IX-S Development and Research of Advanced Tunable Solid State Lasers

Diode-pumped solid-state lasers can provide excellent spatial mode quality and narrow linewidths. The high spectral power brightness of these lasers has allowed high efficiency frequency extension by nonlinear frequency conversion. Moreover, the availability of new and improved nonlinear optical crystals makes these techniques more practical. Additionally, quasi phase matching (QPM) is a new technique instead of conventional birefringent phase matching for compensating phase velocity dispersion in frequency conversion. These kinds of advanced tunable solid-state light sources, so to speak "Chroma Chip Lasers," will assist the research of molecular science.

In this projects we are developing Chroma Chip Lasers based on diode-pumped-microchip-solid-sate lasers and advanced nonlinear frequency conversion technique.

IX-S-1 300W Continuous-Wave Operation of Diode Edge-Pumped, Hybrid Composite Yb:YAG Microchip Laser

TSUNEKANE, Masaki; TAIRA, Takunori

[*Opt. Lett.* **31**, 2003–2005 (2006)]

300 W continuous-wave operation of a diode edge-pumped, hybrid (single-crystal/ceramic) composite, Yb^{3+} :YAG microchip laser with a 5-mm-diameter and 300-µm-thickness, single-crystal core uniformly bonded to a water-cooled heat-sink by the new Au–Sn soldering system has been demonstrated. The beam quality factor, M^2 follows the mode-mismatch between the core and the fundamental mode, and was improved to 17 with the maximum output power of 230 W. The thermally induced convex mirror with a spherical radius of curvature ranging from –2.5 to –1.5 m, which decreases as the pump power increases by thermal deformation of a microchip, was observed.

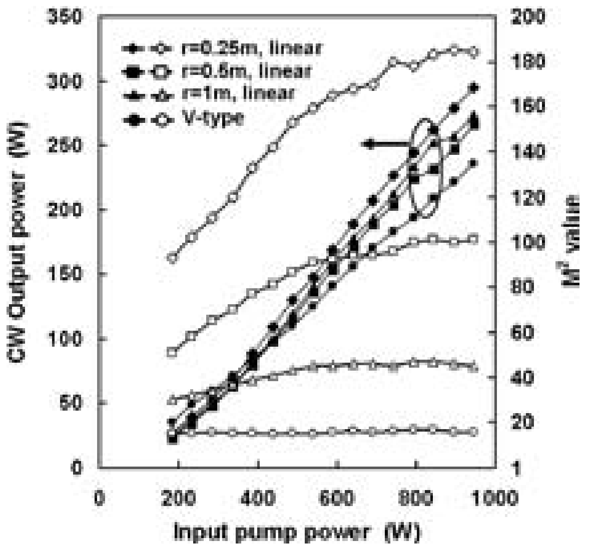

Figure 1. CW output power and the beam quality characteristics (M^2 factor) with four different cavity configurations as a function of input pump power.

IX-S-2 Spectroscopic Properties and Laser Emission in Layer-by-Layer Type Nd:$Y_3ScAl_4O_{12}$/Nd:$Y_3Al_5O_{12}$ Composite Ceramics

SATO, Yoichi; TAIRA, Takunori; IKESUE, Akio[1]
(*[1]JFCC*)

[*OSA Topical Meeting of Advanced Solid State Photonics* TuB3 (2006)]

We have fabricated the all-ceramic layered composite device with Nd:YAG and Nd:YSAG, which can perform efficient laser oscillation. From its spectroscopic properties, this layer-by-layer composite device will offer new function of laser oscillation by pump wavelength tuning. For example when pumped from YSAG side at 810.5 nm, it can oscillate at 1064 nm. On the other hand, it will oscillate at 1061 nm when pumped at 808.5 nm.

Due to the difference in the dependence on the wavelength of, the portion of the pumped power absorbed in Nd:YAG-layer and in Nd:YSAG-layer depends on the pumping wavelength. This resulted in the tuning of the component ratio of the Nd:YAG and Nd:YSAG in the fluorescence. The dependence of fluorescence profiles in this composite on the pump wavelength is shown in Figure 1.

