Energy-transfer upconversion in $Al_2O_3:Er^{3+}$ thin layers

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Erbium-doped aluminum oxide (Al_2O_3:Er) is a promising material for integrated amplifier or tunable laser applications due to its wide gain spectrum around 1550 nm. We deposited Al_2O_3 layers on thermally oxidized Si-wafers by reactive co-sputtering at 550°C [1]. Propagation losses were 0.11 dB/cm at λ =1.5 µm. Channel waveguides were fabricated by reactive ion etching with propagation losses down to 0.21 dB/cm [2]. Under pumping at 977 nm, the optical small-signal gain at 1533 nm is 0.84 dB/cm, resulting in 5.4 dB net gain over the waveguide length of 6.4 cm [1]. Net gain is obtained over a wavelength range of 41 nm (Fig. 1).

The Er concentration was measured using Rutherford Back-Scattering (RBS). Lifetimes of the $^4I_{13/2}$ level of up to 7 ms were measured for Er concentrations around 2×10^{20} cm^{-3}. A faster decay with an increasingly non-exponential initial component is measured for higher Er concentrations (Fig. 2). While the initial quenching is probably due to migration-accelerated energy-transfer upconversion between neighboring Er^{3+} ions in the $^4I_{13/2}$ level, the decreasing exponential tail is due to either pair-induced energy-transfer upconversion or quenching by impurity ions. Detailed investigations of the quenching mechanisms are currently under way.

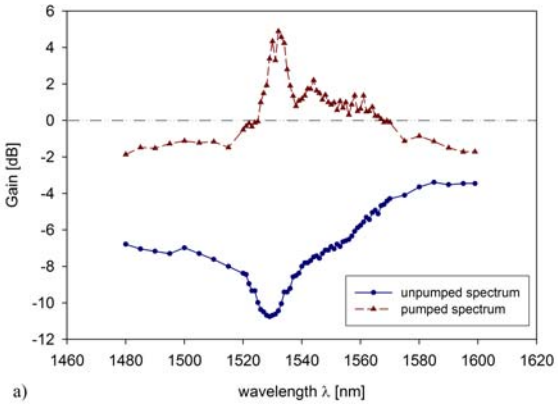

Fig. 1. Net gain in a sample with Er concentration 0.09at% (0.8×10^{20} cm^{-3}) as a function of wavelength

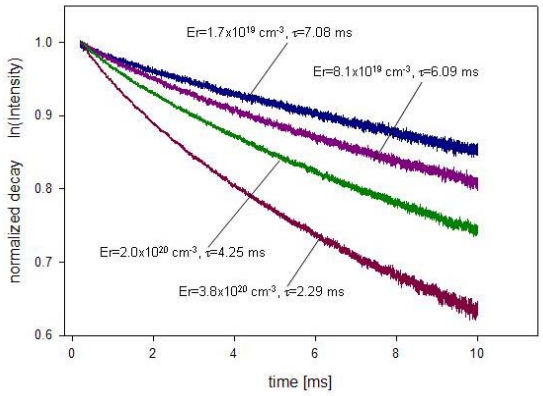

Fig. 2. Luminescence decay curves at 1.5 µm for different Er concentrations

References

[1] K. Wörhoff, J.D.B. Bradley, F. Ay, D. Geskus, T.P. Blauwendraat, M. Pollnau, *"Reliable low-cost fabrication of low-loss $Al_2O_3:Er^{3+}$ waveguides with 5.4-dB optical gain"*, IEEE J. Quantum Electron., submitted (2008).

[2] J.D.B. Bradley, F. Ay, K. Wörhoff, M. Pollnau, *"Fabrication of low-loss channel waveguides in Al_2O_3 and Y_2O_3 layers by inductively coupled plasma reactive ion etching"*, Appl. Phys. B **89**, 311-318 (2007).

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7. Solid state amplifier and laser materials