Label-free and aberration-corrected endomicroscopic imaging using GRIN lens

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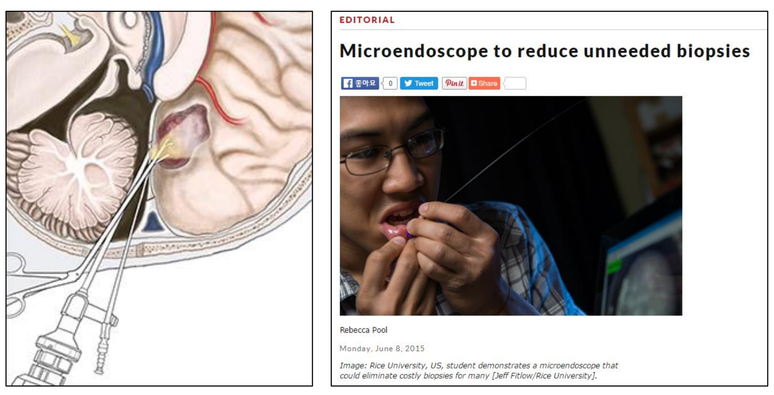
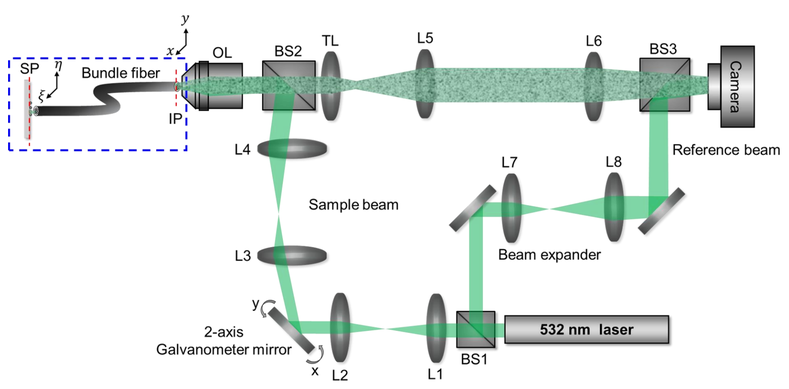
Abstract: The intrinsic aberration of the GRIN lenses makes it hard to obtain high resolution image. Recently, adaptive optics is widely used to correct the aberration, but it requires additional wave-front shaping devices and fluorescent label. Here, we present a label-free and aberration-corrected GRIN lens endomicroscopy. Using our aberration correcting algorithm and complex-field measurement, we can compensate both GRIN lens aberration and sample induced-aberration. Compared with typical GRIN lens-based confocal imaging we obtained higher spatial resolution and image contrast

Introduction: The necessity for microendoscope

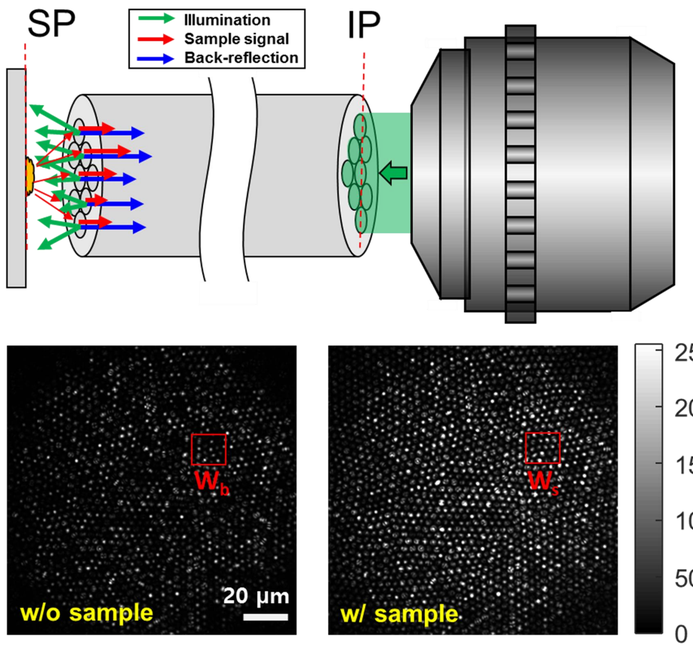


- It is possible to minimally invasive endoscopic imaging
- Microscopic level of spatial resolution

Previous work: Reflectance endoscopic imaging free from back-reflection noise

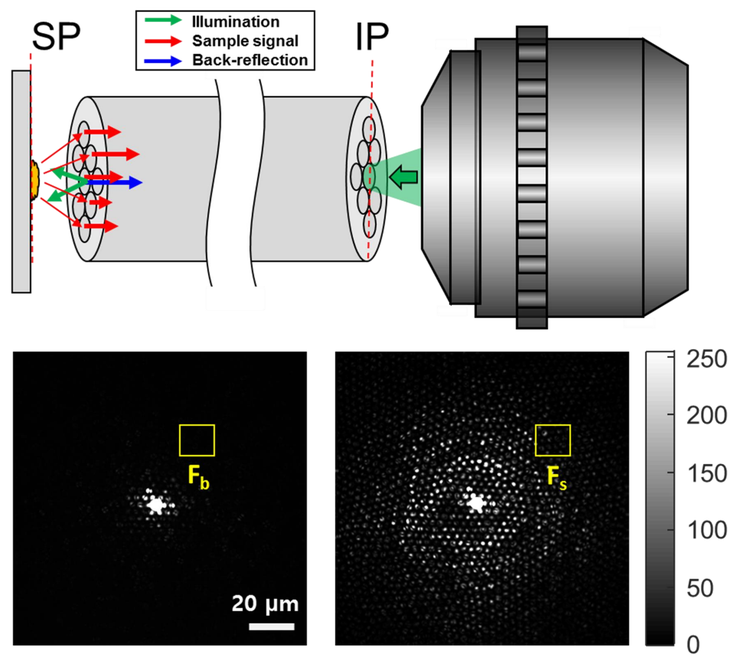


- Interferometric system for complex field measurement
- 2- axis galvanometer mirror scan the focused beam for sample illumination



