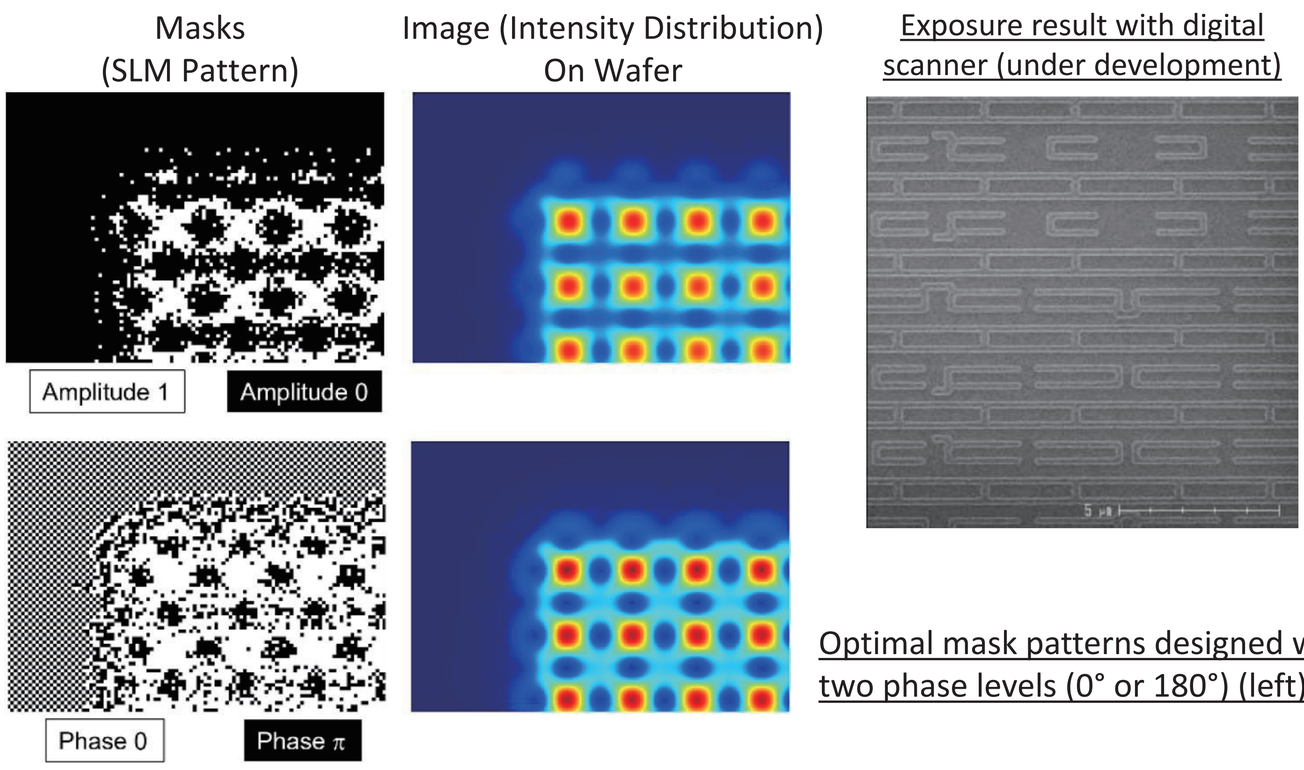
MATSUI LAB.

What will the optical instruments of the future look like?

