Experimental study of Nd(TTA)$_3$Phen-doped 6-FDA/Epoxy Waveguides

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The infrared fluorescence (890nm, 1060nm, 1330nm) of a Nd(TTA)$_3$Phen (TTA = thenoyltrifluoroacetone, Phen = 1, 10-phenanthroline) doped 6-FDA epoxy (6-fluorinated-dianhydride cured epoxy) film was observed by pumping with a Ti:Sapphire laser at 800nm. Furthermore, Nd(TTA)$_3$Phen doped 6-FDA epoxy channel waveguides were fabricated and their loss spectrum was measured.

Introduction

Lasing and amplification by rare-earth doped polymer materials has been widely investigated [1-2]. In our previous work [3], a Nd(TTA)$_3$phen doped 6-FDA epoxy film was spin-coated on an thermally oxidized wafer. The Judd-Ofelt analysis based on the absorption spectrum shows that this neodymium doped polymer material has a good potential to be used as a planar waveguide in lasers or amplifiers.

In this paper, the spontaneous emission spectrum of this neodymium doped film and the fabrication of Nd(TTA)$_3$phen doped 6-FDA epoxy channel waveguides by backfilling the core material in inverted cladding channels are presented.

Spontaneous emission spectrum of neodymium doped film

The absorption spectrum of Nd(TTA)$_3$phen doped 6-FDA epoxy film, which is obtained in our previous work [3], indicates the absorption peaks at 580nm, 740nm, 800nm and 865nm.

Therefore, the recording of the room temperature fluorescence spectrum was performed using the 800 nm line of a tunable Ti:Sapphire laser as the excitation source. The spontaneous emission spectrum was recorded by an optical spectrum analyzer (Spectro 320, Instrument System) and is shown in Fig. 1 Three distinct emission bands with peaks at 890 nm, 1060nm and 1330nm can be seen clearly. They correspond to transitions from the $^4F_{3/2}$ level to the $^4I_{9/2}$, $^4I_{11/2}$, and $^4I_{13/2}$ levels.

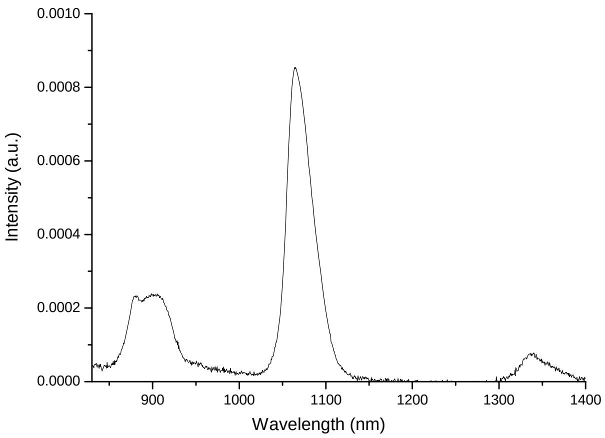

Fig. 1 Room temperature spontaneous emission of the Nd(TTA)3phen doped 6-FDA epoxy film pumped by Ti:Sapphire laser at 800nm.

Waveguide fabrication and loss measurement

By spin-coating and photodefining a cycloaliphatic epoxy prepolymer (code name CHEP) [4], inverted channels in the low index CHEP polymer were obtained on a thermally oxidized wafer. The core material, a Nd(TTA)$_3$phen doped 6-FDA epoxy solution, was then backfilled via spin-coating twice and the Nd doped channel waveguide was realized after thermal curing. A lower refractive index silicon containing epoxy was used as the upper cladding, and on the top of which a Pyrex glass wafer was applied. Fig. 2 shows a microscope picture of the waveguide cross section (~40 μm).
The waveguide loss was determined from the optical output of samples with different lengths using butt-coupled 50 μm multimode fibers, a broadband white light source at the input and the Spectro 320 at the output. The loss spectrum clearly shows the absorption lines of the neodymium, which appear at 580, 740, 800 and 865 nm (Fig. 3).

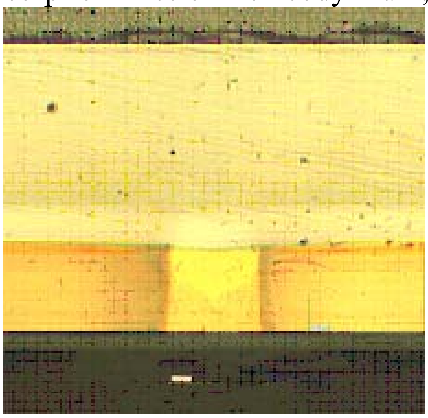

Fig. 2 Microscope picture of the Nd doped channel waveguide cross-section.

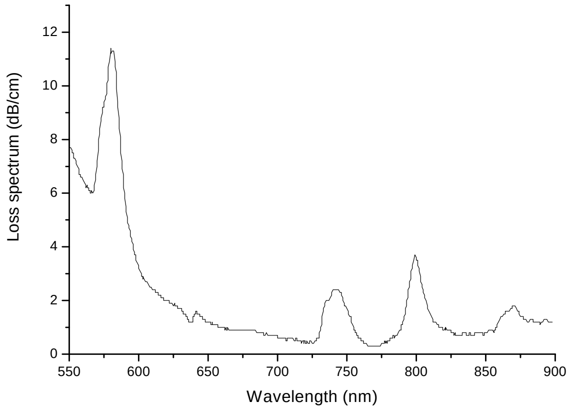

Fig. 3 Loss spectrum of the Nd(TTA)$_3$phen doped 6-FDA epoxy channel waveguide.

Conclusion

Spontaneous emission spectrum of the neodymium doped polymer film with three peaks at 890nm, 1060nm and 1330nm was obtained. Channel waveguides were realized by backfilling the inverted channels in a low index epoxy with the core material and their loss was measured. This study demonstrates that Nd(TTA)$_3$Phen doped 6-FDA epoxy is well suited for lasing or amplification in optical waveguides.

Acknowledgement

The authors acknowledge the financial support of STW (TOE 6986).

References

[1] S. Lin, R. J. Feuerstein, and A.R. Mickelson, "A study of neodymium-chelate-doped optical polymer waveguides", J. Appl. Phys., vol. 79, pp.2868-2874, 1996.
[2] K. Kueki and Y. Koike, “Plastic optical fiber lasers and amplifiers containing lanthanide complex”, Chem. Rev., vol 102, pp. 2347-2356, 2002.
[3] J. Yang, M.B.J. Diemeer, L.T.H. Hilderink, R. Dekker, and A. Driessen, “Judd-Ofelt analysis of Nd(TTA)$_3$phen doped 6-FDA/epoxy planar waveguides,” in Proceedings of the Annual Symposium of the IEEE/LEOS Benelux Chapter 2006, pp. 253-256.
[4] M.B.J. Diemeer, L.T.H. Hilderink, H. Kelderman, and A. Driessen, “Multimode waveguides of Photodefinable epoxy for optical backplane applications,” in Proceedings of the Annual Symposium of the IEEE/LEOS Benelux Chapter 2006, pp. 53-56.