Spectroscopy and gain in Al_2O_3:Er waveguides

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Erbium-doped amorphous aluminum oxide thin films are of great interest for integrated amplifier applications [1]. Due to the amorphous host structure, the Er $^4I_{13-2} - {}^4I_{15-2}$ emission typically results in a broad emission peak on the order of 55 nm centered at 1535 nm, allowing amplification over a wide wavelength range. In addition, such films have been shown to have low background propagation loss, which is important for achieving gain. We have developed both a repeatable and stable deposition process for reactive co-sputtering of low loss Al_2O_3 and Al_2O_3:Er layers [2], and a reactive ion etching (RIE) method for defining high optical quality Al_2O_3:Er channel waveguides with background losses down to 0.21 dB/cm [3]. In such waveguides, under 980-nm pumping, gain of up to 0.8 dB/cm at 1533 nm has been measured for an Er concentration of $\sim 0.8 \times 10^{-20}$ cm^{-3} [4].

The spectroscopic properties of the Al_2O_3:Er layers were investigated by lifetime measurements. Typical Bernoulli-type decay curves were found, with an increasingly fast non-exponential initial component for higher Er concentrations, which results from energy-transfer upconversion between neighboring Er ions. The exponential tail at long decay times exhibits an asymptotic lifetime which decreases from 7 ms for Er concentrations of $\sim 2 \times 10^{19}$ cm^{-3} down to 2 ms for Er concentrations of $\sim 4 \times 10^{20}$ cm^{-3}. This behavior may result from either pair-induced energy-transfer upconversion or quenching by impurity ions present in the metallic Er target used for sputtering. We conclude that at least two different types of quenching mechanisms are present in the decay. Further measurements to detect directly the green upconversion luminescence are currently under way and will provide further evidence of the underlying mechanisms. Detailed results will be presented at the conference.

References

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