УДК 621.373.826

Modeling of a solid-state laser with noninstantaneous Q-switching

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Abstract

In this work, we have studied the energy and time characteristics of short laser pulses generated by an Nd:YAG laser with active Q-switching by Pockels cell using the mathematical model. The main purpose of the simulation is to select the function of switching lasers cavity level of losses in order to optimize the time and energy characteristics of the laser pulse.

Introduction

Since the invention, lasers have come a long way of improvement that is way they can solve a huge number of issues. High energy concentration in a short light pulse is necessary in many spheres of laser technology. In this case, Q-switching mode is used as the most common and simplest one. To implement it, a special element, which could change the level of losses, is placed in the cavity and changes the quality factor of the laser. Switching of losses in the laser cavity could happen quickly or slowly. With fast Q-switching the output pulse has got a so-called substructure with a modulation in order of the time of a complete tracking of the cavity τ_0, which leads to the decrease the duration and increase the energy of the laser pulse. Consequently, using the periodic transmission function of Q-switcher, the characteristics of the output pulse can be improved.

Methods

The simulation has been performed in MathCad software, with the help of the mathematical model, the basic principle of which is to divide the length of the cavity along the optical axis into cells, and to consider the processes that occur during generation of laser beam in each cell, taking into account actions that correspond to the cell location. The Franz-Nodvik formula is used to calculate the gain of the laser active medium (Nd:YAG). Rate equations are used to describe population inversion in laser medium.

Outcomes

A periodic function involved in the simulation has been used within an interval of its half period and an interval of one and a half period. According to the results of the simulation, it can be concluded that, when we use the periodic function of the Q-switcher without complement minimum, taken at the time of a complete tracking of the cavity, generated pulse has a substructure. The faster Q-switching happens the bigger modulation depth is. The pulse with a maximum intensity and a minimum length is obtained in the case of the fastest Q-switching. However, using the periodic function of the Q-switcher with complement minimum (taken on one and half period length), which creates a deeper modulation of the field intensity in the cavity, it is possible to further shorten the pulse length and increase the maximum peak power. The optimal values are achieved at Q-turn-on time which multiples the time of a complete tracking of the cavity τ_0. The use of such transmission function of the Q-switcher has made it possible to obtain the laser emission intensity one and a half times more than in the case of the transmission function taken in a half of period.

Conclusion

Analysis of the results have revealed that the periodic Q-switching function taken on one and a half period length introduces more additional modulation than the function taken on a half period length which improves the characteristics of the laser emission pulse greatly. According to the calculation results, it has been found that in the case of the period of the Q-switch-on function of the cavity T is the same as the time of a complete tracking of the cavity τ_0. As a result, the laser pulse has a minimum duration and maximum peak power.