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Proposed Design of an Optimized Transient Cavity Picosecond Ultraviolet Laser

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Abstract : There is a great deal of interest in developing all-solid-state tunable ultrashort pulsed lasers emitting in the ultraviolet (UV) region for applications such as micromachining, investigation of charge carrier relaxation in conductors, and probing of ultrafast chemical processes. However, direct short-pulse generation is not as straight forward in solid-state gain media as it is for near-IR tunable solid-state lasers such as Ti:sapphire due to the difficulty of obtaining continuous wave laser operation, which is required for Kerr lens mode-locking schemes utilizing spatial or temporal Kerr type nonlinearity. In this work, the transient cavity method, which was reported to generate ultrashort laser pulses in dye lasers, is extended to a solid-state gain medium. Ce:LiCAF was chosen among the rare-earth-doped fluoride laser crystals emitting in the UV region because of its broad tunability (from 280 to 325 nm) and enough bandwidth to generate 3-fs pulses, sufficiently large effective gain cross section (6.0 x10^{-18} cm^2) favorable for oscillators, and a high saturation fluence (115 mJ/cm^2). Numerical simulations are performed to investigate the spectro-temporal evolution of the broadband UV laser emission from Ce:LiCAF, represented as a system of two homogeneous broadened singlet states, by solving the rate equations extended to multiple wavelengths. The goal is to find the appropriate cavity length and Q-factor to achieve the optimal photon cavity decay time and pumping energy for resonator transients that will lead to ps UV laser emission from a Ce:LiCAF crystal pumped by the fourth harmonics (266nm) of a Nd:YAG laser. Results show that a single ps pulse can be generated from a 1-mm, 1 mol% Ce^{3+}-doped LiCAF crystal using an output coupler with 10% reflectivity (low-Q) and an oscillator cavity that is 2-mm long (short cavity). This technique can be extended to other fluoride-based solid-state laser gain media.

Keywords : rare-earth-doped fluoride gain medium, transient cavity, ultrashort laser, ultraviolet laser
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