Department of Fundamental Engineering

Ultra-Precision Optics
Department of Applied Physics, Graduate School of Engineering

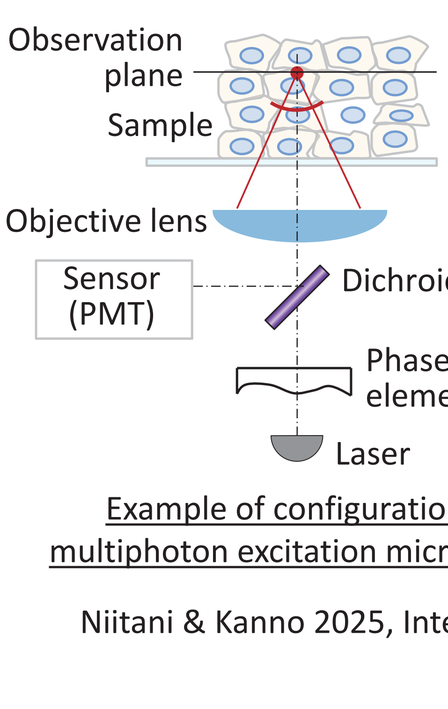
Optical and precision technologies underpin a wide range of products and services in our daily lives, from semiconductor manufacturing and healthcare/life sciences to cameras. With an eye toward the era of Physical AI and quantum technologies, we are pursuing the next generation of optical and precision technologies.



[Future semiconductor manufacturing]
Optimal mask patterns were designed and evaluated for both transmittance and phase modulation, with a focus on identifying modulation schemes suitable for digital scanner under development.
We are also exploring the application of quantum algorithms.

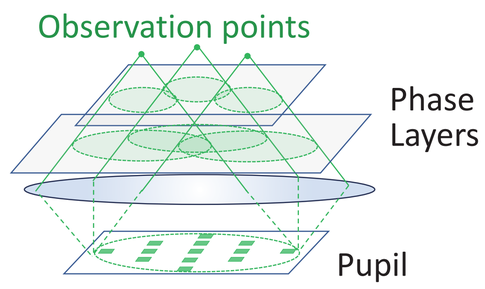
Okudaira, Y. & Yashiki, S. 2020, Proc. SPIE.
Watanabe, Y., et al. 2024, Proc. SPIE.

Optimal mask patterns designed with two transmittance levels (0 or 1) and two phase levels (0° or 180°) (left), and the resulting images (right)



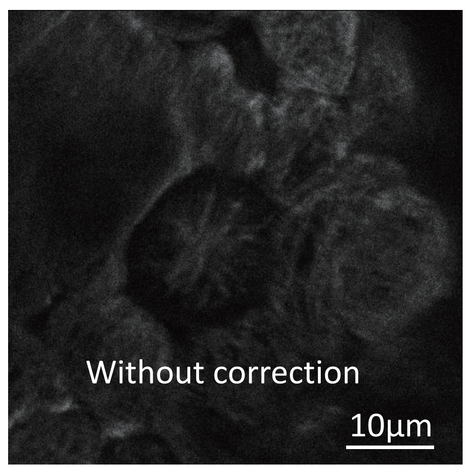
Example of configuration in multiphoton excitation microscopy.

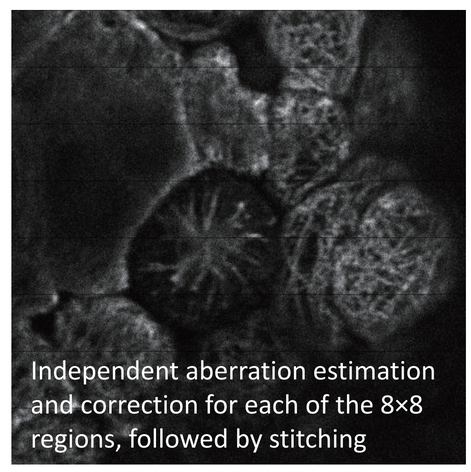
[Future microscope] Field-dependent aberrations were estimated and corrected using a phase-layer model, enabling wide-field deep imaging of biological specimens with complex aberrations.



Phase layer model

Two-photon imaging of tubulin at a 100 µm depth inside a spheroid





Niitani & Kanno 2025, International Day of Light Commemorative Symposium, hosted by the Science Council of Japan.

[Future camera]
A wide-angle lens with a 170° field of view using a metalens was fabricated and evaluated.
Owing to the strong light-bending capability of the metalens, the lens achieved a compact and lightweight design.

Toba, H., et al. 2023, International Optical Design Conference.