

Compact Refractive Adaptive Optics using Deformable Phase Plate Technology

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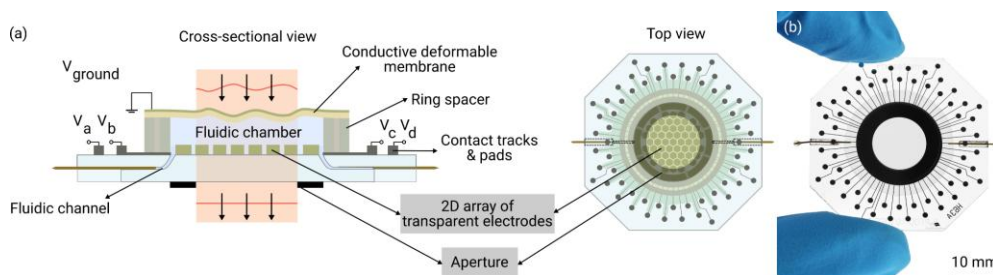
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Adaptive optics (AO) systems play a critical role in compensating for optical aberrations, originally developed for astronomy to mitigate atmospheric turbulence that severely limits the resolution of ground-based telescopes. Recent innovations have extended AO applications to imaging and microscopy, requiring unique approaches to meet the needs of these very different markets.

Phaseform GmbH, a spin-off from the University of Freiburg, Germany, has recently introduced the innovative, Deformable Phase Plate (DPP) technology. DPP is a novel optofluidic refractive wavefront modulator characterized by a sealed, liquid-filled chamber bounded by a flexible polymer membrane. Electrostatic forces generated by transparent electrodes patterned on a rigid substrate dynamically deform the membrane, enabling precise modulation of the optical path length. With its compact form factor (less than 1 mm thick) and fully transmissive nature, the DPP provides real-time dynamic wavefront correction capabilities up to the 7th radial Zernike order, making it a viable refractive complement and alternative to deformable mirrors, particularly for imaging applications.

The key advantages of the DPP technology are its compactness and simplicity, allowing direct integration into optical systems without the need for beam folding or additional relay optics. The refractive and continuous-surface operation ensures high optical efficiency without diffraction losses or polarization changes. It is also compatible with sensorless wavefront estimation methods, which may eliminate the need for traditional wavefront sensors in certain use cases, further simplifying system architecture and reducing implementation costs.

We demonstrate the adaptability and performance of the DPP through several case studies, including life science microscopy, ophthalmology, and neuroscience imaging. Quantitative assessments show improvements of up to 10x in image resolution for retinal imaging. The examples suggest that the DPP technology can effectively address existing implementation barriers and economic constraints, expanding the market for AO beyond traditional use cases. By providing a lower-cost, compact and efficient solution, the DPP opens up new opportunities for the broader scientific and commercial communities seeking advanced AO capabilities in life science microscopy, ophthalmology and neuroscience imaging.



References:

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