The Influence of Deep Defects on Exciton Dynamics in CdS

R. Heitz, A. Hoffmann, and I. Broser
Institut für Festkörperphysik, Technische Universität Berlin
Hardenbergstrasse 36, 1000 Berlin 12, Germany

II-VI semiconductors are very suitable for electro-optical devices in the visible spectral region. Nevertheless, up to now it is hard to control their conductivity due to self-compensation mechanisms and the quantum yields in the blue/green spectral region of real devices are found to be low. One critical reason is the interaction with deep centres created during doping or by unintentionally added impurities leading to competing relaxation channels. In the present paper the luminescence in the near band gap region of high purity and of Ni-activated CdS crystals is investigated to study energy transfer processes between excitonic states and the deep Ni acceptor which has been demonstrated to be an extremely efficient recombination centre for free holes[1], recently. It will be shown that the incorporation of Ni-centres disturbs the near band gap luminescence and alters the dynamics of excitonic transitions.

The near band gap luminescence of "undoped" CdS crystals is dominated by two line groups[2] attributed to the radiative decay of acceptor bound (A^0,X) and of donor bound (D^0,X) exciton complexes with binding energies around 17meV and 6meV, respectively. The lifetimes of the bound exciton complexes in not intentionally doped CdS crystals are found to vary between 650 and 1000ps ((A^0,X)) and 100 and 300ps ((D^0,X)). Impurity-impurity interaction[3] can shorten the lifetimes, but in the undoped samples it seems more likely to associate the varying lifetimes to chemical different (A^0,X) and (D^0,X) complexes. After band-to-band excitation the entire bound exciton dynamics can be described within a three-level system using the lifetimes of the bound exciton and of the free A-exciton. Neither the formation of free excitons nor the relaxation of excited states of the bound exciton complex is found to contribute more than a few ps.

For Ni-activated CdS crystals a strong reduction of the near band gap luminescence efficiency is observed. Additionally, the bound exciton resonances become broader and a new line appears in between of the (A^0,X) and (D^0,X) complexes corresponding to a binding energy of 13meV. Time resolved spectra show a strong reduction of the (D^0,X) lifetime down to 35ps indicating energy transfer processes to deeper bound exciton complexes. The new line decays with a time constant of 650ps and shows a similar LO-phonon sideband as the (A^0,X) complex. Thus, the new line is discussed in the framework of the radiative decay of an exciton bound to an Ni-associated acceptor. Excitation spectra prove, that the d-d transition of the Ni-centre are not efficiently excited via the various excitonic complexes.

[1] R. Heitz, A. Hoffmann, and I. Broser, Optical Materials **1**, 75 (1992)
[2] D.G. Thomas, and J.J. Hopfield, Phys. Rev. **128**, 2135 (1962)
[3] C. Fricke, U. Neukirch, R. Heitz, A. Hoffmann, and I. Broser, J. Cryst. Growth **117**, 783 (1992)