Nd^{3+}-Doped Graded Index Single-Mode Polymer Waveguide Amplifier working at 1.06 and 1.32 μm

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Recently, intense research on single-mode rare-earth doped fiber lasers and amplifiers[1] has led to the development of a range of active devices. The possibility of ion-doping of standard integrated-optic waveguides has recently allowed the demonstration of Nd- and Er-doped single-mode channel waveguide lasers in single crystal Ti:$LiNbO_3$ waveguides[1-2] and various glass waveguides[3-5]. However, there are a number of intrinsic limitations associated with these material systems. First, glass waveguides have no electrooptic(EO) effect; therefore, an active device cannot be made using these substrates. Second, $LiNbO_3$ waveguides have significant walk-off between the refractive indices of microwave and optical waves. Consequently, the modulation speed of the EO modulator, which serves as the input signal generator for the waveguide amplifier, is limited to ~40 GHz[6]. Third, the waveguide fabrication methods for $LiNbO_3$ and glass substrates are not universal. They are not transferable to other substrates. For instance, Si and GaAs are the most frequently used substrates for optoelectronics. $LiNbO_3$ and glass waveguide lasers cannot be implemented on these substrates as amplifiers without violating the monolithic integration preference.

Photo lime gel-based polymer waveguide is an excellent guiding medium due to its wide transmission bandwidth(300nm to 2700nm). The GRIN characteristic of this material[7] allows the formation of high quality(loss < 0.1 dB/cm) single-mode passive and active devices on an array of substrate[8].

In this paper, we report a graded index(GRIN) polymer waveguide amplifier working at 1.06μm wavelength using Nd-doped photolime gel as the active medium. Fluorescent spectrum at 1.32μm region (see Figure 1) was also observed for the first time. The polymer introduced is soluble in water. As a result, the chemical compounds containing rare earth ions(REIs) can be mixed with the host polymer as long as they are hydrophilic. But the doping concentrations should be below the level of microscopic clustering[5] which quenches the active ions. There are other quenchers which shorten the lifetime of metastable states of active ions. The most serious quenchers are the admixed O-H groups whose concentration must be less than $3\text{-}5\times10^{18}/cm^3$ [4] for glass waveguide amplifier. The existence of O-H groups generates a number of intermediate states between the transition states. Such states, primarily from water molecules, significantly reduce the lifetime of metastable states. The general rule of thumb is that the lifetime of the excited state will be temperature dependent if the gap is less than ten times the effective phonon frequency and completely quenched if less than four times[5].

Experiment results will be presented at the conference.

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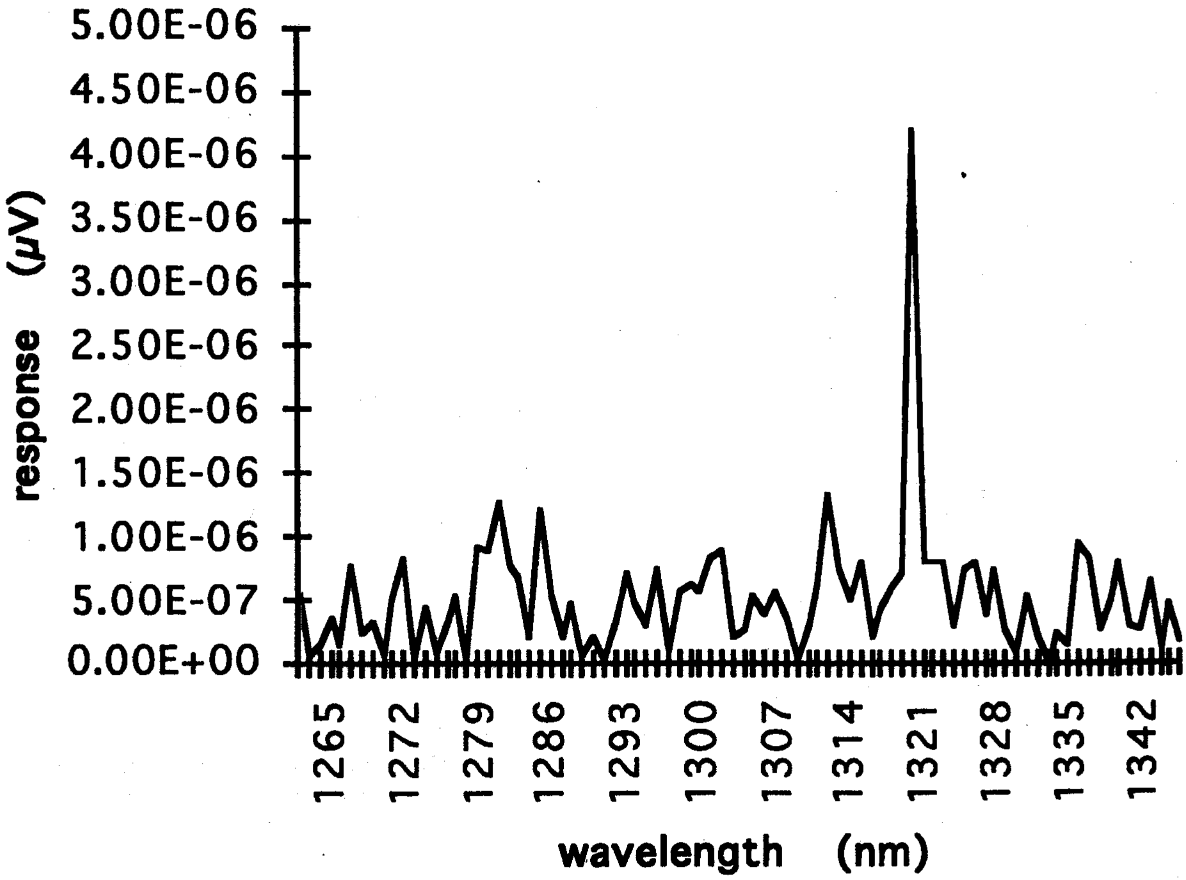

Figure 1 Fluorescent Spectrum of a Nd^{+++}-doped Photolime Gel thin Film