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Study of Nd^{3+} doped wave guide amplifiers optical gain at 1330nm

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Abstract— **$Nd3^{+}$ complex doped 6-FDA/UVR and Al_2o_3:Nd^{3+} channel waveguide amplifiers have been experimentally and theoretically investigated at three Nd^{3+} transition for Al_2o_3:Nd^{3+} channel waveguide amplifiers a gain of 1.93 dB/cm at 1330nm was observed in a 1.4cm long waveguide with Nd^{3+} concentration of $1.68x10^{20}$ cm^{-3} at a launched pump power of 45 MW. By use of rate equation model, the gain in the two types of waveguides at each wavelength was calculated and macroscopic ETU parameter as a function of Nd^{3+} concentration was derived. The high internal net gain indicates that these two types of $Nd3^{+}$ doped channel waveguide amplifiers are suitable for providing sufficient gain in many integrated optical devices.**

Index Terms— **waveguide amplifiers, Net gain, pump power, Nd^{3+} ion , rate equation model, propagation length**

INTRODUCTION

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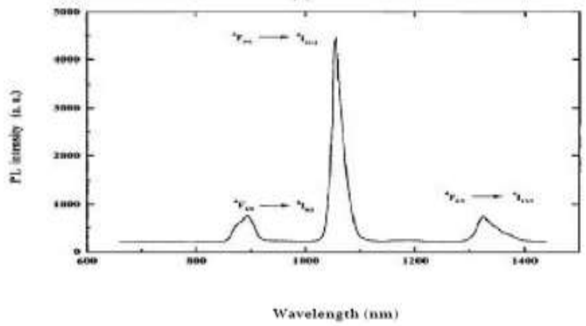
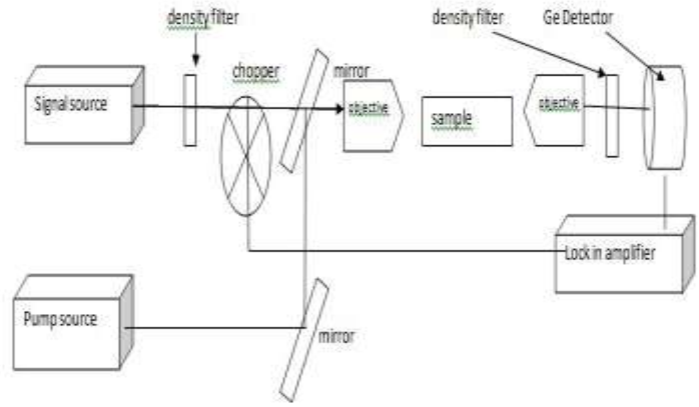
Nd^{3+}ions: - Neodymium doped lasers are of interest for amplifications at the ions specific emission wave lengths and have been widely studied. There are five main absorption bands of Nd^{3+}in the visible and near infrared wavelength range which are 520nm, 580nm, 745nm, 800nm and 880nm. The three luminescence peaks around 880nm, 1060nm and 1330nm corresponds to the transitions.

$4Fy_2 \rightarrow 4I_{9/2}$, $F_{3/2} \rightarrow 4\,I_{11/2}$ and $4Fy_2 \rightarrow 4I_{13/2}$



Optical gain was experimentally investigated using a pump probe method. Small signal gain of Nd^{3+} complex doped small core polymer channel waveguide amplifies at 1330nm was measured.

Set up is shown below:-



With the aid of rate equation models for the peak wave length of 1330nm the optical gain in two types of wave guides has been simulated and compared with the measured results

Table below shows the experimentally determined spectroscopic parameters of Nd^{3+} . Complex doped 6-FDA/UVR and Al_2o_3:Nd^{3+} channel waveguides used for the measurements and simulations.

Parameters	Nd^{3+} doped	Al_2o_3:Nd^{3+}
Pump wavelength	800nm	800nm
Signal wavelength	800nm	1330nm
Refractive index core n	800nm	n Al_2o_3= 1.649
Refractive index cladding	800nm	N air = 1.0
Refractive index lower cladding	800nm	N Sio_2 =1.448
Signal intensity I_s at 1330 nm	800nm	$7.71x10^5 W/m^2$
Nd^{3+} concentration	0.3 to $2.03x10^{20}$ cm^{-3}	0.65 to 2.95 $x10^{20}$ cm^{-3}

Optical gain and results

High wave guide losses have been observed in Nd^{3+}complex doped FDA./UVR channel wave guides around 1330nm due to optical absorptions of the residual C-H bonding in polymer hosts. Thus these Nd^{3+}doped polymer channel waveguides are not suitable materials for optical amplification in the telecom band (1260-1360)nm.

