Three-dimensional Nonlinear Imaging Using a 3D MEMS Enabled Compact Fibre Endoscope

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Recently, fibre-optical nonlinear endoscopy has been increasingly attractive for early recognition and diagnostics of gastrointestinal tract cancers due to the non-invasive, flexible and miniaturised feature. To reduce the volume of the system, several miniaturised scanning mechanisms have been employed, including a two-dimensional (2D) microelectromechanical system (MEMS) mirror [1] and a PZT actuator. However, these scanning devices only perform on one dimension or two dimensions. To achieve a three-dimensional (3D) imaging, another scanner such as a bulk one-dimensional (1D) scanning stage or an actuator is usually used to move samples axially which seriously obstructs the system size reduction and simplification. To overcome this disadvantage, a 3D MEMS mirror is applied for the 3D scanning in this paper. Figure 1 is the experimental setup for a 3D MEMS enabled fibre endoscope. A double-clad photonic crystal fibre (DC-PCF) is one of the key components for a compact endoscope because it has a large core for single-mode delivery of excitation laser beam and a large inner cladding with a high numerical aperture (NA) for efficient signal collection at separate wavelengths. To examine the effectiveness of the miniaturised endoscopic system, two-photon fluorescence images of 10 µm microspheres in three dimensions have been obtained at a laser excitation wavelength of 800 nm with a repetition rate of 80 MHz and a pulse width of 80 fs (Spectra Physics, Maitai).

Fig. 1. Experimental Setup for 3D nonlinear imaging. ND: neural density filter; DCM: dichroic mirror; CO: coupling objective; DC-PCF: double-clad photonic crystal fibre; PC: processing computer; BF: band pass filter; PMT: photomultiplier tube; GRIN: gradient index. The endoscope uses a small probe with a 3D MEMS mirror and a GRIN lens in it as indicated by a green dashed frame.

References: