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# Metasurface Enhanced Lensless Endoscope

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## 1. Main Text

Recent advancements in lensless endoscopes promise non-invasive, in-vivo imaging of biological tissues, particularly within the brain. However, challenges persist in miniaturization and optimizing optical performance, such as improving resolution of the imaging, transmitted power and scanning capabilities. In systems utilizing multicore fibers as probes, beam control at fiber outputs is managed by Spatial Light Modulators (SLMs) from the input, compensating for phase delay and group delay induced inside the fiber cores [1]. However, SLMs impose constraints such as their big size comparing to the fibers and the need for additional bulky optical components like waveplates and lens objectives. Additionally, the efficiency and field of view of SLMs are limited.

Metasurfaces emerge as innovative alternatives for wavefront shaping and polarization control [3]. Integration of metasurfaces with multicore fibers creates a flexible, minimally invasive probe for two-photon endoscopy. Metasurfaces offer precise control over light properties, including amplitude, phase, and polarization, enabling multifunctionality within the endoscope. By replacing SLMs with metasurfaces, phase and group delays can be corrected, polarization controlled, and the overall footprint of the endoscope reduced, as metasurfaces align with the diameter of the optical fiber and their multifunctionality obviates the need for other bulky optics. This convergence of multicore fibers and metasurfaces represents a significant advancement in endoscopic technology, with promising implications for biomedical imaging and clinical applications.

## 3. Funding

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## 4. References

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