MICROMACHINING OF INTEGRATED OPTICAL CIRCUITS

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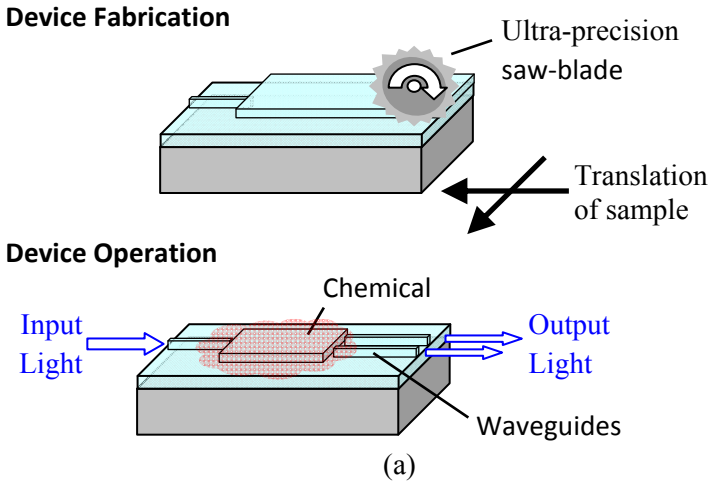
The presented work describes a revolutionary new technique for fabricating optical waveguide devices through ultra-precision micromachining. The novel fabrication technique offers a new avenue of optical material processing, allowing rapid prototyping of miniaturised health care diagnostic systems.

Optical waveguides are widely used for telecommunications and medical applications such as endoscopes and medical diagnostic systems [1]. Integrated optical (IO) waveguides have the benefit of miniaturisation, performance enhancement and usability. The techniques used to fabricate IO circuits largely derive from the microelectronics industry and generally involve photolithography and etching processes, which are time intensive, lack design flexibility, have two-dimensional design limitations and are inherently unsuitable for rapid prototyping. The presented work highlights a revolutionary new way of fabricating IO circuits using a computer controlled ultra-precision micromachining process, illustrated in Figure 1 (a). The technique literally cuts physical relief structures that can be less than 1/10th the thickness of a human hair (~10 μm) into optical materials, illustrated in Figure 1 (b). The technique allows the fabrication of ridges, channels and V-grooves while simultaneously offering well defined sidewalls with an optical quality finish. Micromachining gives the freedom from expense and time investment associated with photolithography and etching, whilst allowing rapid prototyping and the potential of three-dimension structure fabrication.



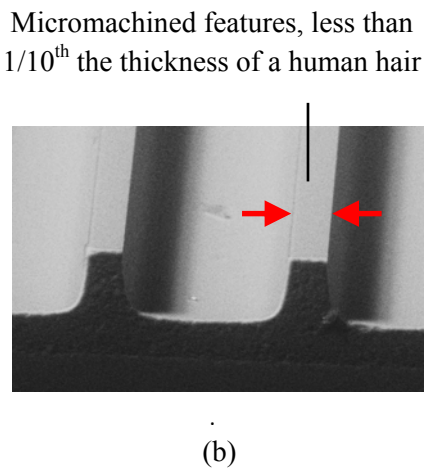


Figure 1 Schematic depicting (a) ultra-precision micromachined fabrication process and (b) an electron-microscope image of a micromachined integrated optical chip

The micromachined structures presented can achieve a side wall surface roughness (Ra) of 9 nm, which is a high quality surface finish required for IO device operation. The micromachining research being developed to fabricate IO circuits is a unique concept that is being led by researchers in the UK. This work is funded by the UK Engineering and Physical Sciences Research Council (EPSRC) and offers a whole new approach to integrated optics.

Micromachined optical circuits display potential application as medical diagnostic devices, for example the chips could be used to asses the health of the elderly in real time by incorporating them seamlessly into their everyday lives. Such sensors could form part of a smart toothbrush system that automatically looks for markers for dehydration, anaemia or malnutrition.

[1] F. Baldini, A.N. Chester, J. Homola, S. Martellucci, 'Optical Chemical Sensors', Springer, Dordrecht (2004)