- Signal to back-reflection ratio $\frac{W_s}{W_b} < 2$

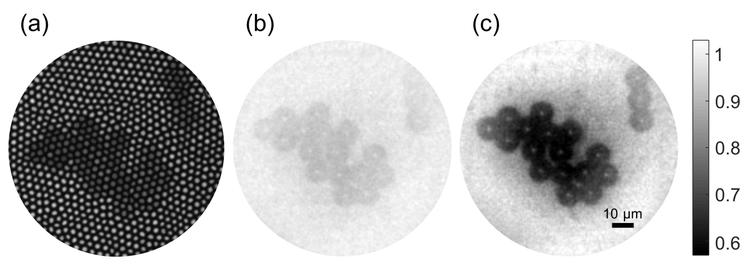
Single-core illumination and wide-field detection



- Single-core illumination and wide-field detection (SIWD)
- Signal to back reflection ratio $\frac{F_s}{F_b} > 10$

- The strong reflection from the surface of a probe spoils the image contrast
- Using an image bundle fiber, we can separate the illumination fiber and detection fiber

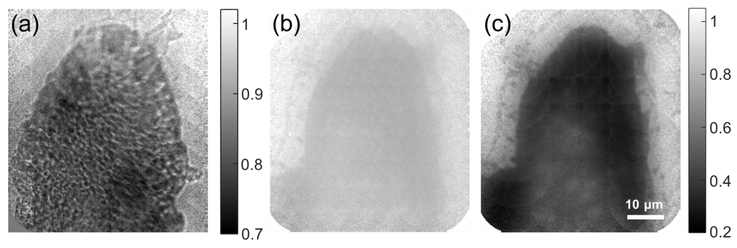
Results



(a) LED epi-illumination, the beads are on the surface of the fiber

(b) Reconstructed image, the beads are 100 μm from the distal end. (WIWD)

(c) With the SIWD method



Ex vivo imaging of a small villus of a rat intestine
(a) WIWD in oil (b) WIWD in air (c) SIWD in air
SNR of SIWD is 3.2 times better than the WIWD method

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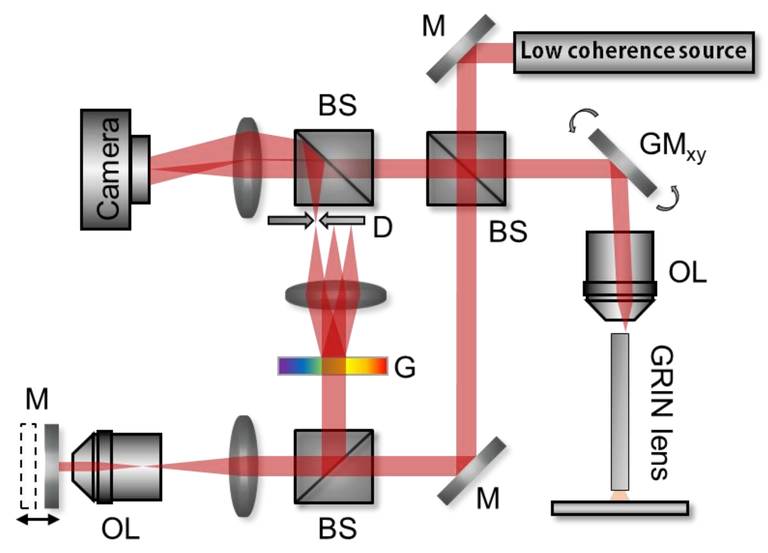
High-resolution endomicroscopy using GRIN lens

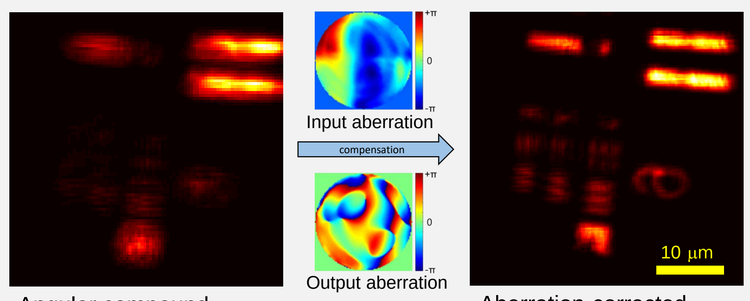
- The inherent aberration of GRIN lens degrades spatial resolution
- To obtain high-resolution imaging, the aberration has to be corrected
- The CLASS algorithm will be used to correct the aberration

Experimental Setup



- Off-axis interferometry for complex-field measurement
- High NA GRIN lens (0.8 NA)
- Low coherence laser for time-gated detection

Results



Angular compound intensity image

Aberration-corrected intensity image

- Using aberration-correction algorithm, we can obtain the clearer image through GRIN lens

Summary

- We explored endoscopic imaging using GRIN lens
- By using aberration-correction algorithm, we can compensate the aberration of the GRIN lens

Reference

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[3] Youngwoon Choi, Changhyeong Yoon, Moonseok Kim, Taeseok Daniel Yang, Christopher Fang-Yen, Ramacandra R. Dasari, Kyoung Jin Lee, and Wonshik Choi, "Scanner-Free and Wide-field Endomicroscopic imaging by Using a Single Multimode Optical Fiber", Phys.Rev.Lett. **109**, 203901 (2012)