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Excited State Absorption in Mn^{2+} doped Phosphate Glass

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Abstract. The possibility of obtaining laser action from Mn^{2+} doped glass has been investigated. The excited state absorption at the expected laser wavelength was measured and explains the unsuccessful attempts to obtain laser action.

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The luminescence of Mn^{2+} in phosphate glasses has been studied by Reisfeld et al. and it was noticed that depending on the concentration of the Mn^{2+} ion, the fluorescence was rather strong with surprisingly high quantum efficiency and long lifetime [1]. Triggered by these observations, we set out to exploit the possibility of a tunable solid state laser in the visible.

Experimental

Phosphate glass with the appropriate Mn^{2+} concentration of approx. 9.5×10^{20} ions/cm^3 was prepared for us by Schott, Mainz according to the recipe provided by A. Kisilev [2]. Rods of good optical quality with very few bubbles and little schlieren were drilled from the glass melt (15 mm × 120 mm).

Figure 1 shows the absorption spectrum of the Mn^{2+}-doped phosphate glass. It shows two main absorption peaks at 345 nm and 408 nm and a very weak one at 500 nm and is similar to that of $Mn:MgAl_2O_4$ recently published [3, 4].

Figure 2 shows the fluorescence spectrum of the Mn^{2+}-doped phosphate glass when excited at 415 nm. The fluorescence peaks at 611 nm and has a half-bandwidth of approximately 90 nm. The average fluorescence lifetime was measured to be 11.8 ms.

Because of the rather low absorption coefficient of Mn^{2+}, the rod was excited by six linear xenon flashlamps (ILC 4L 12) in a close-coupled polished aluminium reflector cavity. The pump pulse was ~5 ms (FWHM) and each lamp was coupled to 500 μF + 8 mH to provide a maximum pump energy of ~6 kJ per lamp. A 2 mm thin sheet of 2×10^{-4} M solution of stilbene 3 in ethylene glycol was inserted and flown between the lamps and the rod to provide additional pumping of the rod via fluorescence conversion of the dye. Figure 3 shows the cross section through the pumping chamber and the excitation pulse shape.

The experimental setup shown in Fig. 4 was used to measure the gain/absorption. An excimer laser (XeCl) pumped tunable dye laser (Sulforodamine B in methanol) provided the probe beam through the rod.

The beam intensity was measured before and after transmission through the rod with the rod unpumped and then pumped with the photodiodes PD1 and PD2 (ITT FW114A). A synchronisation circuit allowed the probe dye laser beam of ~10 ns width (FWHM) to be sent through the rod 5 ms after triggering the flashlamps so that enough pumplight could be integrated by the rod. The transmitted beam signal was delayed by about 50 ns with respect to the incident beam signal via 10 m RG58 cable so that both signals could be observed in a single shot on the oscilloscope screen (Tektronix 7104 with 7A26 plug-in in the add mode).

The results of the transmission measurements are summarized in Fig. 5. It is seen that there is increasingly strong attenuation of the 610 nm probe beam with increasing pumping of the rod. Similar results were obtained with probe beams at 596 nm and

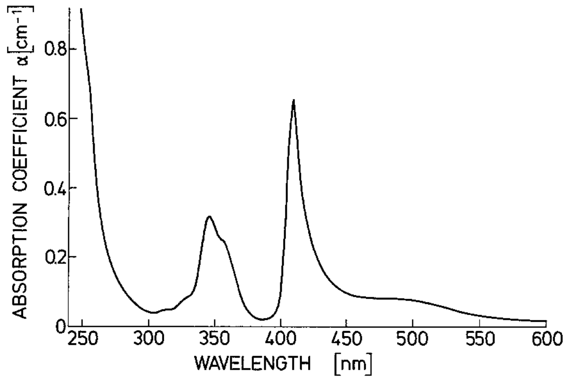

Fig. 1. Absorption spectrum of Mn^{2+}-doped glass

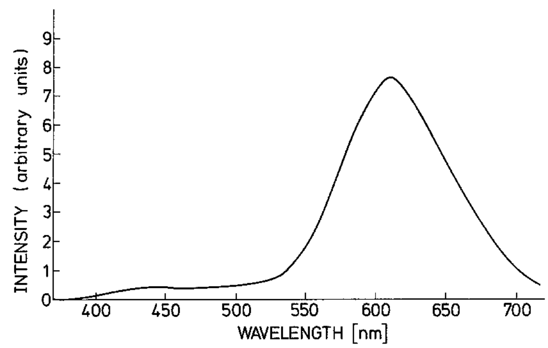

Fig. 2. Room temperature fluorescence spectrum of Mn^{2+}-doped glass

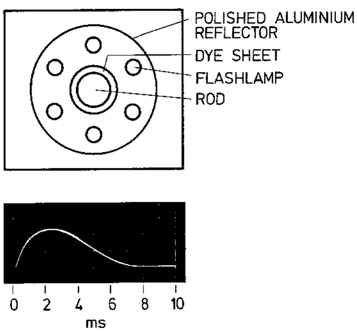

Fig. 3. Cross-section through the pump-chamber and the pump pulse shape

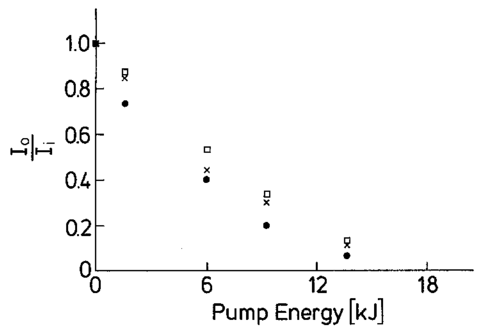

Fig. 5. Normalised transmitted probe signal dependence on the pump energy; □ 596 nm; × 610 nm; ● 626 nm

626 nm. These observations confirm the results of Petermann et al. [4] with Mn:$MgAl_2O_4$ in that excited state absorption reabsorbs the fluorescence of the Mn^{2+} and hence no laser action can take place in the Mn^{2+}-doped phosphate glass.

Conclusion

The measured Mn^{2+} spectra in phosphate glass clearly demonstrate that excited state absorption is an important and detrimental factor preventing laser action of Mn^{2+} ions.

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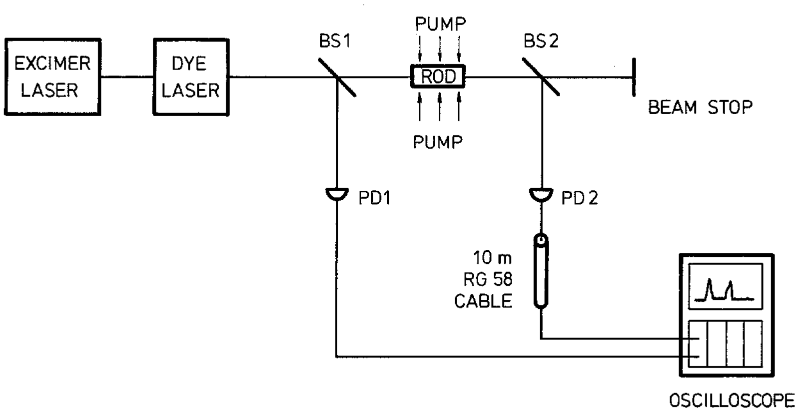

Fig. 4. Experimental setup for gain vs. excited state absorption measurements; BS1, BS2 beam splitters; PD1, PD2 photodiodes