Summary
A novel miniaturised laser scanning confocal/multiphoton endomicroscope enables depth resolved imaging via an endoscope that can be significantly less than 1 mm in diameter. By utilising spatial light modulator technology and a multicore optic fibre bundle, it can focus and scan a laser beam without the need for any distal components including objective lens or scanner.

Background
Laser scanning confocal and multiphoton endomicroscopes can offer significant advantages over conventional video or optical wide-field endoscopes, which may include optical sectioning (and therefore subsurface and 3-D imaging), superior image contrast and spatial resolution. Multiphoton excitation is of particular interest for imaging tissue autofluorescence, which may provide label-free contrast to diagnose cancer and other diseases. The use of ultrashort-pulsed excitation laser pulses also enables fluorescence lifetime imaging (FLIM).

Several limitations restrict current endoscopes from being used for confocal or multiphoton endomicroscopy: the physical size of device required to implement distal scanning (typically >3 mm), unwanted background fluorescence in the optical fibres when using radiation appropriate for (single photon) excitation of tissue autofluorescence and unwanted nonlinear optical effects when transmitting ultrashort pulses in single mode optical fibres for multiphoton excitation.

Technology
A team at Imperial College London led by Professor Paul French developed the miniature laser scanning endomicroscopes. The key features of this technology are:

- Exploits adaptive optics implemented with spatially coherent illumination and a spatial light phase modulator (SLPM) at the proximal end of an imaging optical fibre bundle.
- The technology and IP is also applicable to endoscopes based on multimode optical fibres.
- The approach leads to lower intensities in the optical fibre cores, thereby reducing nonlinear optical effects.
- To date the team have demonstrated that this generic endoscope concept can be implemented using only proximal phase measurements and that phase variations due to motion (e.g. bending) of the endoscope fibre can be dynamically compensated.

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Applications
This technology should make it possible to develop thinner and more flexible confocal or multiphoton endomicroscopes, which will be able to pass through thinner cavities or vessels. This could increase the utility of clinical endoscopy for diagnostic imaging and monitoring minimally invasive surgical intervention and can enable new applications for preclinical imaging in small disease models.

Market
The global endoscopy market is expected to expand at a compound annual growth rate (CAGR) of 6.9% and reach USD $9.7 billion by 2021. The most promising areas of growth include colonoscopy, gastroscopy and cystoscopy, where there has been significant focus on pipeline development due to increasing patient population and awareness.

Team
• Professor Paul French: Vice Dean (Research) for the Faculty of Natural Sciences at Imperial College London
• Dr. Chris Dunsby: Reader in Biomedical Optics in the Faculty of Natural Sciences at Imperial College London
• Professor Mark Neil: Professor of Photonics in the Faculty of Natural Sciences at Imperial College London
• Dr. Carl Paterson: Reader in Physics in the Faculty of Natural Sciences at Imperial College London

Intellectual Property
The technology is protected by International Patent Application (PCT/GB2009/001725) and its protection extends to the USA (13/003387) and Europe (09784.4).

Relevant publications
