Fusion splicing of silicon optical fibres

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Abstract: The first splicing experiments between silicon optical fibres (SOFs) and conventional fibres are investigated. An optimized fusion splicing approach for a polycrystalline SOF is demonstrated and the material properties after splicing are characterized.
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Silicon optical fibres (SOFs) have many important potential applications such as functional optoelectronic devices and all-fibre nonlinear photonics [1-2]. Compared to planar silicon devices, they have the unique advantage of being geometrically matched to standard optical fibres and, thus, offer the potential to be fully integrated into existing networks. To take full of advantage of this, it is important to develop a means of splicing SOFs with conventional fibres to produce robust all-fibre structures and devices. However, so far, there has been no reported success in this area as the challenges of splicing two fibres with distinctly different core materials has proven problematic.

The polycrystalline SOFs (p-SOFs) used in this work are fabricated using a modified fibre draw process, a technique that can produce long lengths of low-loss crystalline silicon in the core [3]. In this paper, we present a method of splicing a p-SOF with a single mode fibre SMF28 using a commercially available Ericson fusion splicer. To ensure that the silicon does not distort during the splicing process, it is important that the fusion temperature is kept relatively low [4]. The p-SOF we used had a core diameter of 8.5 µm, and a cladding diameter of ~125 µm (Fig.1(a, b)). Using optimized splicing parameters, we could robustly splice the p-SOF to the SMF-28 without distorting the silicon core (Fig. 1(a)). Example parameters for the process are a fusion time of 0.3 s, a fusion current of 12 mA, an overlap of 5 µm and an offset of 50 µm. Fig. 1(c) shows a comparison between the back reflection measured when light is launched down a bare SMF and when the SOF is spliced to the end. Owing to the high refractive index of silicon, there is a significant increase in the reflection from the spliced joint, indicating that the core is well aligned and not distorted after the splice procedure. The estimated loss at the fusion joint is ~1.9 dB which includes the reflection of ~0.9 dB at the silicon/silica interface. Finally, we note that there is only a minimal change of the Raman spectrum from the polycrystalline core after splicing, as shown in Fig. 1(d), which confirms that the material quality has not deteriorated during the splicing process.

We believe that our initial splicing approach will accelerate the integration of semiconductor fibre photonics. To further reduce the high reflection loss from the ends of the SOF and improve the mode-matching, a designed tapering-core structure of the SOF could be used in future investigations.

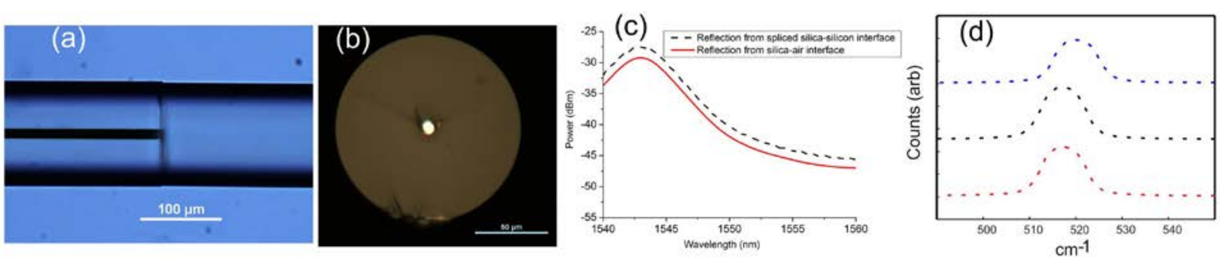

Fig. 1 Images of (a) the fusion splicing joint and (b) the cross-section of the p-SOF. (c) The measured back reflection from the splicing interface. (d) The Raman spectra: standard single crystalline silicon wafer (4.07 cm^{-1},blue), p-silicon (4.34 cm^{-1}, red), and p-silicon after splicing (4.53 cm^{-1}, black).

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