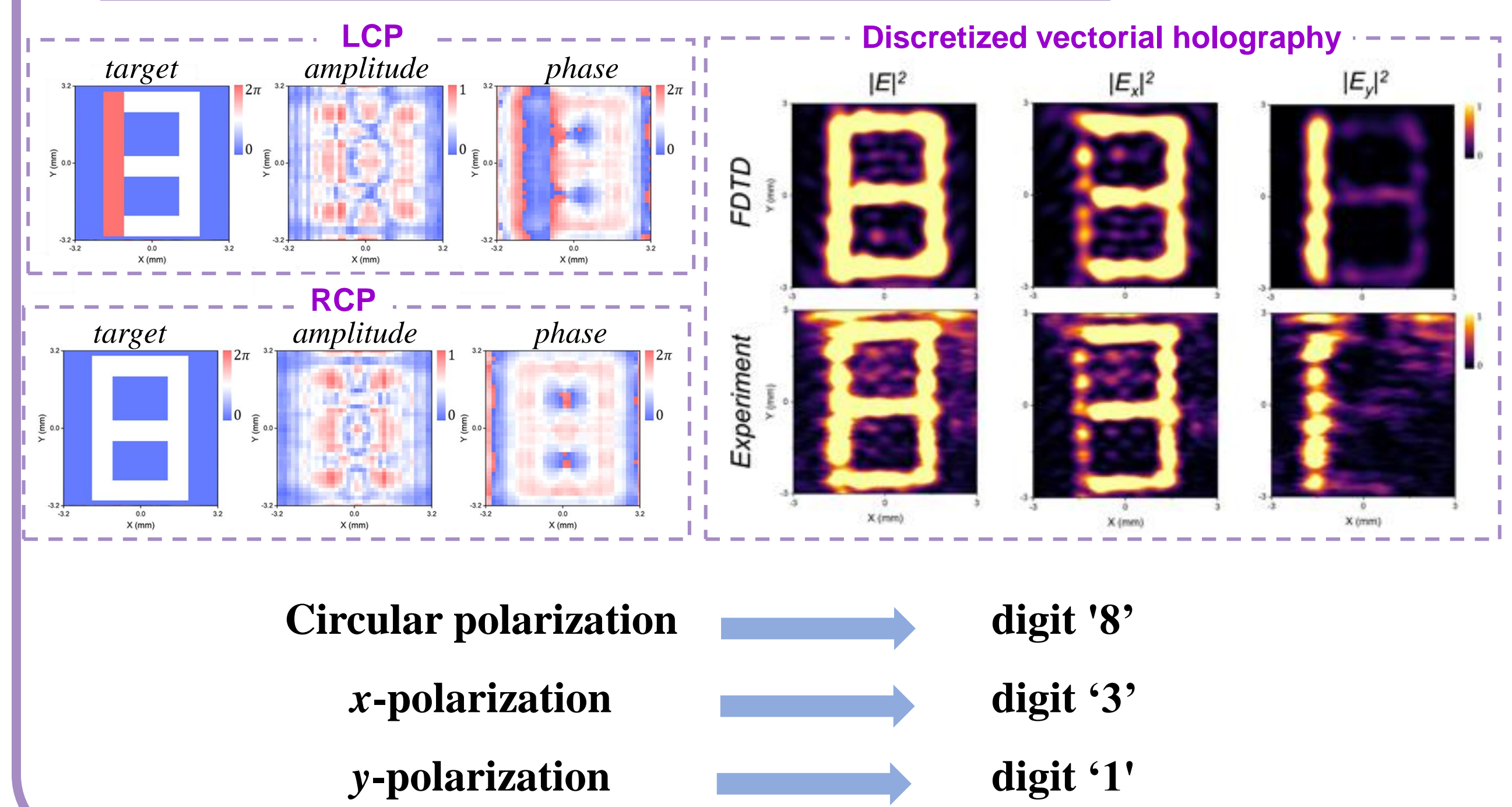


Sample fabricated by magnetron sputtering and deep silicon etching, characterized by terahertz near-field probing technology detection.

