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Review

Technology and engineering aspects of high power pulsed single longitudinal mode dye lasers

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Abstract

Tunable single mode pulsed dye lasers are capable of generating optical radiations in the visible range having very small bandwidths (transform limited), high average power (a few kW) at a high pulse repetition rate (a few tens of kHz), small beam divergence and relatively higher efficiencies. These dye lasers are generally utilized laser dyes dissolved in solvents such as water, heavy water, ethanol, methanol, etc. to provide a rapidly flowing gain medium. The dye laser is a versatile tool, which can lase either in the continuous wave (CW) or in the pulsed mode with pulse duration as small as a few tens of femtoseconds. In this review, we have examined the several cavity designs, various types of gain mediums and numerous types of dye cell geometries for obtaining the single longitudinal mode pulsed dye laser. Different types of cavity configuration, such as very short cavity, short cavity with frequency selective element and relatively longer cavity with multiple frequency selective elements were reviewed. These single mode lasers have been pumped by all kinds of pumping sources such as flash lamps, Excimer, Nitrogen, Ruby, Nd:YAG, Copper Bromide and Copper Vapor Lasers. The single mode dye lasers are either pumped transversely or longitudinally to the resonator axis. The pulse repletion rate of these pump lasers were ranging from a few Hz to a few tens of kHz. Physics technology and engineering aspects of tuning mechanism, mode hop free scanning and dye cell designs are also presented in this review. Tuning of a single mode dye laser with a resolution of a few MHz per step is a technologically challenging task, which is discussed here.

Keywords: Pulsed dye lasers; Single longitudinal mode; Tunable lasers; Tuning mechanisms; Dye gain medium

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Contents

1. Introduction

This paper presents a literature review on pulsed single longitudinal mode (SLM) dye lasers, which is an important source of tunable radiation in the visible and near visible region of the electromagnetic spectrum. This class of laser has excellent properties, such as broad tunability, high peak power and potential for obtaining extremely low bandwidths. The broad electronic levels characteristic of the organic dyes provide wide tunability. The dye laser can be operated in the single mode with linewidth in the range of a few tens of MHz and can be tuned essentially to any wavelength in the visible and near visible range. It is possible to extend the tunability of single mode dye laser using non-linear processes such as second harmonic generation (SHG) and sum frequency mixing (SFM). The broad tuning range and narrow linewidth of the single mode dye laser provide higher resolutions; for example, a single mode dye laser operating with a linewidth of a few MHz, having a tuning range in nanometers is capable of spectral resolution of $\sim 10^8$ across its tuning range.

The first pulsed dye laser was demonstrated by Sorokin and Lankard [1]; they had observed stimulated emission of spectral width of 150 GHz ($\sim 5\ cm^{-1}$ that is, $1\ cm^{-1} \sim 30$ GHz) at 755 nm from solutions of an organic dye chloro-aluminum phthalocyanine, while pumping by a ruby laser. Schafer et al. [2] had independently observed stimulated emission while studying saturation and hole burning in organic dyes of the cyanine type by absolute intensity measurement of the ruby laser induced fluorescence. They had used purely organic dyes dissolved in the various organic solvents in the concentration range of 10^{-3} to 10^{-6} mol/l. A giant ruby laser pulse was used to pump the dye solutions contained in a plane parallel cuvette, which acts as a resonator cavity and generates megawatts of peak power, wavelength from 730–830 nm, beam