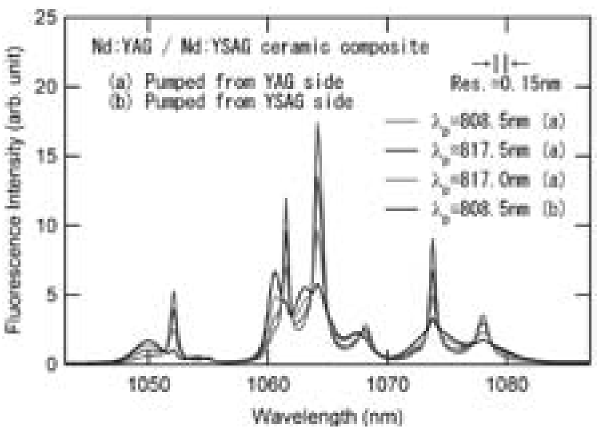

Figure 1. Measured fluorescent spectral profiles by changing pumping wavelength.

IX-S-3 Thermal Properties of $Y_3Al_5O_{12}$, $GdVO_4$, and YVO_4

SATO, Yoichi; TAIRA, Takunori

[*Conf. Lasers Electro-Optics* JThC30 (2006)]

We have measured thermal conductivity of $Y_3Al_5O_{12}$, $GdVO_4$, and YVO_4. In order to avoid the miss leading from three-dimensional (3D) thermal diffusion, we developed the quasi-one-dimensional (q1D) flash method. By taking in account the heat radiation effect in transparent materials for this measurement, YVO_4 was found to have larger thermal conductivity than $GdVO_4$. The measured thermal conductivities were 12.1, 10.5, 10.1, 8.9, and 8.5 W/mK for *c*-cut YVO_4, *c*-cut $GdVO_4$, YAG, *a*-cut YVO_4, and *a*-cut $GdVO_4$, respectively. The measured value in the range from room temperature to 200 °C is shown in Figure 1. The dependence of Nd-conductivity coefficient ($d\kappa/dC_{Nd}$) for convenient evaluation of the doping effect in thermal conductivity is also discussed.

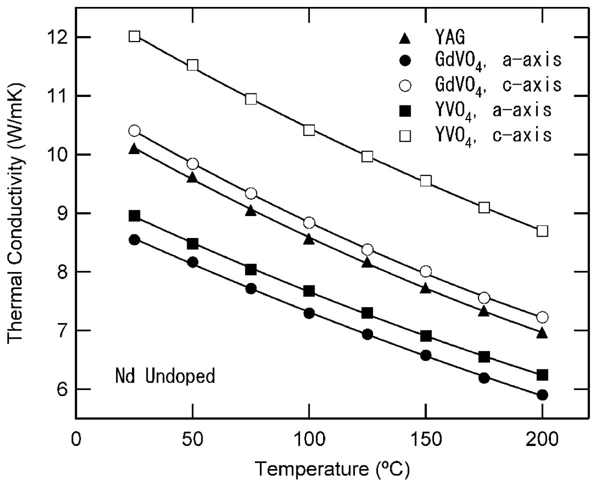

Figure 1. Thermal conductivities of undoped YAG, $GdVO_4$, and YVO_4.

IX-S-4 Spectroscopic Properties and Laser Operation of RE^{3+}-Ion Doped Garnet Materials

TAIRA, Takunori; SATO, Yoichi; SAIKAWA, Jiro; IKESUE, Akio[1]
([1]JFCC)

[*Proc. SPIE* **6216**, 62160J (2006)]

Lately developed RE^{3+}-ion-doped disordered laser ceramic materials, $Y_3Sc_xAl_{5-x}O_{12}$, which are a solid solution of YAG and $Y_3Sc_2Al_3O_{12}$ (YSAG), have been interested in because of its compositional tuning of parameter *x*. The disordered $Y_3ScAl_4O_{12}$ (YAG/YSAG) ceramics exhibit relatively low minimum pump intensity (I_{min}) and broad emission bandwidth. The value of I_{min} in the Yb:$Y_3ScAl_4O_{12}$ ceramics was found to be 2/3 compared with the Yb:YAG single crystal under 970nm zero-line pumping. Efficient laser oscillation of 72% slope efficiency was obtained for input power. Next, we have demonstrated passively mode-locked Yb:$Y_3Sc Al_4O_{12}$ disordered ceramic laser by using a semiconductor saturable-absorber mirror. Pulses as short as 280 fs having an average power of 62 mW at 1035.8 nm was obtained as shown in Figure 1. As a conclusion, the possibility of tailored fluorescence spectral profile in layer-by-layer type ceramic composite is also discussed.

