SEMICONDUCTOR FIBRE DEVICES FOR NONLINEAR PHOTONICS

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A number of technologies are starting to emerge which bring new functionality to optical fibres. In particular, fibres that offer improved nonlinear performance are currently receiving much attention for use in all-optical signal processing. The underlying principles of this field allow for the manipulation of signals carried by light at speeds and capacities far beyond the abilities of electronic systems. Although conventional silica optical fibres have already been demonstrated for applications such as regeneration, switching, and encoding/decoding of information carried in light form, long fibre lengths and high power levels are typically required. New fibre materials that exhibit enhanced nonlinear properties would not only allow for reduced device lengths and lower energy consumption, but they could also be chosen to extend the transmission window beyond that of silica for a wider range of applications. To this end, a new class of fibre that incorporates semiconductor materials into the core was proposed and demonstrated in 2006. Importantly, the ability to intricately control both the optical and electronic properties of semiconductor materials has led to semiconductor photonics becoming one of the largest growing areas of research in recent years. In this poster I will describe my research on the characterization of these semiconductor core fibres with the aim to developing all-optical nonlinear photonic devices.

The semiconductor optical fibres used in this research are fabricated using a high pressure chemical deposition technique. This technique is extremely flexible so that fibres can be readily fabricated to have a range of core sizes with different semiconductor materials, including silicon and germanium which are commonly used in optoelectronic devices on-chip. Characterization of the fibres involves measuring material composition, crystallinity, optical transparency as well as the strength of the nonlinearity. This information can then be used to simulate the propagation of light in the fibres which can be used for the design of the semiconductor fibre devices. Through the continued optimization of the deposited materials and fibre designs we have provided the first demonstration of nonlinear optical transmission in a silicon core fibre for use in optical switching and signal regeneration. Importantly, this work led to the development of an all-optical silicon fibre modulator which operated on a femtosecond (10^{-15} s) timescale, far higher than what has previously been reported and without the need for any active electronics. The simplicity of this modulator which allows for seamless integration into an all-fibre network is illustrated in Fig. 1. However, due to its ultra-fast performance, conventional instruments could not be employed to determine the performance so that new techniques had to be developed. While the silicon fibre devices work well within the telecom wavelength bands, both silicon and germanium have very broad transmission windows and our fibres have also been shown to have low losses extending into the mid-infrared (above 2µm). The generation and processing of light within this wavelength band has a promising future for high power medical applications that require the ablation of certain tissues and sensing applications due to the strong chemical resonances in this regime.

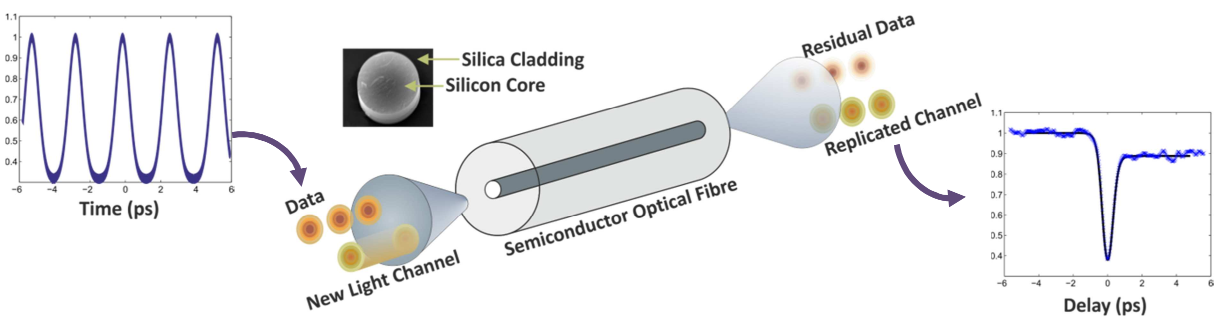

Figure 1. Implementation of a semiconductor optical fibre for use with all-optical modulation and all-optical wavelength switching. Inset shows a high resolution image of the fibre end face.