## L.2: Growth of Nd:$LuVO_4$ single crystals and demonstration of CW Lasing

The rare earth doped $LuVO_4$ crystal shows excellent lasing property due to its higher absorption at pump wavelength and larger emission cross-section in comparison to the other orthovanadate ($YVO_4$ and $GdVO_4$) crystals. It also exhibits high damage threshold and better thermal properties. Particularly, Nd-doped $LuVO_4$ is considered as one of the excellent laser materials for generating laser emission near 1 µm.

In the present work, single crystals of 0.5 at% Nd doped $LuVO_4$ were grown by optical floating zone (OFZ) method using the [100]-oriented seed. The growth rate was optimized and kept 12-15 mm/h for obtaining good quality crystal. During the growth of the single crystals, a mixture of 20% of $O_2$ and 80% of $N_2$ was used at a flow rate of 1 l/min (LPM). Crystals of length ~15-30 mm and diameter 4-6 mm were grown (Fig. L.2.1(a)). The rocking curve of (200) plane exhibited a FWHM of ~130 arc-sec, and the nearly straight fringes observed in the birefringence pattern (Fig. L.2.1(b)) further confirmed the good crystalline quality.

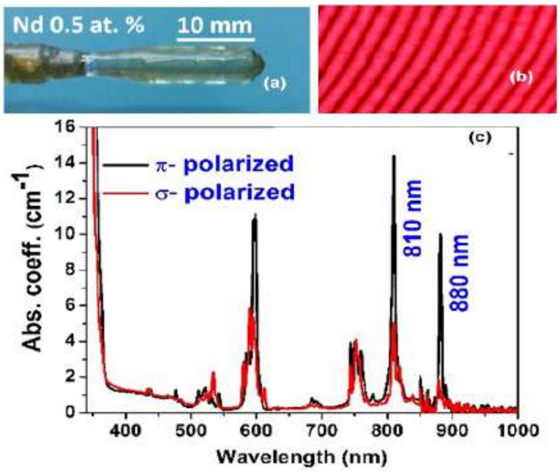


*Fig. L.2.1 (a) Photograph of an as-grown crystal, (b) Birefringence pattern, (c) Absorption spectra.*

Further, optical absorption was found to be polarization sensitive with higher absorption coefficient for π–polarized light. The coefficient at 810 nm is ~14.8 and 5.1 $cm^{-1}$ for π- and σ- polarization, respectively (Fig. L.2.1(c)). Emission spectra for excitation at 810 and 880 nm resulted peaks at ~916, 1065, 1087 and 1342 nm with highest emission intensity for 1065 nm (Fig. L.2.2).

Further, 'a'([100])-oriented laser elements of dimension ~4x4x7 $mm^3$ were fabricated [inset of Fig. L.2.3] from the grown crystals using Laue diffraction pattern (inset of Fig. L.2.3). The [100] direction was chosen as vanadates exhibit better absorption and emission characteristic along this direction.

These elements were precisely polished, achieving surface parallelism within 20-40 arc-seconds. Subsequently, to relieve the mechanical stress induced during cutting and polishing and to mitigate oxygen vacancies, the elements were annealed at 1100°C for 24 hours in a flowing oxygen atmosphere at 1 LPM. To minimize cavity losses, an anti-reflection (AR) coating of $SiO_2$, optimized for 808 and 1065 nm, was applied on both the entrance and exit faces using the Ion-assisted electron-beam evaporation.

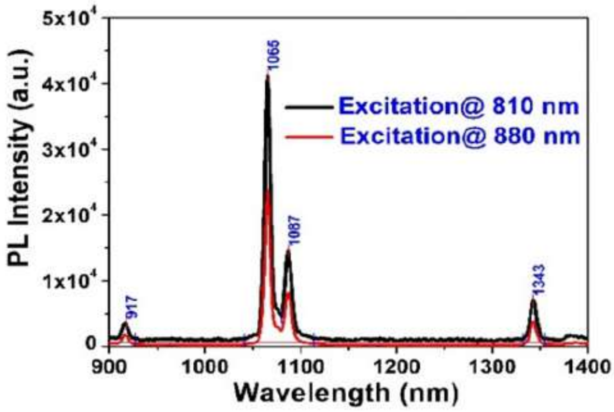


*Fig. L.2.2: Emission spectra of 0.5 at% Nd:$LuVO_4$*

To demonstrate the laser performance, a plane-parallel resonator with a cavity length of 35 mm was designed. Testing of lasing was conducted using an 808 nm diode laser as a pump source, along with an output coupler mirror with 89% reflectivity. Continuous-wave (CW) laser emission at 1065 nm was achieved, delivering an output power of ~10 W with a high slope efficiency of ~48.5%.

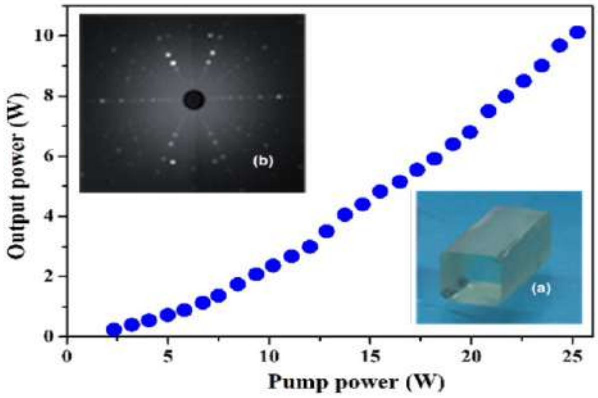


*Fig. L.2.3: Laser output [Inset: (a) A fabricated laser element and (b) Laue pattern].*

This work is significant for the development of diode pumped compact solid-state laser used for marking and engraving applications. This crystal also has a potential use in the laser ignition systems for Indian space programme.

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