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FEMTOSECOND LASER DIRECT WRITING OF CRYSTAL-IN-GLASS LABGEO5 WAVEGUIDES

Sergey V Lotarev, Alexey S Lipatiev, Tatiana O Lipateva, Vladimir N Sigaev

Mendeleev University of Chemical Technology of Russia, Russia

Femtosecond lasers have become a powerful tool for three-dimensional precision micromachining of dielectrics. One of its promising applications is space-selective laser-induced crystallization of glasses providing growth of continuous crystalline architectures with functional properties such as second-order optical nonlinearity. Though laser-induced precipitation of different crystalline phases was demonstrated in a wide set of glasses, writing single-crystal tracks which could operate as channel waveguides was a challenge which required optimization of laser treatment parameters and beam profiling. Such crystalline channel waveguides consisting of ferroelectric stillwellite $LaBGeO_5$ phase have been recently obtained in lanthanum borogermanate glass. In particular, we reported laser writing of oriented $LaBGeO_5$ tracks with improved homogeneity providing waveguide effect by applying the femtosecond beam with elliptical waist cross-section and demonstrated second harmonic generation in this waveguide. In the present study, we revealed the possibility and investigated conditions of laser direct writing of oriented LaBGeO5 crystal tracks at various pulse duration from 300 fs - 5 ps and various pulse repetition rates from 25 kHz to 500 kHz. It is shown that there is a constant minimal value of peak pulse intensity about 1,6 10^{12} W/cm^2 in the pulse repetition rate range of 100-500 kHz, while at lower repetition rates this value rapidly grows with repetition rate decrease. We also suggest a method of fast laser-induced growth of a seed microcrystal which is necessary as a starting point for writing a crystalline track and is formed in glass by the stationary beam. Exposure of glass to the beam with gradually increasing pulse energy is shown to greatly reduce and stabilize time required to grow a seed crystal as compared to the beam with constant pulse energy. The obtained data will be useful for further improvement and feasibility of crystal-in-glass waveguides writing method.

sergey_lot@mail.ru
slotarev@muctr.ru