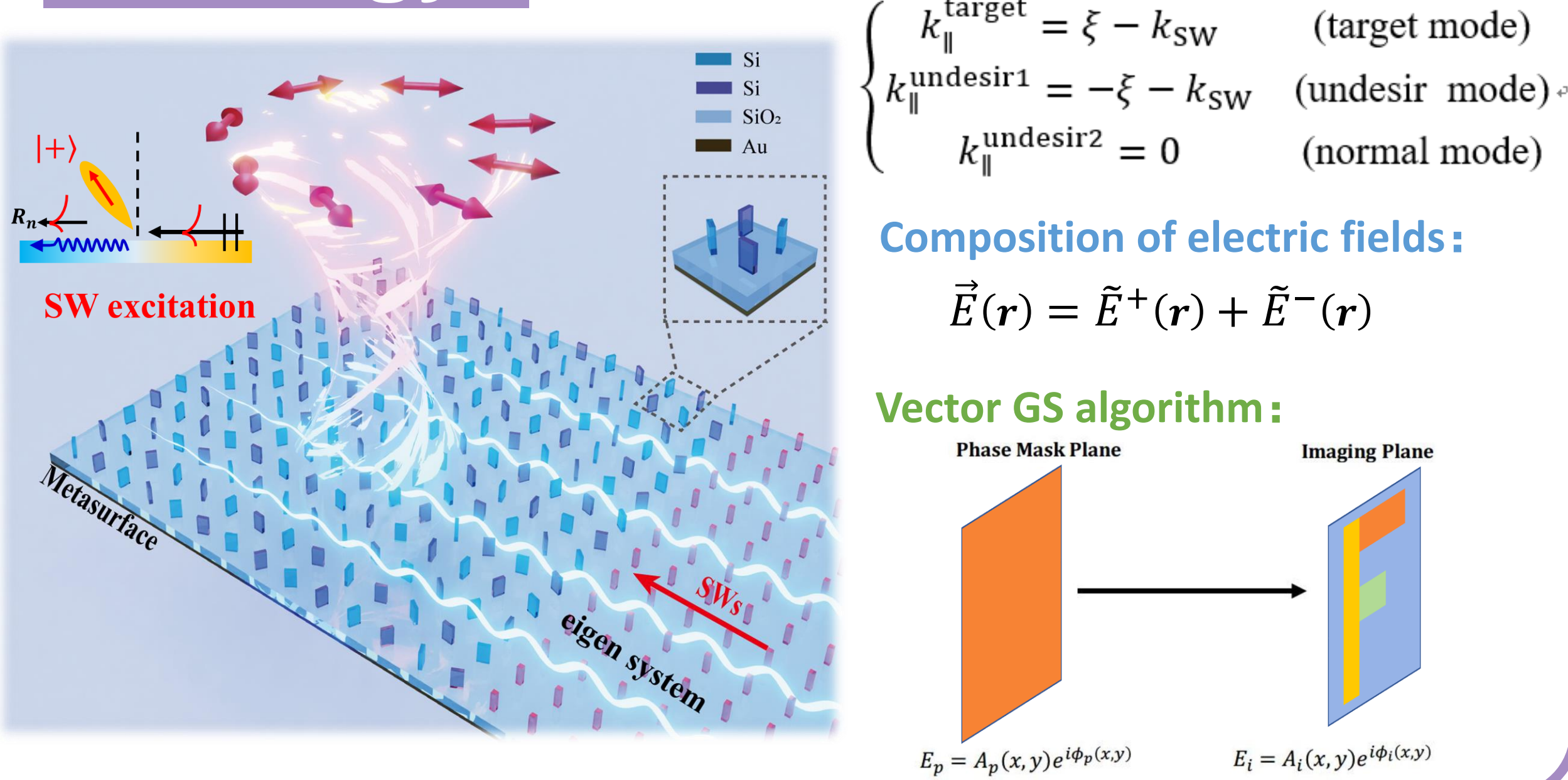
Bosch process



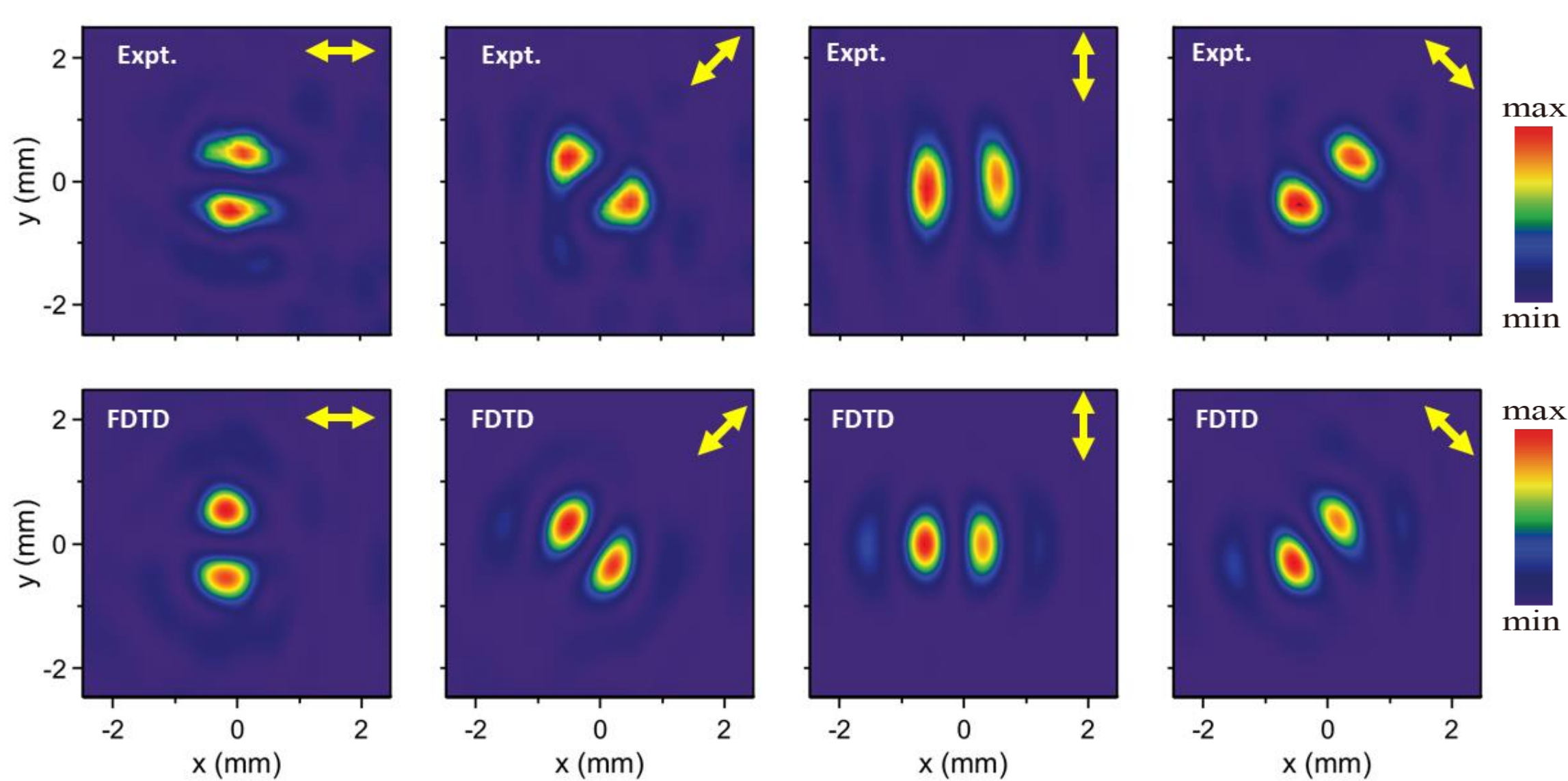
## Vectorial holography



## Strategy



## Vectorial Bessel beam



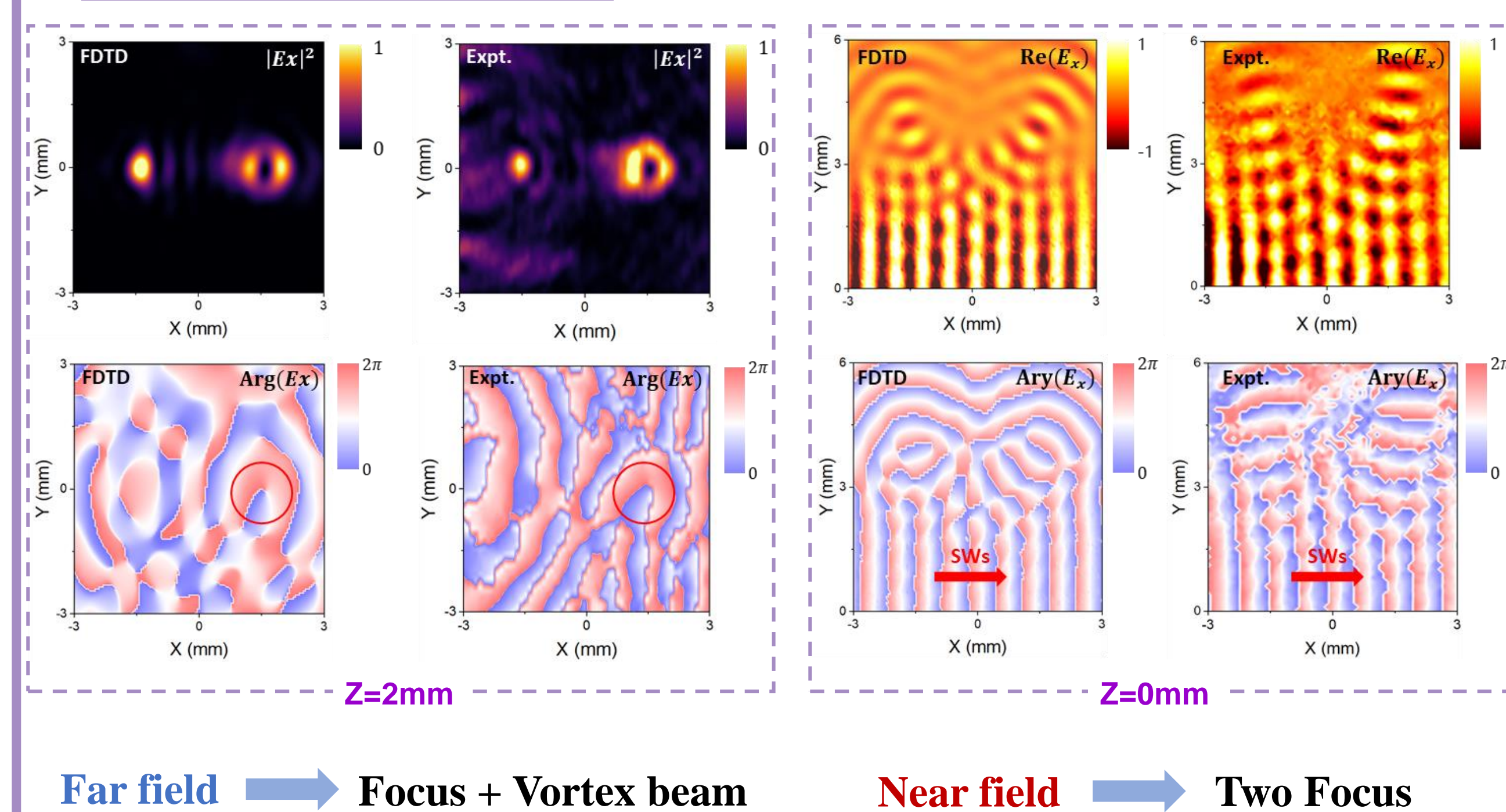
M-th order Bessel equation

$$r^2 \frac{d^2 R}{dr^2} + r \frac{dR}{dr} + (k_p^2 r^2 - m^2) = 0$$

$$\begin{cases} \varphi_+(x, y) = -k_{\text{SW}} \cdot x - k_0 \rho \sin \theta_\rho + \arctan\left(\frac{y}{x}\right) \\ \varphi_-(x, y) = -k_{\text{SW}} \cdot x - k_0 \rho \sin \theta_\rho - \arctan\left(\frac{y}{x}\right) \end{cases}$$

