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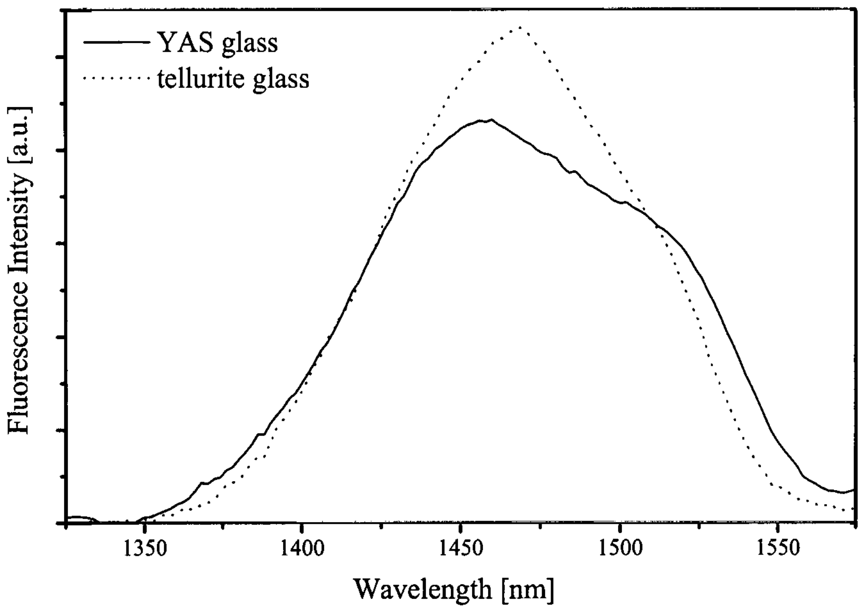
Spectroscopy of Tm^{3+}-doped yttrium-aluminosilicate glass

P. Jander and W. S. Brocklesby
Optoelectronics Research Centre, University of Southampton
Southampton SO17 1BJ, United Kingdom

Introduction:
Research into Tm^{3+}-doped glasses as gain media for optical amplifiers in the telecommunications S-band has been focused on glasses with low phonon energy like tellurite[1] and fluoride glasses, because the high phonon energy of silicate glasses precludes emission around 1470nm. Glasses in the $Y_2O_3 - Al_2O_3 - SiO_2$ (YAS) system[2] have, despite their silica content, a maximum phonon energy of about 950cm^{-1}, as well as good transparency and thermal stability. We report preliminary spectroscopy on Tm^{3+}:YAS glass which highlights their potential as S-band amplifier gain media.



Experimental:
Glasses with compositions close to the yttria-rich border of the glass-forming region, doped with 3200ppm Tm_2O_3 were melted for 1h at 1600°C in a 20g batch and cast onto a stainless steel mould. DTA measurements showed that the glass is reasonable stable with $T_x - T_g = 240$°C.
Fluorescence spectra and lifetimes were measured by pumping with a Ti:sapphire laser, λ=793nm and about 200mW power. The spectra were recorded with an Acton Spectrapro monochromator with 5nm resolution and an InGaAs diode.
The lifetime of the upper laser level was measured at 802±3nm with a PMT; the lifetime of the lower laser level with an InGaAs diode and a Ge-filter to block the excitation light.

Results:
In the figure, the fluorescence spectrum of YAS glass is compared with a spectrum of Tm^{3+}: tellurite glass. The fluorescence band of the YAS glass is wider and flatter than of the tellurite glass, with a FWHM of 120nm, stretching from 1411nm to 1532nm. The peak emission cross-section, $0.24 \cdot 10^{-20}$cm^2, at 1460nm was calculated with the Füchtbauer-Ladenburg equation, and is the same as in tellurite glass.
The fluorescence decay of the lower laser level was single exponential with a lifetime of 1.2ms. This indicates there are no concentration quenching effects for the doping level used. The decay of the upper laser level was fitted with a single exponential decay function to yield a lifetime of 100µs. With the radiative lifetime of 474µs, calculated with the Judd-Ofelt formalism, the quantum efficiency can be estimated as 20%.

Conclusion:
Thulium doped $Y_2O_3 - Al_2O_3 - SiO_2$ glass is a very promising material for S-band optical amplifiers, because of the broad, flat emission curve, together with good potential for fibre production. Its quantum efficiency may limit its usage to high duty cycle amplification, or power amplification, but in these areas it has great potential.

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[1] E. R. Taylor, Li Na Ng, N. P. Sessions, H. Buerger, J. Appl. Phys. **92**(1), 112-117 (2002)
[2] J. T. Kohli, R. A. Condrate Snr., J. E. Shelby, Phys. Chem. Glasses **34**(3), 81-87 (1993)