DESIGNING FIBRE PROBES FOR BRILLOUIN ENDOSCOPY

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Brillouin imaging allows assessing viscoelastic properties of tissues and cells with diffraction limited resolution in a label-free, non-contact and non-invasive way. It is based on the principle of inelastic scattering of light by thermally activated acoustic vibrations, first described in the beginning of 20th century [1-2]. However, it was not until the end of the last century, that the technology required for fast-acquisition and high-resolution measurements of gigahertz Brillouin signals became available in the form of a virtual-image phase-array (VIPA) dispersive device [3] at the heart of the spectrometer. Optimised VIPA spectrometers for narrow-bandwidth and high extinction ratio helped to revolutionise the field of Brillouin microscopy, enabling the probing of micromechanical properties in biological tissues [4], individual collagen and elastin fibres [5], whole cells and cellular components [6].

Most efforts in Brillouin imaging to date have focused on improvements to the detection, such as increasing the Brillouin signal over the noise background or suppressing the elastic Rayleigh component of the scattered signal in order to reduce the undesired cross-talk [7]. The distal end of the instrument has so far utilised traditional microscope construction methods using lenses and mirrors, ofte with the confocal detection [4, 6]. It is, however, clear that in order to translate the technique of Brillouin imaging from the laboratory environment to clinical use for *in vivo* and *in situ* applications, drastic changes to the distal end are required. In particular, the delivery of the illumination light and the collection of the scattered light need to be achieved by means of flexible and miniature fibre probes replacing current bulky setups that are limited in scalability and prone to misalignment.

In this work we demonstrate the first fibre-integrated Brillouin spectroscope, based on fibre-optic probes for light delivery and collection. We show how the endoscope can be constructed out of two single-mode optical fibres and a fibre graded-index (GRIN) lens, achieving robust measurements of Brillouin signals in liquid samples (water, ethanol, glycerol). We then discuss the theoretical model that enables the calculation of the collection efficiency of the scattered light by our Brillouin fibre probes and how to optimise this efficiency using Fourier analysis. We also highlight the role of photonic technologies such as photonic lanterns [7] and direct microfabrication techniques for complex fibre lens systems that will advance the field of endoscopy and fibre-assisted imaging.

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