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Charge trapping processes and energy transfer in PbMoO4 studied by electron paramagnetic resonance and thermally stimulated luminescence

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Lead molybdate (PbMoO4) crystal is isotructural to lead tungstate but it features a lower light yield. On the contrary, it is a promising candidate as scintillator for high energy physics and the neutrinoless double β decay experiment, due to the inevitable occurrence of the 100Mo isotope. PbMoO4 crystals were also suggested to find application in cryogenic dark matter experiments. Point defects (e.g., color centers, vacancies, accidental impurities etc.) responsible for trap states in a bandgap have a significant influence on the luminescence and scintillating properties of the crystal. The traps interfere with the charge transport process contributing to afterglow and degrading the light yield. Therefore, the present study is dedicated to an investigation of the charge trapping and energy transfer in lead molybdate.

Single crystals of undoped PbMoO4 irradiated with 420 nm light were studied by means of electron paramagnetic resonance (EPR) and wavelength resolved thermally stimulated luminescence (TSL). After light irradiation EPR spectra displayed two new. After a detailed analysis, both signals have been attributed to Mo5+ centers. Their spin Hamiltonian parameters have been determined and thermal decay characteristics studied. Both centers exhibit a relatively low thermal stability (limited to 90 K). The very good matching between EPR and TSL data allowed to correlate some of the observed TSL glow peaks within the 60-100 K temperature range to the EPR signals of the molybdenum centers. Additional TSL peaks were also detected in the 100-160 K temperature interval, possibly due to the depletion of non-paramagnetic traps. The traps are characterized by first order recombination kinetics: by using the partial cleaning procedure and initial rise method, the corresponding trap depths and frequency factors have been determined.

Remarkably, the temperature dependencies of TSL and RL emission spectra are drastically different: the former features a stepwise low energy shift of the maximum emission energy from 2.4 eV at 10 K to 2.15 eV at 300 K, whereas the latter displays an opposite trend, with a slightly lower energy shift of 0.08 eV in the whole temperature region. The phenomenology is clearly due to the occurrence of several spectral components with different thermal stabilities in TSL and RL. The emission mechanisms in the two measurements are, therefore, different. The results are discussed by taking into account the origin of the different emission centers, their thermal stabilities, and the existence of different pathways of charge carrier recombination in case of TSL.

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