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Highly efficient cavity-dumped Q-switched Alexandrite laser

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Alexandrite as laser active medium has many benefits for spaceborne earth observation missions, e.g. a tunable laser wavelength in the range of 700 to 850 nm, a high thermal conductivity (23 $Wm^{-1}K^{-1}$) and a good breaking strength [1]. Another advantage is the high efficiency due to the small quantum defect, especially if used in laser diode-pumped systems. Therefore, Alexandrite lasers are good candidates to be used in LIDAR applications like altimetry or vegetation monitoring, in which pulse durations in the nanosecond range and high pulse repetition frequencies (PRF) are required.

We present an enhanced cavity-dumped Q-switched Alexandrite laser with CW double-pass diode pumping to achieve high-efficiency and short-pulse laser operation in a PRF range of 1-20 kHz. For the L-shaped laser system (see Fig. 1a), a 0.22 at%-doped Alexandrite crystal with an aperture of 4 x 4 mm² and a length of 10 mm was embedded in a thermoelectric cooler controlled copper mount to tune the crystal temperature between 25 °C and 120 °C. The crystal was pumped by a fiber-coupled laser diode offering maximum 43 W at a center wavelength of 638 nm. A retro-reflecting pump-optic (PO) was used to optimize the amount of pump absorption (90 %). The beam at the focus position inside the crystal had a super-Gaussian shape with a diameter of 320 µm. The cavity was implemented using an input coupler (IC), a bending mirror (BM) and a highly reflecting end mirror (HR). Cavity-dumped Q-switching was achieved by an integrated BBO Pockels cell in combination with a quarter-wave plate (QWP) and a thin-film polarizer (TFP). The laser pulse inside the cavity built up during the switching-on time of the Pockels cell and was coupled out at the TFP by rapidly switching off the high voltage. During the measurements, the delay between switching on and off as well as the axial pump focus position was optimized to reach the maximum output energy.

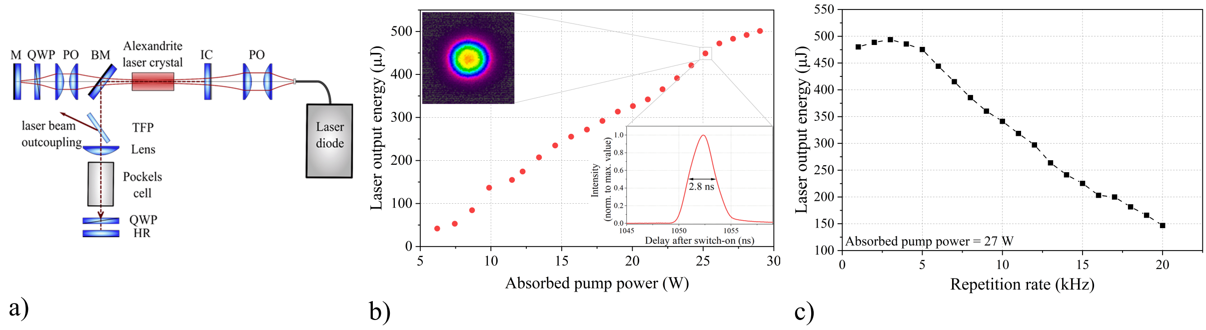

Fig. 1 a) Schematic drawing of the cavity-dumped Q-switched Alexandrite laser with double-pass diode pumping; b) Laser output energy as a function of the absorbed pump power, inset: temporal pulse shape with 2.8 ns FWHM and beam profile at around 25 W absorbed pump power; c) Variation of the pulse energy with PRF, measured for an absorbed pump power of 27 W.

The laser output characteristics achieved with the setup are shown in Fig. 1b for a PRF of 5 kHz. A maximum output energy of more than 500 µJ (average power of 2.5 W) at 755 nm with a pulse duration of 2.8 ns could be achieved, which results in a record peak power exceeding 179 kW reached within a cavity-dumped Q-switched Alexandrite laser with CW diode pumping (more than twice of the value found in literature [2]). Moreover, the optical-to-optical efficiency could be improved from 5.0 % to 8.2 % using the fiber-coupled laser diode with a super-Gaussian beam profile at the pump focus position inside the crystal. The beam profile of the laser output, shown in the inset of Fig. 1b, revealed a TEM_{00} mode beam with $M_x^2 = 1.33$ and $M_y^2 = 1.42$. During a long-term stability measurement at an output energy of around 350 µJ with 5 kHz PRF, no degradation over 150 megashots was observed. The variation of the pulse energy with the PRF adjusted in the range of 1 kHz to 20 kHz at a fixed pump power of 27 W is illustrated in Fig. 1c. The resulting curve shows a maximum at 3 kHz and a nearly linear decrease afterwards. This is the first time that cavity-dumped Q-switched Alexandrite laser operation was demonstrated for PRF over 10 kHz.

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References

[1] J. C. Walling, O. G. Peterson, H. P. Jenssen, R. C. Morris, and E. W. O’Dell, “Tunable Alexandrite Lasers,” IEEE J. Quant. Electron. 16 (12), 1302–1315 (1980).
[2] G. M. Thomas, A. Minassian, X. Sheng, and M. J. Damzen, “Diode-pumped Alexandrite lasers in Q-switched and cavity-dumped Q-switched operation”, Optics Express 24 (24), 27212 (2016).
[3] Cordis Europa, Horizon2020, Fact Sheet: “High Performance Alexandrite Crystals and Coatings for High Power Space Applications.”, https://cordis.europa.eu/project/id/870427