Notification No: 545/2023
Date of Award:15-09-2023

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Topic of Research: Investigations of Fluid Medium Lasers and Their Scalability Aspects

Findings

- Fluid medium lasers specifically flowing gas medium COIL and rare-earth ions dissolved inorganic aprotic solvent host based flowing liquid medium Nd^{3+}:$POCl_3$:$SnCl_4$ laser have been investigated for their scalability aspects.

- Flowing gas medium COIL as a scalable laser is the most promising candidate that can provide MW class power with near diffraction limited laser beam through single aperture, but its slow operation, large size, heavy weight and logistic burden are few challenges which restrict its practical deployment. One of the contributing sub-systems towards larger size and weight of COIL source is the resonator assembly which along with several associated components is coupled with laser cavity to extract the laser power.

- In the present research work, an innovative decoupling mechanism between optical mirrors of resonator and laser cavity is implemented. The decoupling isolates the low pressure laser cavity from the resonator mirrors. It greatly simplifies alignment of resonator optics. Once the resonator optics are aligned, the assembly is unaffected by the occurrence of shocks and vibrations occurred during COIL operation thereby eliminating the need for repeated alignments.

- The implemented decoupling mechanism removes several associated components which efficiently reduce the overall length and weight of the COIL source up to 20-30% making it convenient for use in transportable platform more effectively.

- The technique also improves the readiness time of the COIL source by providing anytime alignment and checking of the resonator.

- The research work is carried out to investigate the scalability aspects in transversely flowing Nd^{3+}:$POCl_3$:$SnCl_4$ liquid laser medium which is optically pumped using high power laser diode stacks under suitable optical configuration.

- Liquid laser mediums consisting of inorganic aprotic $POCl_3$ solvent host with Lewis acid $SnCl_4$ having different Nd^{3+} doping molarities from 0.1 M to 0.3 M have been synthesized. The compact and modular opto-electronic setups for absorption, emission, lifetime and medium transmission loss measurements have been successfully realized and utilized in iterative manner for optical characterization studies of synthesized liquid medium for preparing high quality liquid laser medium.

- Two optical configurations for inorganic aprotic liquid medium laser keeping in view the scalability aspects have been proposed. Laser kinetic modeling using space dependent laser rate equations have been performed in order to estimate the input-output parameters

of laser diode-pumped rare earth Nd^{3+} ions dissolved inorganic aprotic liquid laser. A set of optimized parameters is obtained for designing an efficient transversely diode pumped flowing liquid laser. These theoretical calculations can further be extended for liquid laser medium with large cross-section for designing the scaled-up laser.

- In order to check the efficacy of the optical configuration and to validate the design parameters, experimental setup consisting of various major components such as optical pump source, laser cavity, circulation system and heat exchanger of liquid laser have been realized using liquid medium compatible material.

- These components have been successfully integrated and rigorously tested for their readiness and optimization of flow parameters. Thermal studies using He-Ne laser as a probe beam in flowing liquid laser medium have been performed to observe the medium response under high power laser diode pumping. It is inferred that the circulating liquid medium largely mitigates the convective heating effect occurring in the sealed-off static medium and is capable of handling high pump irradiance.

- At high pumping power, there is a likelihood of deterioration in beam quality owing to non-uniform heat loads which also impacts the medium response. Therefore, it is imperative to measure the small-signal gain in the flowing liquid laser medium before conducting the lasing experiment. Amplification method is used to measure the small-signal gain in the liquid laser medium using Nd:YLF laser at 1053 nm wavelength as a probe signal.

- An experimental setup is developed for the small-signal gain measurement which helps in investigating the liquid medium response under high power laser diode pumping. The liquid medium is circulated transversely through the laser cavity under laminar flow regime at flow rates of 15-20 lpm to mitigate the thermal induced effects.

- The spatial (2-D) profile of the small-signal gain is also plotted to check the uniformity of the gain distribution in the active region of the laser cavity. The detailed experimental and theoretical results of the small-signal gain measurements are indicative that high power laser diode-pumped flowing Nd^{3+}:$POCl_3$:$SnCl_4$ liquid laser medium under suitable optical configuration provides uniform gain distribution which is conducive for development of scalable laser.

1. Summary of Abstract (only 2 pages)

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