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V\(^{3+}\):YAG as saturable absorber for near infrared lasers

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Saturation of near infrared absorption was investigated recently in tetravalent chromium doped garnets and forsterite [1]. These systems were shown to be effective solid state saturable absorbers for neodymium lasers. In this paper we report on vanadium doped YAG as a new solid state passive shutter for near infrared laser systems.

Tetrahedral V\(^{3+}\) ion has a 3d\(^2\) electron configuration and is characterized by the two strong broad absorption bands in the near infrared with peaks at 1.3 \(\mu m\) and 0.83 \(\mu m\). These bands are assigned to transitions from the \(^3A_2\) ground state to the excited states \(^3T_2\) and \(^3T_1\), respectively. Saturation of absorption was observed for both these transitions. The saturation energy density of \(24 \pm 7 J/cm^2\) was estimated at 1.08 \(\mu m\).

An upper limit for intra \(^3T_2\) state vibrational relaxation time of \(10 \pm 5 ps\) and absorption recovery time of about \(5 \pm 2 ns\) were estimated from picosecond pump-and-probe relaxation measurements.

Mode-locked and Q-switched laser operations were obtained using V\(^{3+}\):YAG as a saturable absorber for Ti-Al\(_2\)O\(_3\) laser at 770 nm and Pr-YA\(_3\)O\(_3\) laser at 747 nm. The \(^3A_2 - ^3T_1\) transition of absorber was excited by the emission of these lasers. Ultrashort pulses observed were \(0.3 - 0.5 ns\) in duration and 0.5 mJ in energy for both these lasers. Q-switched pulses with energy up to 5 mJ were 50 - 80 ns in duration for Pr-YA\(_3\)O\(_3\) and approximately 300 ns for Ti-Al\(_2\)O\(_3\) laser.

Mode-locked laser operation was realized also for 1.34 \(\mu m\) Nd-YA\(_3\)O\(_3\) and 1.06 \(\mu m\) Nd-YAG lasers. The train of ultrashort pulses with total energy of about 8 mJ was observed at 30 J pump energy for Nd-YA\(_3\)O\(_3\) laser. Single pulses were \(0.1 - 0.3 ns\) in duration.