# Upconversion-induced heat generation and thermal lensing in Nd:YLF and Nd:YAG

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We investigate the influence of interionic upconversion between neighboring ions in the upper laser level of Nd:YLF and Nd:YAG on population dynamics, heat generation, and thermal lensing under lasing and nonlasing conditions. It is shown that cascaded multiphonon relaxations following each upconversion process generate significant extra heat dissipation in the crystal under nonlasing compared to lasing conditions. Owing to the unfavorable temperature dependence of thermal and thermo-optical parameters, this leads, first, to a significant temperature increase in the rod, second, to strong thermal lensing with pronounced spherical aberrations and, ultimately, to rod fracture in a high-power end-pumped system. In a three-dimensional finite-element calculation, excitation densities, upconversion rates, heat generation, temperature profiles, and thermal lensing are calculated. Differences in thermal lens power between nonlasing and lasing conditions up to a factor of 6 in Nd:YLF and up to a factor of 2 in Nd:YAG are experimentally observed and explained by the calculation. This results in a strong deterioration in performance when operating these systems in a *Q*-switched regime, as an amplifier, or on a low-gain transition. Methods to decrease the influence of interionic upconversion are discussed. It is shown that tuning of the pump wavelength can significantly alter the rod temperature.
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