On the other hand, the propagation losses ofAl_2o_3:Nd^{3+}channel waveguides at 1330nm is relatively

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low, typically ~0.35dB/cm. Although the emission peak of the Nd^{3+} transition 4 $F_{3/2}$ 4$I_{13/2}$ in Al_2o_3:Nd^{3+} is at 1340nm the gain was measured at 1330nm this is because of the availability of signal source at 1330nm at which the emission cross-section has a value equaling 75% of its peak value at 1340nm.

The internal net gain versus propagation length was measured and simulated by the rate equation model for Al_2o_3:Nd^{3+} channel waveguides with various Nd^{3+} concentrations the results of which are plotted in fig 1.

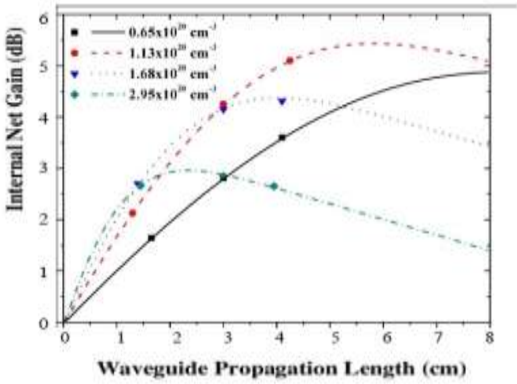

Fig 1

A maximum of 5.1dB internal net gain was observed in a 4.25cm long channel wave guide with a Nd^{3+} concentration of $1.13x10^{20}$ cm^{-3} fig 2. Shows the measured and simulated gain per unit length for different ND concentrations for short waveguide length (1.30 to 1.65) cm. The maximum gain per unit length at 1330nm was measured at concentration of $1.68x10^{20}$ cm^{-3}.

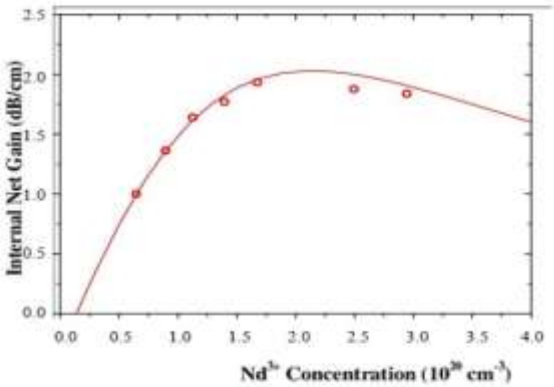

Fig 2.

Since there is no re absorption at the 4 $F_{3/2}$ → 4$I_{13/2}$ transition, higher gain is expected at the luminescence peak of 1340nm, and higher total gain in dB can be achieved in longer samples with sufficient launched pump power.
The gain in dB/cm verses launched pump power in the sample of optimal concentration was investigated with various channel length and is given in fig 3.

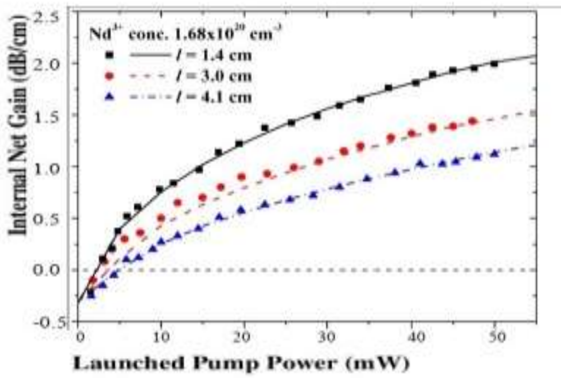

fig 3.

CONCLUSION

The result indicates that Al_2o_3:Nd^{3+} channel waveguide are well suited for amplification in telecommunication around 1330nm. Since a high speed Al_2o_3:Er^{3+} waveguide amplifier at a transmission rate of 170 Gbit/s has been demonstrated at 1550nm high speed amplification around 1330nm in Al_2o_3:Nd^{3+} channel waveguides is also possible.

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