Photoluminescence from a Nd^{3+}-doped AlGaAs semiconductor structure

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Abstract: We report room-temperature photoluminescence from a Nd^{3+} -doped AlGaAs semiconductor. Oxidation of the AlGaAs greatly improves the luminescence efficiency of the Nd^{3+} ions.

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Rare-earth ions exhibit narrow linewidths and high quantum efficiencies and can be incorporated into a number of hosts. A rare-earth-doped semiconductor has potential for acting as an integrated optoelectronic structure for uses including single-photon light emission for quantum information and quantum computing. Use of molecular beam epitaxy (MBE) to grow Nd-doped heterostructures allows us to accurately control the concentration and spatial position of the Nd ions, which will enable fundamental studies of individual rare-earth ions.

As a preliminary test of a Nd-doped III-V semiconductor, we measure photoluminescence (PL) from a Nd^{3+}-doped $Al_{.9}Ga_{.1}As$ structure. The structure contains an MBE-grown, 1000 nm thick $Al_{.9}Ga_{.1}As$ layer that is doped with a Nd^{3+} concentration of 2×10^{20} cm^{-3}. This layer was wet oxidized in a flow of H_2O and N_2 at a temperature of 460 °C, as this oxidation process has been shown to improve the light output of a similar, Er^{3+} -doped semiconductor [1].

Figure 1 shows the output spectrum of our sample, pumped at room temperature with a Ti-Sapphire laser at 810 nm. These data are the first reported PL for an oxidized Nd-doped AlGaAs semiconductor structure. The PL peak centered at 1060 nm corresponds to the $4F_{3/2}$ to $4I_{11/2}$ transition in Nd^{3+}. The metastable $4F_{3/2}$ state can be excited over a range of wavelengths, but pumping at 810 nm is particularly useful because pump light of this wavelength can be produced with an AlGaAs diode laser, allowing for monolithic integration of Nd-doped heterostructures with conventional III-V semiconductors. Figure 2 demonstrates the dependence of the 1060 nm emission on the excitation wavelength. This shows that the emission is due to the direct excitation of the Nd ions. This work is supported by ARDA under Contract No. MOD 7084.03.

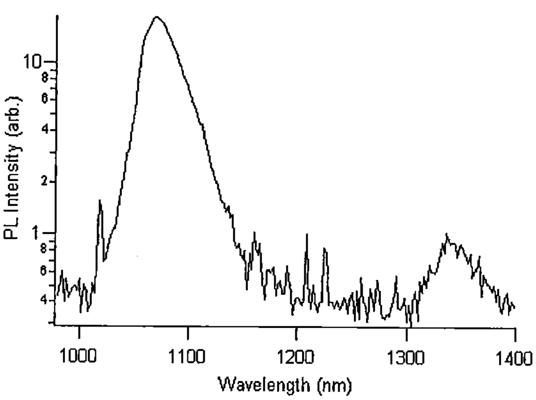

Fig. 1. Room-temperature PL from an oxidized Nd^{3+} doped $Al_{.9}Ga_{.1}As$ structure pumped at room temperature by a Ti-Sapphire tuned to 810 nm.

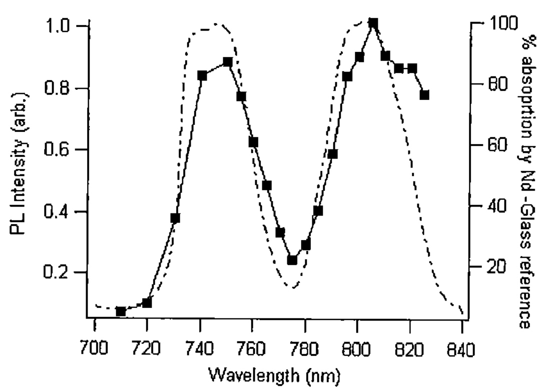

Fig. 2. Pump wavelength dependence of the 1064 nm PL intensity (line and points) compared to the absorption spectrum of a Nd-glass reference (dotted line). The two peaks at 795 nm and 740 nm are the ground state absorption transitions to the

$2H_{9/2}$+$4F_{5/2}$ and $4S_{3/2}$ + $4F_{7/2}$ states, respectively.

[1] L. Kou, D. C. Hall, and H. Wu, "Room-temperature 1.5 μm photoluminescence of Er^{3+} - doped $Al_xGa_{1-x}As$ native oxides", Applied Physics Letters **72**, 3441 (1998).