596

Neodymium-Diffused Lithium Niobate Waveguide Lasers at 1084nm

Martin Hempstead, James S. Wilkinson and Laurence Reekie
Optoelectronics Research Centre, The University, Southampton, SO9 5NH, England.

We report the demonstration of waveguide lasers in $LiNbO_3$ into which neodymium has been diffused. Optical feedback from the polished endfaces alone yielded an absorbed power threshold of 13±3 mW, and a slope efficiency of 55±8%.

Neodymium-Diffused Lithium Niobate Waveguide Lasers at 1084nm

Martin Hempstead, James S. Wilkinson and Laurence Reekie
Optoelectronics Research Centre, The University, Southampton, SO9 5NH, England.

Introduction: Waveguide lasers have been fabricated in neodymium-doped $LiNbO_3$ by titanium- and proton-diffusion [1,2], and in erbium-doped $LiNbO_3$ using initial diffusion of the rare-earth into the crystal [3]. Here we report the demonstration of waveguide lasers in $LiNbO_3$ into which neodymium has been diffused.

Fabrication: A neodymium layer of density approximately 2 μg cm^{-2} was deposited on x-cut $LiNbO_3$, leaving a region of the surface uncoated. The sample was heated at 1015°C for 203 hours in dry oxygen. The neodymium-diffused surface was found to be rough, with height fluctuations of the order of 10nm. The sample was then diffused in dry oxygen at 1070°C for a further 210 hours, after which the surface had become uniformly smooth. Stripes of titanium 76nm thick, parallel to the crystallographic y-axis and ranging from 2.5 to 9 μm wide, were defined by photolithographic lift-off. One identical set of stripes was deposited on the region undoped with neodymium. The titanium was diffused into the sample at 1005°C for 9 hours in dry oxygen. The endfaces were cut and polished to yield waveguides 38mm long.

Results: Light from a Ti:Sapphire laser at 814nm was coupled into the waveguides, and fluorescence was observed from the endfaces, with spectra, shown in Fig. 1, closely similar to those for bulk-doped Nd:$LiNbO_3$ [2].

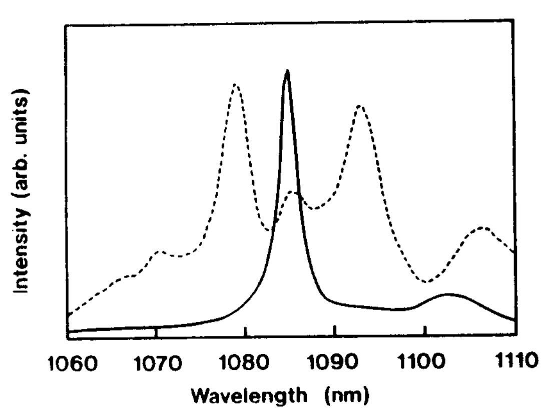
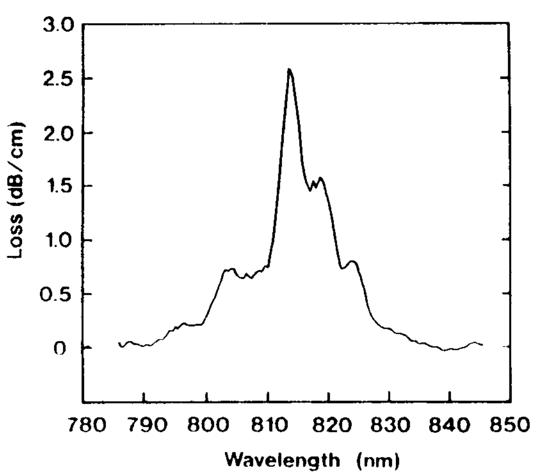


Figure 1. Fluorescence emitted by Nd-doped waveguide pumped at 814nm.
Solid line: π-polarised pump; broken line: σ-polarised pump.

Fig. 2 shows the absorption spectrum of the widest waveguide for π-polarised light, obtained by dividing the transmission of a neodymium-doped guide by that of an undoped one on the same substrate, and not significantly different from that for bulk-doped $LiNbO_3$ [2]. Waveguide losses were estimated to be 0.4dB cm^{-1} at 809nm, excluding absorption by the neodymium, using the scattered light method [4]. The sample was placed on a plate at 225°C for continuous annealing of photorefractive damage [5]. With π-polarized pump light at 814nm and feedback only from intrinsic endface reflections (R $\approx$ 14%), lasing was observed in channels greater than 5μm wide, implying gains over 2dB cm^{-1}. Emission was at 1084nm, with a FWHM linewidth of approximately 0.3nm. The lasing characteristic of the widest channel is shown in Fig. 3. Total laser power is estimated by doubling the measured power emitted from the non-pumped end of the waveguide. Absorbed pump power was computed from transmitted pump power, waveguide losses, and pump absorption at 814nm deduced by comparison of transmitted powers at 840nm, at which absorption due to neodymium is negligible, and at 814nm. A linear fit to the data with absorbed pump power below 100mW, yields a threshold of 13±3mW absorbed pump power and slope efficiency of 55±8%.



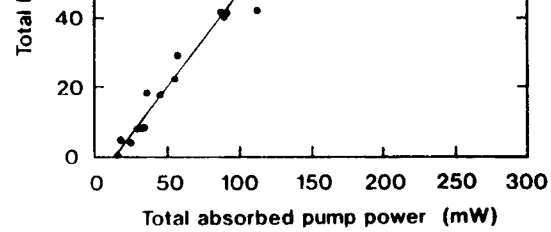


Figure 2. Waveguide absorption spectrum. **Figure 3.** Lasing characteristic.

Acknowledgements: We acknowledge the support of the UK Science & Engineering Research Council and the assistance of Y.T.Chow and E.K.Mwarania.

[1] R. Brinkmann et al., IEEE J. Quant. Elec. **28**, 466 (1992).
[2] E. Lallier et al., IEEE J. Quant. Elec. **27**, 618 (1991).
[3] R. Brinkmann et al., Elec. Lett. **27**, 415 (1991).
[4] Y. Okamura et al., Appl. Opt. **25**, 3405 (1986).
[5] A. M. Glass, Opt. Eng. **17**, 470 (1978).