Two metasurfaces are interleaved in a checkerboard pattern to generate two orthogonal beams, which interfere and synthesize to produce a THz vector Bessel beam.

## Bifunctional



## Conclusion

- High-efficiency decoupling from SPPs via on-chip metasurface design
- Full control of amplitude, phase, and polarization
- Experimental realization of a set of vectorial beam metasurface devices
- Dual-function near-field and far-field beam generation
- Ultra-compact platform for arbitrary structured-field generation

Reference:

- [1] Weikang Pan, Zhuo Wang, Yizhen Chen, Xiaoying Zheng, Shiqing Li, Xinzhang Tian, Qiong He, Lei Zhou, and Shulin Sun ACS Photonics 2023 10 (7), 2423-2431.
- [2] Wang Z, Pan WK, He Y et al. Efficient generation of vectorial terahertz beams using surface-wave excited metasurfaces. Opto-Electron Sci 4, 240024 (2025).
- [3] X.Jin, Z.Wang, M.Liu, J.Li, Z.Zhu, Y.Wang, L.Li, Y.Chen, W.Pan, S.Ma, Q.He, L.Zhou, S.Sun, Vectorial Beams With Longitudinally Varying Polarizations Generated by Surface-Wave Metasurfaces. Laser Photonics Rev2025. 19. 2402298.