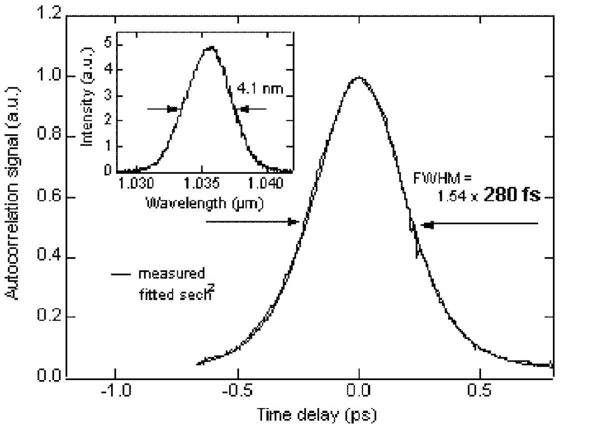

Figure 1. Second-harmonic autocorrelation trace and spectrum (inset) for the shortest-pulse generation with a 0.5% output coupler. The solid-line indicates ideal $sech^2$ shape.

IX-S-5 Comparative Study on the Spectroscopic Properties of Nd:$GdVO_4$ and Nd:YVO_4 with Hybrid Process

SATO, Yoichi; TAIRA, Takunori

[*IEEE J. Sel. Top. Quantum Electron.* **11**, 613 (2005)]

We have proposed the hybrid procedure of determining spectroscopic parameters for uniaxial solid-state laser crystals. Figure 1 shows the procedure of this process. By using our procedure the spectroscopic properties of Nd:$GdVO_4$ were evaluated and compared to those of Nd:YVO_4. The product of stimulated emission cross section and fluorescence lifetime ($\sigma\tau$ product) of Nd:$GdVO_4$ was smaller than that of Nd:YVO_4 under 1.0-at.% of Nd^{3+}-doping concentration. Because of the low value of radiative quantum efficiency of Nd:$GdVO_4$ (50%), careful cavity design is required for creating a well performing solid-state laser with Nd:$GdVO_4$, based on the larger $\sigma_{em}\tau_f$ product than $\sigma_{em}\tau_f$ product of Nd:YAG.

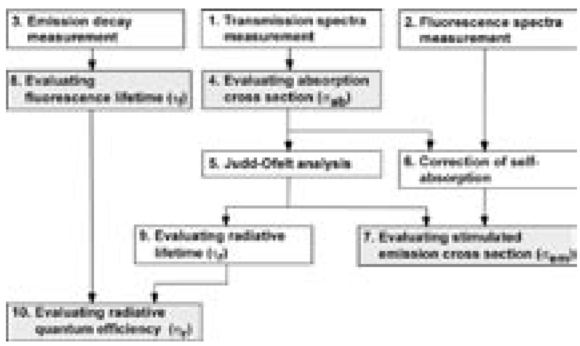

Figure 1. Flow-chart of the Hybrid process in this work.

IX-S-6 High-Energy, Narrow-Bandwidth 2-µm Optical Parametric Oscillator/Power Amplifier Based on Periodically Poled MgO:$LiNbO_3$

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([1]Tokyo Tech)

[*Conf. Lasers Electro-Optics* CThG3 (2006)]

We demonstrated a high-energy, high-efficiency quasi-phase-matched optical parametric oscillator/power amplifier system based on 5×5 mm^2 large aperture periodically poled MgO:$LiNbO_3$. Maximum pulse energy of 52 mJ (optical conversion efficiency of 60%) with resolution limit spectral bandwidth of < 2 nm at 2.128 μm degeneracy point was obtained. These experimental result shows that large aperture PPMgLN device is useful for the development of the high-energy, efficient, narrowband 2μm light source.

IX-S-7 High-Energy Quasi-Phase Matched Optical-Parametric Oscillation in Periodically Poled MgO:$LiNbO_3$ Device with 5 mm x 5 mm Aperture

ISHIZUKI, Hideki; TAIRA, Takunori

[*Opt. Lett.* **30**, 2918–2920 (2005)]

Fabrication of 5mm-thick periodically poled MgO-doped $LiNbO_3$ device with 32.1μm period for mid-infrared generation was demonstrated. The periodic structure was evaluated by measurement of second-harmonic generation with d_{31}-coefficient. Optical-parametric oscillation using the device with uncoated 5 mm $\times$ 5 mm aperture and 36mm effective length realized a high-energy output of 77 mJ for both signal (wavelength: 1.83 μm) and idler (2.54 μm) waves with 72% slope efficiency at 110mJ pumping of Q-switched Nd:YAG laser with 12ns pulse duration.