Broadband all-optical fiber transistors

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The fundamental building block of modern electronic computing; junction field effect transistors, are essentially voltage controlled resistance based switches, which operate on the basis that electric charge flows through a semiconducting channel between "source" and "drain" terminals. By applying a reverse bias voltage to a "gate" terminal, the channel is "pinched", so that the electric current is impeded. Here, we demonstrate the optical analogue of such devices relying on photoinduced effects within chalcogenide fibers. As a proof of principle, using the optical fiber as the channel, we demonstrate both single and multiwavelength operation in the visible part of the spectrum, essential to such a device for future realisation of all-optical logic gates. Furthermore, we go on to integrate these class of transistors with the silica based industry standard erbium doped fiber amplifiers (EDFA), showing higher gain operation at $\lambda = 1.5\mu m$ **(Figure 1)**.

Recently, the prospect of realising an optical transistor has energised the photonic community to search for different implementations of this class of fundamental information processing devices. Proposed devices thus far have included the utilisation of cesium gas in ultra-low temperatures as well as optomechanically-induced transparency in micro-disk resonators [1, 2]. We propose that the implementation of such a device using chalcogenide fibers, taking advantage of photodarkening inherent to their material properties, would open up room temperature operation from visible to mid-infrared for a variety of applications.

During illumination with near or sub-bandgap light, a shift in the optical absorption edge produces transient effects commonly known as photodarkening, within sulphide and sulphide/silica based fibers [3]. While the transient changes decay upon switching off the illumination, the rate of recovery depends on photonic or thermal annealing induced within such materials. This enables many different applications in all-optical modulation for telecommunication, switching and sensing in future photonic computing paradigms [4,5].

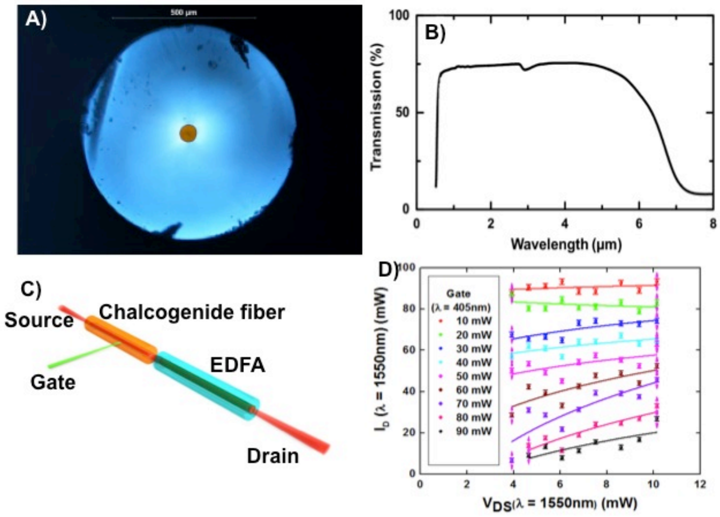

Fig. 1 **A) Optical microscopy image of the chalcogenide Gallium lanthanum sulphide (GLS) core/silica clad optical fiber. B) Transmission window of GLS. C) Schematic of optical fiber transistor. D) I_D,V_{DS} characteristic of optical transistor configured for $\lambda = 1.5\mu m$ operation.**

Chalcogenide fiber optic transistors taking advantage of nonlinear photoinduced effects allow in-line fiber information processing which reduces the bottleneck in electro-optic modulation observed within current fiber networks. Furthermore, the reliance on material properties enables scaling of such transistor technology using nanowires and pure or hybrid chalcogenide based waveguides, to realise room-temperature broadband all-optical transistors from microfiber scale to nanowires within a mass-manufacturable material platform.

References

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