ANALYTICAL SOLUTION FOR PULSE EVOLUTION IN Q-SWITCHED LASERS WITH INTRACAVITY RAMAN CONVERSION

Yu. V. Loiko, A. A. Demidovich, V. A. Lisinetskii, A. P. Voitovich
Institute of Molecular and Atomic Physics, NASB, Minsk

Q-switched operation of lasers with intracavity Raman conversion has been considered analytically on the basis of the rate equation model. We consider the stationary intracavity stimulated Raman scattering (SRS). The analytical expressions which describe the shapes of pulses at fundamental laser (FL) and Stokes-shifted frequencies have been derived. These expressions describe the dependence of the FL and Stokes photon number densities on the population inversion but they can be transformed to obtain the time evolution of the pulses. It has been found that the analytical expressions for the Q-swicthed lasers with intracavity SRS can be obtained if the similar expressions are known for the identical lasers without the intracavity SRS. Good agreement with the numerical integration of the rate equation model has been found not close to the Stokes pulse generation threshold. The obtained analytical expressions have been applied for the Cr^{4+}:YAG Q-switched Nd:LSB microchip solid state lasers (SSLs) with the $Ba(NO_3)_2$ Raman medium. The analytical results correlate with the experimental data.

The analytical expressions and results of this investigations are applicable (under the used approximations) for any Q-switched laser with intracavity Raman conversion. They will be valid until the analytical solution for identical laser without the intracavity Raman conversion persists to be valid. The validity of the analytical results should be revisited when the Stokes pulse duration will be on the time scale of the transverse relaxation time of the vibrational modes in the Raman medium. In solid state Raman media this relaxation time is in the range from few to tens pisoseconds, hence for the microchip SSLs this gives the validity of the analytical results up to the subnanosecond time scale.

Derived analytical expressions can be applied either when the stimulated emission of the FL photons and their Raman conversion occurs in single medium (self-Raman conversion) or when the gain and Raman active media are different. They can be used to find and optimize the peak power, output energy, and time durations of the FL and Stokes pulses.