Kinetics of charge carrier recombination in beta-Ga_2O_3 single crystals

Cuong Ton-That, Tung Huynh, Laurent Lee Cheong Lem, Akito Kuramata, Matthew Phillips

Abstract
We used temperature-resolved cathodoluminescence to determine the characteristics of luminescence bands and carrier dynamics in edge-defined film-fed grown (EFG) beta-Ga2O3 single crystals synthesized by Tamura Corporation. The crystal is nominally undoped and has a (-201) surface orientation. The main impurities are Si, Ir, Al and Fe, with [Fe] ~ 10^17 cm-3 verified by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The CL emission was found to be dominated by a broad UV emission peaked at 3.40 eV, which exhibits strong quenching with increasing temperature; however, its spectral shape and energy position remain virtually unchanged up to 500 K. Depth-resolved analysis reveals the luminescence spectrum is independent of sampling depth. We observed a super-linear increase of CL intensity with excitation density; this kinetics of carrier recombination can be explained in terms of carrier trapping and charge transfer at Fe3+/2+ centers. The temperature-dependent properties of this UV band were found to be consistent with weakly bound electrons in self-trapped excitons with an activation energy of 48 +/- 10 meV. In addition to the self-trapped exciton emission, a blue luminescence (BL) band is shown to be related to a donor-like defect, which increases significantly in concentration after remote hydrogen plasma treatment. The point defect responsible for the BL, likely an oxygen vacancy or a complex, is strongly coupled to the lattice with a Huang-Rhys factor S = 7.3.