Submitted to '94 Cleo'

786

A Study of UV Absorption in Germanosilicate Fibre Preforms

L. Dong, J. Pinkstone, P.St.J. Russell and D.N. Payne

Optoelectronics Research Centre,

University of Southampton,

Southampton S09 5NH, U.K.

Tel: +44 703 593147

Fax: +44 703 593142

Abstract

The strength of the 242 nm absorption band in MCVD germanosilicate fibre preforms is observed a) to be linearly dependent on Ge concentration and b) to increase by a factor of ~2.5 if O_2 is replaced with He during the collapse process. It also reduces when the preform is co-doped with phosphors, fluorine, aluminium and boron.

A Study of UV Absorption in Germanosilicate Fibre Preforms

L. Dong, J. Pinkstone, P.St.J. Russell and D.N. Payne

Optoelectronics Research Centre,

University of Southampton,

Southampton S09 5NH, U.K.

Summary

Since the discovery that gratings could be written directly into germanosilicate fibres by side-exposure to UV interference fringes[1], a considerable amount of work has been directed towards understanding and optimising the underlying physical effect. An absorption band at 242 nm from oxygen deficient sites in these fibres has been identified as playing a key role, its strength ultimately determining how much energy will be absorbed when the fibre is exposed to UV radiation.

An important issue, not yet addressed in detail in the literature, is the effect that different processing conditions have on the absorption spectrum of the fibre preform, which is similar to that in fibres[2]; these are discussed in this paper. We have devised a very simple technique for studying UV absorption spectra in MCVD preforms. This new technique offers a rapid route for optimising fibre performance. At different points during the collapse process, samples of ~2 cm long are cut from the partially-collapsed silica tubing. A section of the preform is then fully collapsed into a solid rod and its refractive index profile measured on a York P101 index profiler. The volume of core material is thus obtained, and used to calculate the thickness of the MCVD-deposited film on the inner surfaces of each of the

partially collapsed tubes (inner diameters known). The germania concentration is estimated from the core index. Each sample is then cut along its axis into two equal halves and the UV absorption spectrum measured using a Perkin-Elmer spectrophotometer (with a beam width of ~1 mm). The loss in the substrate silica tube itself is found to be negligible in the wavelength range of interest (in the vicinity of 242 nm). The measurements on partially collapsed tubes reveal that, after a small increase following the first two passes of the flame during collapse, the strength of the 242 nm band does not change, retaining the same value even in the fully collapsed rod (measured using a thin polished disc of preform with the cladding masked off). In samples with a range of different germania concentrations, the same qualitative effect was consistently seen (Figure 1). The strength of the 242 nm band after two collapse passes is found to depend linearly on germania concentration (Fig.1) with a slope of 36 dB/mm per mol% of GeO_2 (solid line in Fig.1). The 242 nm band is found to be enhanced by using reducing atmosphere during collapse. In a sample collapsed with a) O_2 switched off, b) O_2 substituted by N_2, and c) O_2 replaced by He, increases of a) ~44%, b) ~74% and c) ~150% were measured respectively (Fig.2; all samples taken after two collapse passes). The peak of the 242 nm absorption in the top two curves in Fig.2 could not be resolved, owing to background fluorescence at longer wavelengths. Since the data is absent for these parts of the curves, they have been filled in with a scaled-up version of the curve measured on the sample made under normal collapse condition (i.e. in the presence of O_2, see dotted lines). The effects of co-dopants on the 242 nm band were also studied, P, B and F being introduced separately during deposition, and Al being incorporated by solution-doping. All the co-dopant ions are found to reduce the 242 nm peak, P yielding the largest reduction (Fig.3; all measurements were taken after two collapse passes, apart from the P co-doped samples which were measured un-collapsed). P, F, Al and B produce successively smaller reductions in the 242 nm band strength. Williams et al has reported enhanced photosensitivity in a B co-doped fibre[3]. This indicates that some other factors, e.g. stress, may also play a role in the photosensitivity in these B co-doped fibres. A strong band at 205 nm was discovered in the Al co-doped germanosilicate samples; it was not seen in any of the other samples.

Acknowledgement: The authors would like to thank Ping Hua for polishing the samples used in this work.

References

1. G. Meltz, W.W. Morey and W.H. Glenn, Opt. Lett., **14** (823-825) 1989.
2. M.D. Gallagher and U.L. Österberg, Appl. Phys. Lett., **60**, (1791-1793) 1992.
3. D.L. Williams, B.J. Ainslie, J.R. Armitage, R. Kashyap and R. Campbell, Elect. Lett., **29**, 1993, pp.45-47.

