High-performance Low-loss Fibre Polarizer Based on Graphene and PVB

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Graphene has exceptional electronic transport and photonic properties [1, 2] and as a result this 'wonder material' is steadily finding wide-ranging applications in optoelectronic technologies. Although in the short time since its discovery much of the focus has been on its use for electrical devices, more recently a number of graphene-based photonic devices have been demonstrated, including graphene polarizers and electro-absorption based modulators [2, 3]. In this paper, we present a high-performance low-loss broadband fibre polarizer. Previous iterations of such a device require that the optical fibre is polished into the core to provide the required strength of interaction between the graphene sheet and the propagating electromagnetic field, see Fig. 1a [3]. The penalty for this extent of polishing is large device loss (20 dB, at 1550 nm [3]), which has prevented this type of polarizer from becoming a major disruptive technology. With this in mind, we present the first steps towards producing a low-loss in-fibre graphene based polarizer by polishing the fibre close to, but not into, the core. Additional cladding between the fibre core and the graphene sheet reduces the propagation losses but, unfortunately, also decreases the polarizer's extinction ratio. To address this, we spin coat a polyvinyl butyral (PVB) over-layer onto the graphene which as well as acting as a protective layer, also serves to increase its interaction with the electromagnetic field. A cross-section of the device is shown in Fig. 1b.

The fibre polarizer is fabricated by side-polished an optical fibre to a distance of 1 μm from the core. The resulting fibre has no transmission loss with an air cladding and more than 30 dB loss when a liquid with a refractive index of 1.464 is dropped onto the polished surface. A graphene film grown by a chemical vapour deposition (CVD) method using copper as a substrate is covered with a thin PVB layer. The copper is then etched away in an ammonium persulfate solution and the PVB coated graphene film is transferred onto the side-polished fibre's planar surface, covering a length of 2 mm. The polarization extinction ratio at near-infrared wavelengths was measured using a polarized Tunics laser source (tuneable from 1425 nm to 1600 nm). At a wavelength of 1550 nm an extinction ratio of 26.2 dB was measured, as shown in Fig. 1c. The maximum output light which is -6.8±0.5 dBm occurred at polarization angles $\theta = 0^{\circ}$ and 180°, while the minimum value of -33±0.5 dBm appeared at polarization angles $\theta = 90^{\circ}$ and 270°, providing evidence of the s-polarized nature of the transmitted light. The transmission loss of the fibre polarizer is less than 2 dB, which is almost 2 orders of magnitude less than any previous graphene based fibre polarizer [3]. Additional polarization measurements were also undertaken across the full wavelength range of our tuneable laser source and at each wavelength the extinction ratio did not drop below -30±5 dB (Fig. 1d). These results provide clear evidence of the broadband nature of our device, a significant improvement on previously reported results. Finally, we note that as the PVB layer is transparent out to 2300 nm, thus, we anticipate this device will yield a high extinction ratio across the entire transmission window of the silica fibre.

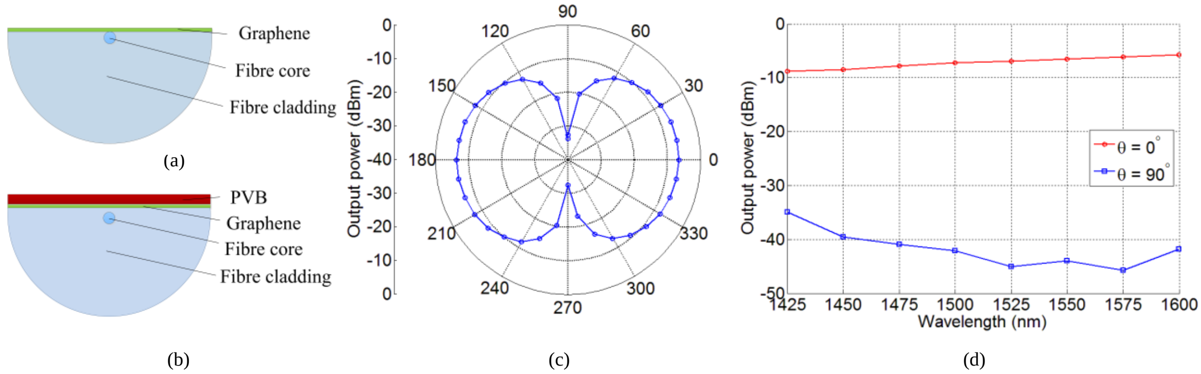

Fig. 1 (a) Cross-section of a typical fibre polarizer based on Graphene [1]. (b) Cross-section of the fibre polarizer designed in this experiment. (c) Polar plot of output power measured at 1550 nm when input is 0dBm. (d) Polarization measurements conducted at $\theta = 0^{\circ}$and $\theta = 90^{\circ}$ in the wavelength range 1425–1600 nm.

References

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