PHOTONIC INTEGRATED CIRCUITS FOR SUPER-RESOLUTION OPTICAL MICROSCOPY

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KEY WORDS: TIRF, *d*STORM, SIM, fluctuation microscopy, integrated optics, waveguides

The evanescent field on the surface of photonic waveguides can be utilized for total internal reflection fluorescence (TIRF) imaging. Making use of high refractive index contrast materials such as Si_3N_4 or Ta_2O_5 on SiO_2 can create high energy density fields of ca. 200 nm penetration depth at arbitrary excitation areas while being compatible as substrates for live cell imaging [1]. Compared to the conventional, objective-based TIRF setups, the chip-based approach offers easy multiplexing by adjustment-free switching of excitation wavelengths, large field-of-view imaging through decoupling of excitation and collection optics, telecom device compatibility for fast circuit switches, among other advantages.

Beyond diffraction limited imaging, different super-resolution techniques have been implemented on the chip platform. The high effective refractive index of the guided mode (e.g., $n_{eff} = 1.7$) inside the waveguide offers higher spatial frequencies than possible with objective-based, far-field approaches, which can push the achievable resolution beyond the possibilities of standard implementations. Chip-based *direct* stochastic optical reconstruction microscopy (*d*STORM) has been demonstrated, achieving unprecedented large field of view [2, 3]. By shifting the interference fringes of multimode waveguides, the excitation intensity can be modulated for fluctuation-based techniques such as ESI or SOFI [2]. When counter propagating waveguides, high frequency sinusoidal illumination can be utilized for chip-based structured illumination microscopy (SIM). Isotropic resolution enhancement for chip-SIM is achieved through different waveguide arms providing a rotation of the interference angle, with phase stepping which can be performed on- or off-chip [4].

The developments so far should be seen as the first steps of this technology. There is much to be explored within chip-based imaging, where retrofitting possibilities to conventional microscopes provide the potential towards a paradigm shift in super-resolution optical microscopy.

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