1.5 μm miniature and chip longitudinally diode pumped passively Q-switched Raman laser

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Abstract—The possibilities of lasing at eye-safe wave length of 1.54 μm have been studied for longitudinally diode pumped passively q-switched laser based on KGd(WO4)2:Nd3+ emitting at F3/2→I13/2 transition of Nd3+ ion followed by Raman self-conversion for miniature and chip cavity configuration.

Keywords—eye-safe laser wavelength 1.54 μm; diode pumping; passive q-switch shutter; miniature and chip laser; Raman self-conversion lasers.

The eye safe lasers and laser systems must comply with class 1, i.e. standard fit on the level of power radiation. This takes account of the wavelength, pulse duration and duration of the pulse series. Lasers and laser systems for Class 1 are not able to cause damage to the human eye. In the spectral range of 1.54 μm cornea and anterior chamber of eyeball absorb almost all incident radiation, which reduces the risk of burning the retina. Also, this range corresponds to the window of atmospheric transmission in the long-wavelength infrared, which has been successfully used in laser range finders and locators.

The Raman conversion has become an efficient way to get the lasing at the additional wave lengths. The efficient conversion of 1.35 micron radiation of neodymium laser into 1.54 micron emission is known to be one of the most promising ways to obtain 1.5 micron radiation, having its own advantages towards the ones based on parametric oscillation and ytterbium-erbium glass lasing. The application of the crystals of neodymium doped potassium–gadolinium tungstate (KGd(WO4)2:Nd3+) as an active medium as well as Raman conversion media and Y3Al5O12:V3+ passive Q-switch has given the possibility to use the simple and compact architecture of the laser similar to the lasers emitting in one micron area. These lasers operate at pumping energies of several units of Joules, output energies being up to 20 mJ.

However the efficiency of lasing and Raman conversion was shown to be considerably dependent on spectral parameters of cavity mirrors and the reflection coefficient of initial wave length 1.06 and 1.35 μm.

The present work demonstrates the miniature 1.54 micron passively q-switched Raman self-converter with longitudinal laser diode pumping. In present research the cavity pumping was carried out with 4 W laser diode manufactured by Russian company "ATC-Semiconductor Devices". The size of the emitting area this laser diode was 200×1 μm. The crystal KGd(WO4)2:Nd3+ as an active element and Raman conversion media has been used. The dimensions of active element were dia.3x4 mm. One of the ends of active element has been made spherical with radius ~3 cm and had coating with high transmittance at wavelength of 0.810 μm and high reflection at 1.35 and 1.54 μm. The optical element with thickness 0.4 mm and initial transmittance 94% at wavelength of 1.35 μm from crystal Y3Al5O12:V3+ has been used as a Q-switch passive shutter. Plane output mirror had the reflection coefficients R ≈ 99.5% at a wavelength of 1.35 μm, R ≈ 90% at λ = 1.54 μm and R ≈ 6% at λ = 1.06 μm.

Raman conversion was obtained for 3 mm long active rod KGd(WO4)2:Nd3+. The lasing at the wave length of 1.54 μm with repetition rate up to 20 KHz has been registered. The 1.54 μm output pulse length was measured to be 3 ns, the leading edge been less than 1 ns. Raman self-conversion lasing has been demonstrated for miniature cavity configuration (cavity length being equal to 10 mm) as well as for chip configuration (cavity length being 4 mm). The crystal Y3Al5O12:V3+ has been used as a passive Q-switch shutter. The thickness of crystal Y3Al5O12:V3+ was 0.6 mm. The external surface of Y3Al5O12:V3+ served as an output coupler. The reflection coefficients were R ≈ 99.5% and R ≈ 90% at the wavelengths λ = 1.35 μm and λ = 1.54 μm respectively. The reflection coefficient at λ = 1.06 μm was R ≈ 6%.

In case of chip cavity configuration the output coupler was put on Y3Al5O12:V3+ passive q-switch shutter external surface. The requirements to cavity mirror spectral parameters to provide effective Raman conversion have been determined.