Conference 7197: Nonlinear Frequency Generation and Conversion: Materials, Devices, and Applications VIII

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Nonlinear Frequency Generation and Conversion: Materials, Devices, and Applications VIII

7197-01, Session 1

Tunable, high-power, solid state sources for the blue and ultraviolet

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High-power solid-state laser sources offering wide tunability in the blue and ultraviolet are of interest for a variety of applications in spectroscopy, laser displays, optical data storage, medical diagnostics, biophotonics, and underwater communication. After nearly 50 years since the invention of the laser, however, practical development of such short-wavelength sources remains illusive because of the scarcity of viable solid-state laser gain materials in the blue and ultraviolet spectral range.

Optical parametric oscillators (OPOs) represent promising alternatives for the generation of tunable coherent radiation in spectral regions inaccessible to lasers. However, more than four decades after the demonstration of the first device, the wavelength range available to OPOs has also remained confined mainly to the near- to mid-IR spectrum. With the advent of new nonlinear materials and laser pump sources, and by deploying additional frequency conversion techniques, it is now feasible to exploit OPO technology for the development of practical solid-state sources capable of providing wide wavelength coverage, high output power, and excellent beam quality in the blue and ultraviolet. By deploying the quasi-phase-matched nonlinear material of MgO:sPPLT in combination with birefringent crystals of BiB3O6 and -BaB2O4 in novel design configurations, we have developed a cw OPO capable of delivering nearly 450 mW of continuous-wave, single-frequency radiation with wide tunability across 425-489 nm in the blue. Using a similar approach based on internal frequency doubling of a femtosecond OPO, we have also generated average powers of up to 225 mW across 250-355 nm in the ultraviolet in 130-fs pulses.

7197-02, Session 1

Highly efficient, compact green laser for laser tv

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We have been conducting the trial manufacture of laser TV's. For the realization of a laser TV, high power laser light sources with the three primary colors are key technologies. Considering many severe requirements as light sources of TV such as size, efficiency, reliability, cost, etc, laser diode (LD) is the most suitable laser light source. Fortunately recently advanced high power edge-emitting laser diodes (LD's) for DVD writing sources could be utilized for red and blue laser light sources for laser TV with slightly modified wavelengths of 640nm and 447nm. On the other hand, LD has not generated high power green light yet, and Second Harmonic Generation (SHG) of 1060nm laser light is believed to be the only technique for high power green light generation. Unfortunately, commercial SHG green lasers using common solid state laser technologies are so big, inefficient, unreliable and costly that it could not be adopted to a laser TV. To improve the green laser performance dramatically and complete the green laser for laser TV, we have introduced a planar-waveguide solid-state laser technologies and newly developed a highly efficient, high-power and ultra-compact green laser for a light source of laser TV. A planar-waveguide configuration improves performance of solid-state green laser dramatically. The laser consists of essential minimum 3 devices (a pump LD, a planar-waveguide Nd:YVO4 and a planar-waveguide PPMgLN). Output green average power of more than 10-W with the corresponding electrical efficiency of 20% is demonstrated. The size of developed laser module is as small as 5cc. The detailed scheme and performance of the developed green laser are reported.

7197-03, Session 1

High-efficiency high-power solid state CW visible lasers for large-format-display applications

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High-efficiency (5 % - 10 % wall-plug efficiency) high-power CW visible lasers have been developed for large-format-display applications (e.g., planetariums, visualization centers, etc.). Using an approach pioneered by Evans & Sutherland (E&S),* a fiber-based master-oscillator-power-amplifier architecture is employed to generate high-power NIR tunable lasers that are then converted to visible wavelengths in external-enhancement nonlinear ring cavities. Depending on the wavelength generated, either second-harmonic generation or sum-frequency mixing (or both) in lithium triborate are utilized to convert 1064 nm and/or 1550 nm to visible wavelengths, with NIR-to-visible optical-conversion efficiencies of 65 % - 95 % routinely obtained. The resulting visible lasers are single-axial-frequency (FWHM bandwidth < 200 kHz) spatially pure ($m^2 < 1.05$) Gaussian beams, and are used as light sources in ultrahigh-resolution projectors manufactured by E&S. The current systems reliably produce 6 W of visible-laser power at 448 nm, 532 nm, and 631 nm, with short-term CW operation yielding up to 18 W visible-laser output per color. Laser-induced damage (LID) on nonlinear-crystal facets is the primary limitation to long-term operation at visible powers > 6 W, and efforts are underway to increase crystal LID thresholds to allow reliable operation at greater power levels.

* F L Williams, Y S Grapov, D F Elkins and A H Tanner, "Apparatus and method for frequency conversion and mixing of laser light," US Patent No. 6,763,042.

7197-04, Session 1

70-Watt green laser with near diffraction-limited beam quality

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A 70-Watt green laser with M2 < 1.4 has been demonstrated. The system consists of an all-fiber-based IR pump laser at 1064 nm and a frequency-conversion module in a compact and flexible configuration. The IR laser produces up to 150 Watt polarized diffraction-limited output beam with high spectral brightness for frequency conversion. The IR laser operates in QCW mode, with 10 MHz pulse repetition frequency and 4 ns pulse width, to generate sufficient peak power for frequency doubling in the converter module. The converter module has an input telescope and an oven with a nonlinear crystal to efficiently convert the 1064-nm IR fiber laser output to 532-nm green beam. The IR laser and conversion module are connected via a 5-mm diameter stainless-steel protected delivery fiber for optical beam delivery and an electrical cable harness for electrical power deliver and system control. Both the IR laser and converter module are run through embedded software that controls laser operations including automated warm up and shut down. An overview of the system and full characterization results will be presented. Such compact, high-brightness green laser sources are expected to enable various scientific as well as industrial applications.