L.1: Demonstration of Diode Pump Alkali (Rubidium) Laser

Diode Pump Alkali (K, Rb & Cs) Lasers (DPALs) are high quantum efficiency (η_Q> 95%) systems emitting coherent radiations in near-infrared region (λ ~ 800-900 nm). These lasers belong to high power & high beam quality class diode-laser pumped gas lasers. DPALs are envisaged as high power brightness converters of semiconductor diode lasers: a promising alternative to high average power (~kW class) solid state & fiber lasers, for numerous scientific & industrial applications. However, efficient absorption of the pump beam (owing to large mismatch of line-widths of the pump beam & alkali atom transitions), establishment of efficient gain through collision mixing of the laser levels and handling of the highly reactive alkalis are some of the severe challenging issues. With this perspective in view, in LSED, a program was taken up for feasibility study of one of the DPALs i.e. Rb-DPAL ($\lambda \approx$795 nm, η_Q> 98%) and a successful demonstration of the laser system was carried out.

In a Rb-DPAL (Fig. L.1.1), the lasant rubidium atoms are resonantly excited in their D_2 line ($5s\ ^2S_{1/2} \rightarrow 5p\ ^2P_{3/2}$) by using high power line-narrowed diode laser (AlGaAs, $\lambda \approx$ 780.25 nm) pump. The excited rubidium atoms subsequently undergo fast collisional quenching to level $5p\ ^2P_{1/2}$ through buffer gas atoms/molecules (He and/or C_2H_6/CH_4) and provide lasing action in their D_1 line ($5p\ ^2P_{1/2} \rightarrow 5s\ ^2S_{1/2}$). The buffer gases also broaden the atomic transitions for enhanced absorption of the pump beam.

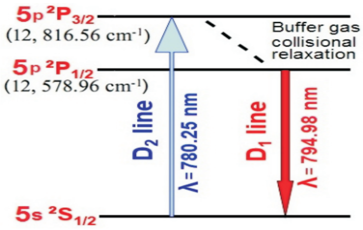
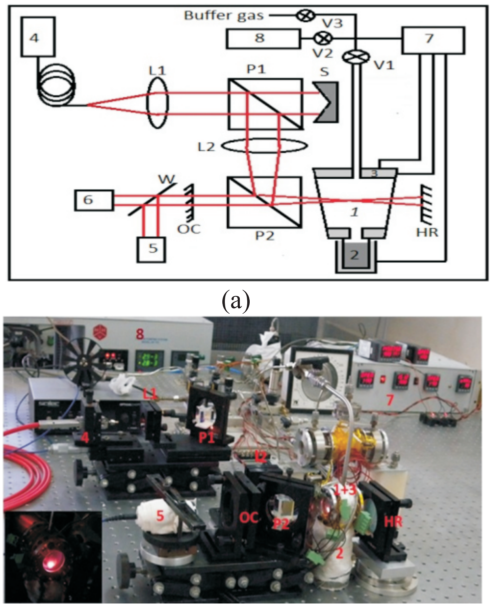


Fig. L.1.1: Energy level diagram of Rbfor Rb-DPAL

Figs. L.1.2 (a) & (b) show the schematic of the experimental set up and the photograph of the developed Rb-DPAL system. It consisted of an in-house developed SS-316 laser cell of internal diameter & length $\approx$ 50 mm (1) with a rubidium reservoir at bottom (2), encapsulated micro-heater assembly (3) separate for body, windows & rubidium reservoir, gas & vacuum handling set up (8) and PID based temperature & buffer gas pressure monitoring system (7). The laser active medium was end-pumped by line-narrowed fiber coupled diode laser (4) (λ ~780 nm, $\Delta\lambda$ ~ ± 0.6 nm) using a pair of beam splitting cube polarisers (P1 & P2) & spherical lens of focal length 15 cm (L2). The laser build up was monitored using a fiber coupled spectro-photometer (5) & infrared sensor (6). High purity (~98%) Rubidium was transferred into the laser cell in a glove box.



(a)

(b)

Fig. L.1.2: Schematic (a) & photograph (b) of the developed Rb-DPAL system in operation (inset on the bottom left corner: bright DPAL fluorescence)

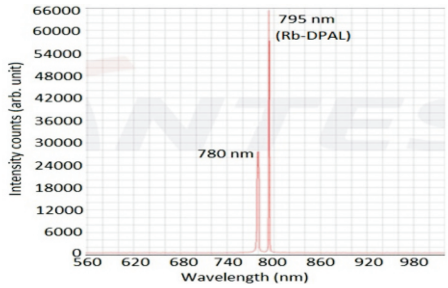


Fig. L.1.3: Spectro-photometer trace of the Rb-DPAL

The optical resonator consisted of a high reflecting plane mirror (HR, reflectivity > 99%) & a plane output coupler of reflectivity ~60% (OC), separated by a distance of about 30 cm. The intra-cavity cube polarizer P2 reflected the 780 nm s-polarized pump beam (~8 W average power) into the laser cell and allowed transmission of 795 nm DPAL beam to build up with orthogonal (p) polarization. At the cell temperature of 140 °C and buffer gas (He) pressure of ~ 3 bar (corresponding to the measured pump beam absorption of ~30% per pass), lasing action was observed (Fig.L.1.3). The lasing action was confirmed by alignment/misalignment of the optical resonator. Further detailed study in terms of effect of different operating parameters, buffer gas mixture & resonator configurations to identify efficient lasing conditions are in progress.

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