Low power resettable optical fuse based on the amorphous silicon ARROW fiber

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Abstract: We present a silicon antiresonance reflecting optical (ARROW) fiber that has power dependent transmission properties. When the throughput power exceeds a nominal value the transmission band structure closes and the fiber can no longer transmit light.

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1. Introduction

The fiber optic fuse is the optical analogue of the electric fuse, it is a passive component designed to protect expensive and sensitive equipment from becoming damaged during power spikes and surges. Surprisingly, it was not until 2004 that Molex Inc. made the first fiber optic fuse commercially available. Their component is based on a glass strand being placed in the optical path that fails once a given power threshold is reached, typically in the order of watts. In this paper we present an alternative approach based on optical absorption bandgap modulation of a silicon ARROW fiber. The silicon ARROW fiber is fabricated by depositing a-Si:H into the capillary holes of a photonic crystal fiber (PCF) template, using the method described in Ref. [1]. Depositing the material in this manner is advantageous as one can control the silicon's absorption characteristics, and hence the fuse threshold, by controlling the hydrogen content. Figure 1(a) shows an SEM image of the template PCF and Fig. 1(b) shows the resulting silicon ARROW fiber, which confirms the inclusion of the silicon rods. These rods have a large thermo-optic coefficient, 2.3×10^{-4} K^{-1}, and through preferential absorption at one end of the fiber their refractive index can be increased sufficiently to red shift the transmission bandgap in this region, which has the effect of narrowing and eventually closing the fiber's band structure. Using this effect, the proposed device can disrupt optical transmission at relatively low power thresholds and resume transmission once the power is reduced below this level.

An example of the band structure disruption is given in given in Fig. 1(c), where the transmission band is plotted for a number of absorbed powers. In this case the fiber was pumped with a 980 nm CW diode while the band structure was mapped to easily demonstrate the effect. In Fig. 1(d) we show the transmission as a function of input power at 1550 nm which illustrates the device's performance as an optical fuse, limiting the throughput power to 1,2 mW, the insertion loss of the fiber is estimated to be ~ 2dB.

Using rigorous characterization techniques we will demonstrate further benefits of the device, including fast 'burn out' speeds and negligible back reflections on 'failure'.

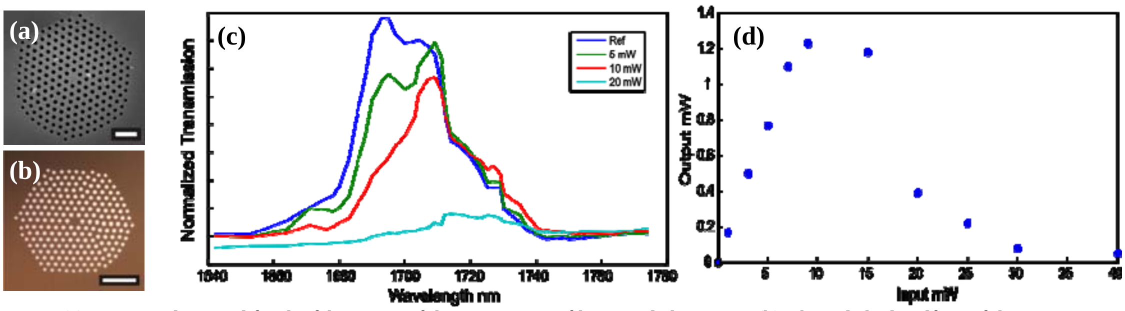

Fig. 1. (a) PCF template used for the fabrication of the Si-ARROW fibers, scale bar 5 µm. (b) The polished endface of the Si-ARROW fiber, scale bar 10 µm. (c) Bandgap disruption through optical absorption. (c) Demonstration of the optical fuse.

2. References

[1] N. Healy, J. R. Sparks, R. R. He, P. J. A. Sazio, J. V. Badding, and A. C. Peacock, "High index contrast semiconductor ARROW and hybrid ARROW fibers," Opt. Express **19**, 10979-10985 (2011) . http://www.opticsinfobase.org/oe/abstract.cfm?URI=oe-19-11-10979