Figure captions

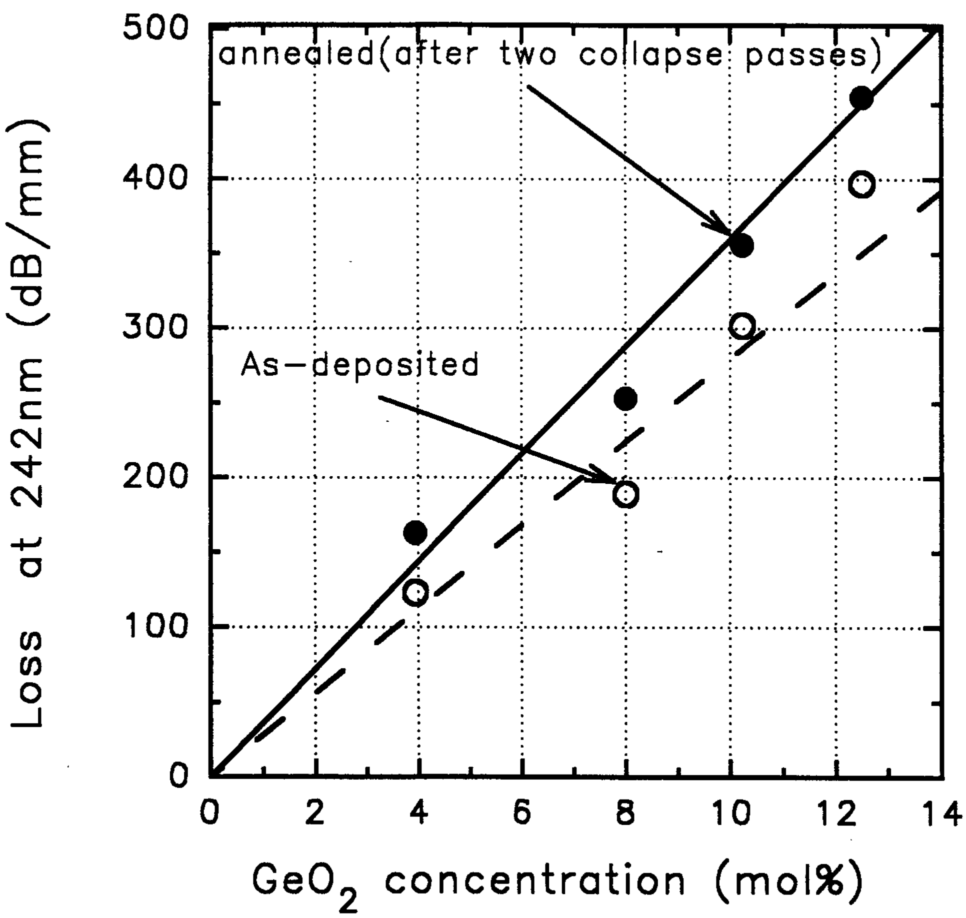
1. The peak in the 242 nm absorption band plotted against germania concentration. The circles are from as-deposited (un-collapsed) samples and the dots from annealed samples (after two collapse passes). The solid line has a slope of 36 dB/mm per mol% of GeO_2 and the dashed line 28 dB/mm per mol% GeO_2.

2. The effect of collapse conditions on the 242 nm band strength. All samples were annealed (taken after two collapse passes). The peak in the top two curves could not be resolved owing to background fluorescence at longer wavelengths. They are filled in by a scaled-up version of the curve from the sample made under normal collapse condition (dotted lines).

3. The peak in the 242 nm absorption band plotted against N/N_{Ge}. N and N_{Ge} are the number densities of co-dopant and germanium ions respectively.

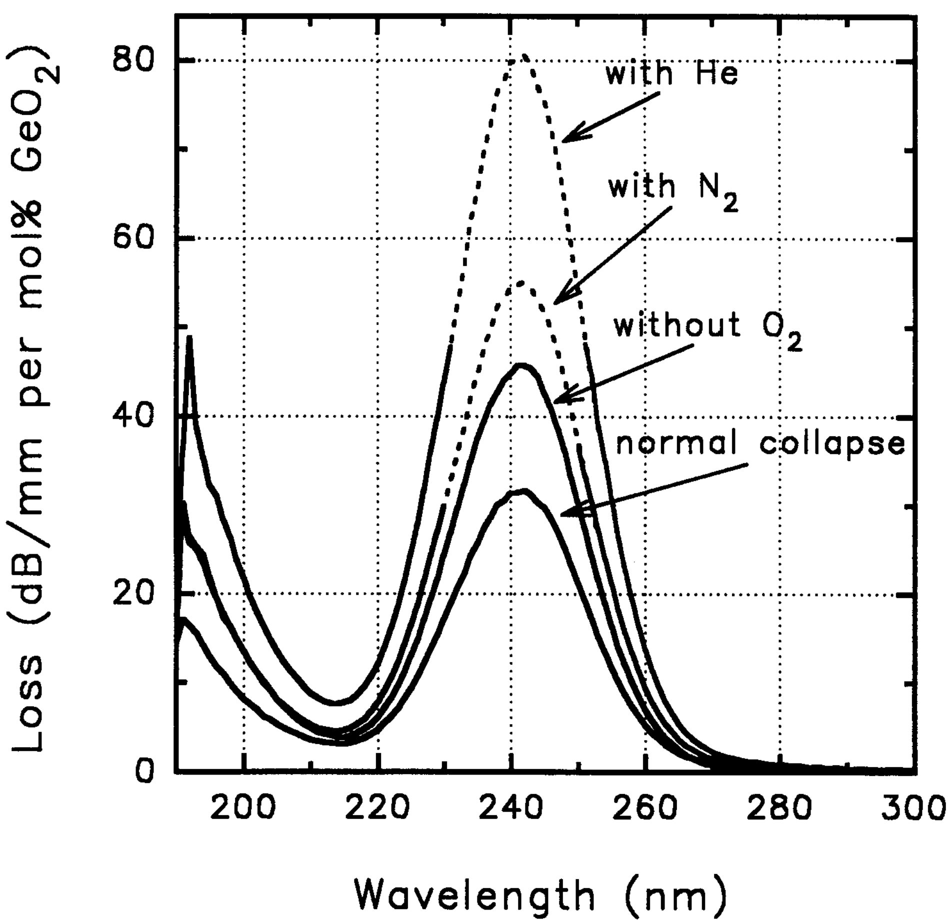
Dong et al "A study of Absorption in Germanosilicate ...."

Fig. 1



Dong et al: "A study of Absorption in Germano-silicate ..."

Fig. 2



Dong et al "A study of Absorption in Germanosilicate ... "

Fig. 3