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High reflectivity photorefractive Bragg gratings in germania-free optical fibres

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Abstract

We present the first report of Bragg gratings with reflectivities exceeding 99% written in germania-free optical fibres by UV exposure. This result has important implications for the production of ultrashort single-frequency fibre lasers.

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Photorefractive gratings in optical fibres are emerging as a key technology for a wide range of applications, such as fibre lasers, optical filtering and sensing. To date, most of the work on fibre gratings has centred on germania-doped optical fibres, as these fibres show by far the highest photosensitivity to ultraviolet radiation. In several applications, however, photorefractive gratings are required in fibres where germania cannot be used as a core dopant. One important example is the erbium:ytterbium fibre laser, the most promising scheme for an efficient ultrashort single-frequency fibre laser at 1550 nm [1]. To obtain efficient energy transfer between the Yb^{3+} and Er^{3+} ions, the fibre core must be doped with large concentrations of P_2O_5 and Al_2O_3 and no GeO_2 [2]. Until recently, we had not been able to form *any* measurable grating in such fibres, due to their extremely poor photosensitivity, which has limited the performance of our single-frequency fibre lasers.

In this paper, we present a first demonstration of nearly 100% reflective gratings in a germania-free optical fibre, which was made photosensitive using the recently developed technique of 'hydrogen loading' [3]. An Er:Yb fibre with an alumina-phosphorus-silica core was soaked in 140 atmospheres of H_2 at 80°C over 15 hours. Lengths of this fibre were then positioned in a UV interferometer set for writing gratings at 1535 nm and exposed to a train of pulses from a KrF excimer laser at 248 nm. The laser was fired at 20 Hz with a pulse fluence of about 0.5 J/cm^2, exposing a 20 mm section of fibre. At such a high average UV intensity level, saturation of the photoinduced index change is usually observed within 5 to 15 minutes in most germania-doped optical fibres. In this case however, a section of fibre was exposed for over 3 hours to a perfectly stable fringe pattern and although the growth of the grating had slowed down considerably, the photoinduced index modulation could still be seen to increase with time. The reflection and transmission spectra of this long exposure grating are shown in Fig. 1. The transmission curve shows a 20dB extinction at the Bragg wavelength, limited by the dynamic range of the measurement, thus corresponding to reflection coefficient of at least 99%. The reflection peak has a bandwidth of 0.365 nm which would correspond to an index modulation of 3×10^{-4} for a perfect 'top-hat' grating profile. However, features seen on the long wavelength side of the reflection spectrum indicate that the grating profile is slightly tapered.

In conclusion, the hydrogen loading technique has been shown to sensitize alumina-phosphorus fibres sufficiently to yield very high reflectivity Bragg gratings. The mechanism of the photoinduced index change and the influence of each dopant is under investigation. The results described here have immediate implications for the development of robust single-frequency fibre lasers as DFB fibre lasers should soon emerge from the combination of highly efficient erbium:ytterbium fibre and strong Bragg gratings.

References

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Figure Captions

Fig. 1 Reflection spectrum of fibre grating in Al_2O_3 / P_2O_5 doped silica optical fibre (linear scale).

Fig. 2 Transmission spectrum of fibre grating in Al_2O_3 / P_2O_5 doped silica optical fibre (logarithmic scale).