SUBMITTED TO OFC '93 POSTDEADLINE. 715

100% REFLECTIVITY FIBRE GRATINGS PRODUCED BY A SINGLE EXCIMER LASER PULSE

L. Reekie, J.-L. Archambault and P.St.J. Russell

Optoelectronics Research Centre,

University of Southampton,

Southampton SO9 5NH,

United Kingdom.

Abstract

We report the production of thermally robust fibre gratings having essentially 100% reflectivity created using a single excimer laser pulse. A new mechanism capable of producing very large photo-induced index changes is described.

100% REFLECTIVITY FIBRE GRATINGS PRODUCED BY A SINGLE EXCIMER LASER PULSE

L. Reekie, J.-L. Archambault and P.St.J. Russell
Optoelectronics Research Centre, University of Southampton,
Southampton SO9 5NH, United Kingdom.

The holographic technique of exposing the photosensitive core of an optical fibre to two interfering UV beams has been widely adopted as the most effective way of producing low-loss gratings in fibres[1]. Recently, the use of high pulse energy, line-narrowed KrF excimer lasers has made it possible to reduce the writing time to 20ns - the duration of a single laser pulse[2, 3]. Here we report on a new grating formation mechanism which is capable of producing high reflectivity and thermally robust gratings using such a technique.

The interferometer used for writing the gratings is similar to that described previously[2]. It was set up to produce fibre gratings with a centre wavelength near λ=1550nm. The pulse energy of the 248nm excimer pulses could be varied using a polariser and half-wave plate. The beam from the laser was partially focused onto a fibre to a cross-section of approximately 15mm $\times$ 0.3mm at the fibre, the long dimension being parallel to the fibre axis.

A total of thirty six single pulse gratings were fabricated over a four hour period under identical experimental conditions - only the laser pulse energy, accurately monitored using a pyroelectric energy meter, was varied. The peak-to-peak index modulation of each grating was estimated from its reflection spectrum and the results are shown in Fig. 1. It is immediately apparent that a sharp threshold occurs at a pulse energy of about 30mJ; when the pulse energy is increased from 20 to 40mJ, the photo-induced index modulation increases by more than two orders of magnitude. Beyond this threshold, the effective index change can be as high as 6×10^{-3}. For convenience, we label gratings formed in the low and high index regimes Type I and Type II respectively. Type II gratings are characterised by very high reflectivities and large bandwidths (Fig. 2). The grating shown had a transmission of <0.2%, limited by the measurement system. The calibrated reflection spectrum confirms that almost 100% of the light at the Bragg wavelength is reflected.

Several Type II gratings were also tested for thermal stability at temperatures ranging from 700°C to 1000°C for 24 hour periods. The results are summarised in Fig. 3. Below 800°C, no significant degradation was observed over a 24 hour period. In contrast, Type I gratings were erased in seconds at T≈450°C.

Observation of Type II gratings under a microscope reveals a periodic damage track localised along one side of the core/cladding interface. This damage region in such close proximity to the core gives rise to a very large modulation in the effective mode index. Under our experimental conditions, it may be shown that a 40 mJ UV pulse will cause an instantaneous temperature rise of several thousand degrees Celsius. At such temperatures the absorption will rise dramatically, explaining the sharp onset of Type II grating formation.

Type II gratings have several advantages over conventional photorefractive gratings, namely:

(a) very large effective index modulations are produced in a single laser pulse, allowing these gratings to be manufactured during the fibre drawing process;

(b) a much higher degree of thermal stability;

(c) they are essentially unaffected by low-level UV/blue/green illumination.

It is anticipated that the superior temperature handling properties of Type II gratings will make them useful in fibre systems operating in hostile environments.

References

1. Meltz, G., Morey, W.W. and Glenn, W.H.: "Formation of Bragg gratings in optical fibres by a transverse holographic method", *Opt. Lett.*, 1989, **14**, pp.823-825.

2. Askins, C.G., Tsai, T.-E., Williams, G.M., Puttnam, M.A., Bashkansky, M. and Friebele, E.J.: "Fibre Bragg reflectors prepared by a single excimer pulse", *Opt. Lett.*, 1992, **17**, pp.833-835.

3. J.-L. Archambault, L. Reekie and P.St.J. Russell: "High reflectivity and narrow bandwidth fibre gratings written by a single excimer pulse", *Electron. Lett.*, 1993, **29**, pp.28-29.

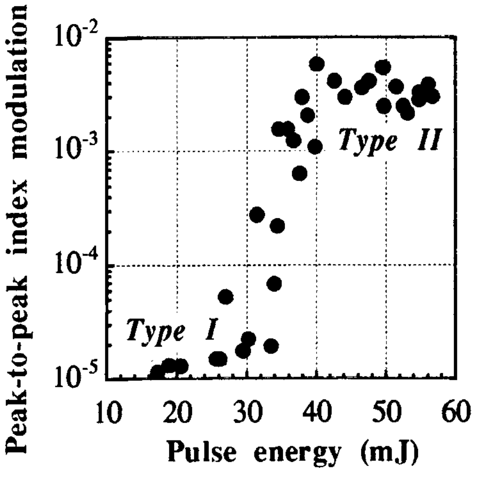

Fig. 1

Peak-to-peak index modulation for different pulse energies.

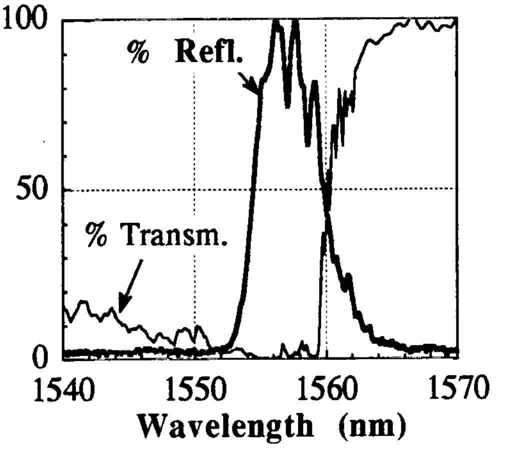

Fig. 2

Reflection and transmission spectra of a typical Type II grating. For wavelengths below the Bragg wavelength, light is coupled strongly into the cladding.

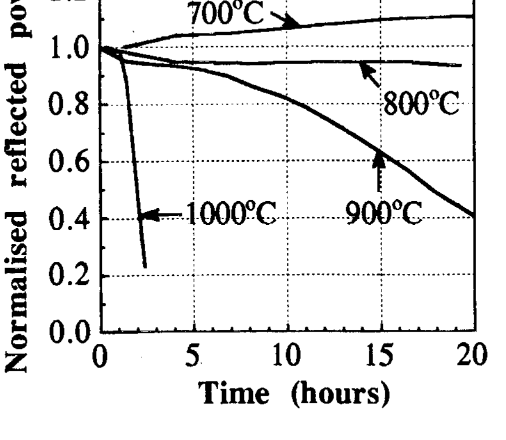

Fig. 3

Temperature stability of Type II gratings.