L.3: Demonstration of self Q-switched lasing using in-house grown Cr:Nd:$GdVO_4$ single crystals

Of late, the neodymium-doped gadolinium orthovanadate (Nd:$GdVO_4$) single crystal has attracted lot of attention as a gain medium for diode pumped solid-state lasers with emission at ~1064 nm. Nd:$GdVO_4$ exhibits larger absorption as well as emission cross-sections for Nd and higher slope efficiency as compared to Nd:YAG. In addition, the segregation coefficient of Nd ion in the $GdVO_4$ is high that makes the growth of homogeneous and high quality crystal relatively easier. Therefore, in the recent past, Nd-doped $GdVO_4$ single crystals were grown in-house and CW lasing at 1064 nm was demonstrated in the fabricated [100]-oriented element using plane-plane mirror cavity having reflectivity of output coupler mirror as R_{out}= 89% and 808 nm pumping. An output power of ~9.1 W with a slope efficiency of ~42% was achieved for 24.4 W input pump power (Figure L.3.1).

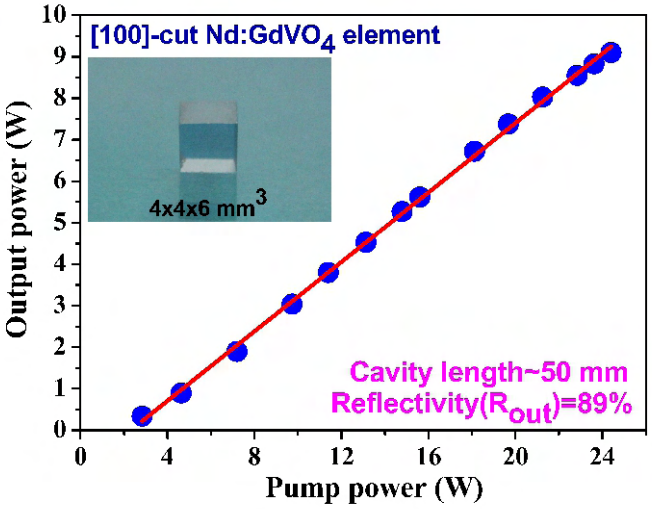

Fig. L.3.1: CW laser output of Nd:$GdVO_4$ crystal.

Further, the pulsed lasers, usually generated by an external Q-switching component like electro-optic modulator, saturable absorber, etc., are desirable for many practical applications. An alternate method to achieve pulsing is by self Q-switching in which ions like Cr^{5+} is co-doped in the gain medium. In this method, sutarable absorption characteristics of the Cr ion are exploited. Hence, in the present work, to achieve self Q-switching the growth of Cr co-doped Nd (0.5 at.%):$GdVO_4$ crystals with 1.0 and 1.5 at.% Cr concentrations in ambience having 10%, 20% and 25% oxygen was carried out by optical floating zone technique. Crystals of size 4-5 mm in diameter and 15-20 mm in length were grown as shown in inset of Figure L.3.2.

The investigation of the effect of the doping concentration and growth atmosphere on the optical properties revealed that with the increase of oxygen in growth ambience, the absorption of Cr^{5+} ion at 1100 nm (important for self-Q-switching) for π-polarized light increases for 1.5 at.% Cr, but decreases for 1.0 at.% Cr co-doping (Figure L.3.2).

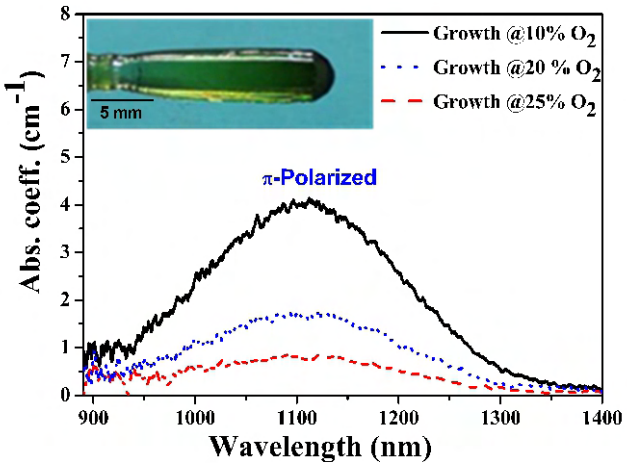

Fig. L.3.2: π-polarized absorption spectra exhibiting the absorption due to Cr^{5+} (Inset: Cr (1.0 at%):Nd (0.5 at%):$GdVO_4$ crystal grown in 20% oxygen ambience).

In accordance with the increase in oxygen in the growth ambience, the photoluminescence (PL) intensity at 1064 nm due to Nd ions increases for 1.0 at.% Cr and decreases for 1.5 at.% Cr co-doping. This observation suggests that both the growth ambience and Cr concentration play important roles in attaining a desired level of saturable absorption.

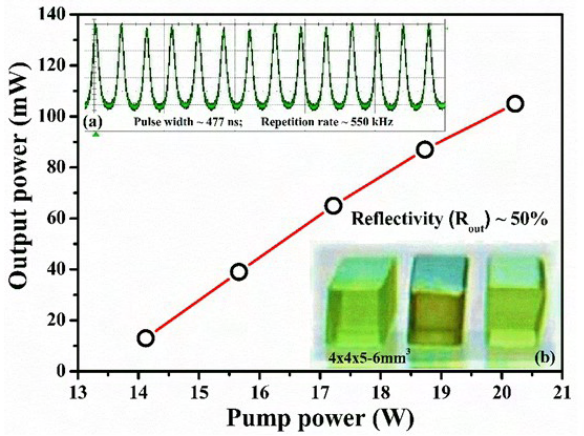

Fig. L.3.3: Pulsed laser output (Inset: (a) screen-shot of the pulsed output, (b) fabricated laser elements).

For self Q-switched pulsed lasing, [100]-oriented laser elements of size 4 x 4 x 5 mm^3 were fabricated from the grown crystals. A plane-plane mirror cavity having 50% output coupler mirror with 808 nm end pumping configuration was used for the lasing operation. For the 1.0 at.% Cr doped crystals grown in 10% oxygen, no lasing was observed due to high absorption of Cr as can be seen from the absorption data (Figure L.3.3). However, a stable pulsed output at 1066 nm with power ~105 mW, pulse width ~477 ns and repetition rate ~550 kHz was obtained in 1.0 at.% Cr co-doped crystal grown in 25% oxygen (Figure L.3.3). Hence, Cr co-doped Nd:$GdVO_4$ is a potential solid-state gain medium for making compact pulsed 1064 nm laser source.

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