FIBER-BASED SEMICONDUCTOR RESONATORS FOR NONLINEAR PHOTONICS

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The escalation of global communication traffic has intensified the need for faster data processing techniques and systems. A combination of excessive browsing and downloading from of the world-wide web and high definition television technologies necessitates a replacement of today's electronic-based data processing with all-optical systems. The light signal, which is carried within thin strands of optical fibre, will be manipulated at speeds and capacities far beyond the capability of existing electronics without the signal having to leave the transmitting fibre. To date, signal regeneration, switching, and encoding/decoding of information have all been demonstrated in conventional silica-based optical fibres. However, the long fibre lengths and high powers necessary to achieve this represent a significant drawback. In order to realize efficient, compact and ultrafast data processing schemes with low energy consumption new fibres will have to be fabricated that incorporate enhanced material functionalities such as high nonlinearities. A recent and promising new fibre platform that incorporates semiconductor materials into the core of a silica glass cladding has opened a route to realize this goal. In this poster, I will describe my research on the demonstration of all-optical signal processing in micron-sized resonators fabricated from silicon core optical fibres.

Microresonators made from highly nonlinear silicon materials (x100 the nonlinearity of silica) that have small mode volumes and high quality factors are ideal systems for use in low-threshold all-optical processing. By etching the cladding away from a 6 μm diameter silicon core fibre we have fabricated a pure silicon fibre-based resonator and demonstrated its use for all-optical switching on picosecond (10^{-12} s) timescales at pump energies that are less than a picojoule. This switching threshold is an order of magnitude lower than what has been reported for silica fibre-based resonators, highlighting the potential power saving benefits of this material platform. Fig. 1 illustrates the simplicity of our switching scheme. In an attempt to further improve the device performance, more recently we have been working on shaping the resonators and making use of the ultra-smooth silica cladding to increase the quality factor by up to an order of magnitude. This has resulted in the observation of nonlinear switching on an even faster femtosecond (10^{-15} s) response time. In conclusion, these results represent a step towards the development of compact, high speed and low-power silicon fibre-based photonics technologies. In the wider perspective, we strongly believe that silicon fibre-based resonators will allow more fundamental investigations of low threshold nonlinear light-matter interactions in the areas of biosensing and life sciences.

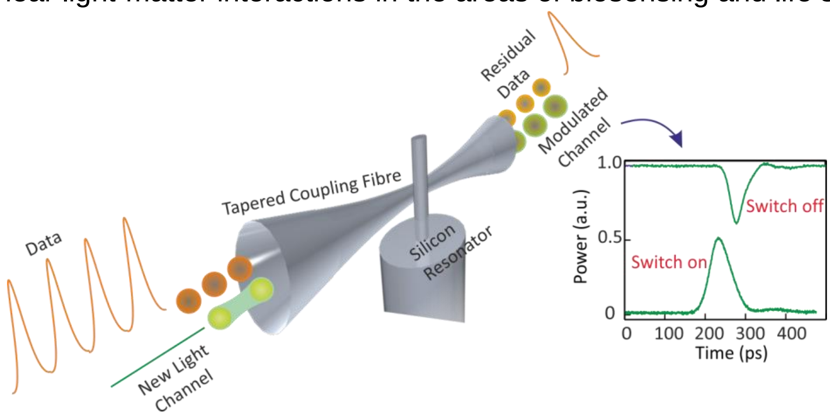

Fig. 1. Implementation of a semiconductor resonator for use of all-optical wavelength switching.