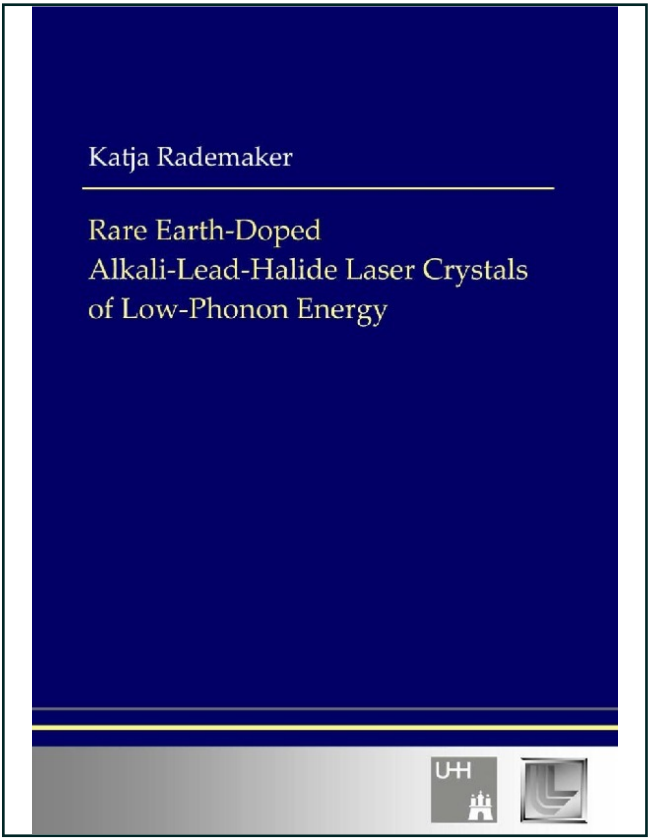
Katja Rademaker (Autor)

Rare Earth-Doped Alkali-Lead-Halide Laser Crystals of Low-Phonon Energy



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Abstract

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In the context of this study two moisture-resistant bromide host crystals of low-phonon energy doped with the rare earth ions Nd^{3+}, Tb^{3+}, and Eu^{3+} are identified, studied, and their low nonradiative rate is exploited to lase new transitions: potassium-lead-bromide (KPb_2Br_5, KPB) and rubidium-lead-bromide ($RbPb_2Br_5$, RPB). The low multiphonon decay rate and other favorable features render them particularly useful as promising candidates for long wavelength-infrared applications.

Laser activity is achieved with Nd^{3+}-doped KPB and RPB crystals at room temperature. Conventional laser activity at 1.07 µm is observed, as well as laser operation at the new wavelengths 1.18 µm and 0.97 µm resulting from the $^4F_{5/2}+^2H_{9/2}\rightarrow^4I_J$ transitions (J=13/2 and 11/2) for the first time for any crystal. Pump-probe spectra are presented to discuss excited state absorption and reabsorption competing with e.g. (laser) emission transitions, as well as depopulation mechanisms of the lower laser levels. Cross relaxation from e.g. the $^4I_{13/2}$ lower laser level is evidenced, providing a pathway for enhanced efficiency of operation for e.g. the 1.18 µm transition. Bright upconversion fluorescence observed in these crystals could also enable short-wavelength lasing. Directly pumpable, broadband 8 µm emission is measured in Tb:KPB samples in addition to 3 µm and 5 µm luminescence due to reduced multiphonon relaxation rates. Emission from the potential 10 µm laser level is also observed.

Detailed spectroscopic investigations at room temperature and below are carried out in this study to characterize these materials and to determine their laser potential. For the same purpose, radiative transition probabilities are calculated and compared with experimentally determined values for relevant (laser) transitions. Beside radiative transition rates nonradiative rates are obtained and fitted to measured rates in order to determine the influence of multiphonon decay and the presence of further quenching mechanisms.