High Power Visible Solid-State Lasers

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ABSTRACT

Recent progress in power-scaling of diode-pumped visible solid-state sources using intracavity-frequency-doubling and single-pass (extra-cavity) nonlinear frequency conversion in periodically-poled lithium niobate will be dicsussed.

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Visible light generation via nonlinear frequency conversion of diode-pumped solid-state lasers is an area which has attracted growing interest over recent years owing to the numerous applications for such sources in areas such as display technology, medicine and optical pumping of solid-state lasers. For many of these applications the requirement for high average power, as well as high efficiency and wavelength diversity, has itself resulted in numerous developments in the power-scaling of solid-state lasers and in techniques for efficient nonlinear frequency conversion, including new nonlinear materials such as periodically-poled lithium niobate.

At present one of the most attractive routes to efficient visible (green) light generation at multiwatt cw power levels is via intracavity-frequency-doubling of Nd lasers [1],[2] in a single-frequency ring configuration. The design of such lasers however, has the problem that the high nonlinear loss at the fundamental (due to second harmonic generation) can itself be detrimental to the laser performance since the laser will try to oscillate in various ways which avoid the nonlinear loss resulting in a decrease in efficiency. Thus optimising the design of such lasers poses some interesting problems which will be discussed.

A particularly interesting feature of this approach for visible light generation is that the output frequency can be continuously tuned over many axial mode spacings by simple adjustment of the cavity length [3]. The explanation for this behaviour is based on the fact that adjacent (non-lasing) axial modes are further suppressed by an additional loss due to sum-frequency generation which is twice the loss due to second harmonic generation experienced by the lasing mode. In a low loss resonator with efficient frequency doubling this additional loss is more than sufficient to offset the increase in gain of non-lasing modes as they move closer to the gain peak. The net result is that continuous (mode-hop free) tuning is possible over a significant fraction of the gain bandwidth.

To investigate this effect experiments have been performed on intracavity-frequency-doubled Nd:YAG and Nd:YLF ring lasers end-pumped by 20W diode bars. In the case of Nd:YLF, when pumped by two 20W diode bars, ~6.2W single-frequency green output at 526.5nm (corresponding to ~8.5W generated internally in the LBO crystal) was achieved, and a mode-hop-free tuning range of ~72GHz, corresponding to ~150 axial mode spacings. The prospects for a further increase in green power and extension of the mode-hop-free tuning range will be discussed.

Single-pass, extra-cavity frequency-doubling of diode-bar-pumped Nd:YAG lasers at 946nm and ~1.32μm to generate blue light at 473nm and red light at ~660nm respectively, and frequency tripling of ~1.32μm to blue light at ~440nm in periodically-poled lithium niobate have also been investigated. The relatively simplicity of this approach combined with the high nonlinear coefficient of periodically-poled lithium niobate suggests that it may be a promising alternative to intracavity-frequency-doubling for the generation of visible light at high average powers. Recent results will be presented.

References

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