EXCITATION SPECTROSCOPY OF THE DEEP IMPURITY CENTER Ni^{2+} IN CdS

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CdS crystals containing nickel impurities show in the near infrared spectral region around 820 nm absorption lines, which have been attributed to the crystal field transitions $3T_1(F) \rightarrow 3T_1(P)$ of Ni^{2+} on lattice sites.[1] The incorporation of Ni^{2+}-ions in concentrations around $10^{-8}cm^{-3}$ into perfect crystals gave rise to a series of extrem narrow lines, so that isotope splittings could be clearly resolved.[2] For the first time also corresponding luminescence lines have been observed.[2] Magneto-optical studies [3] elucidated the symmetry properties of these transitions; a quantitative interpretation of the spectra however was still difficult, as strong Jahn-Teller-interactions made the use of the static crystal field theory questionable.

In this paper we show that excitation spectroscopy of the Ni^{2+} emission allows not only to receive additional information on transitions within the center, but also on charge transfer processes to and from the host crystal.

Using high intensity tunable laser sources, we received excitation spectra with structures around the band edge and very close to the infrared absorption and emission lines.

The high energy excitation spectrum consists of a series of bands, with a spacing of 38 meV, the energy of a longitudinal optical lattice phonon. The series starts at 564 nm, has a maximum intensity at 492 nm, and is observable far above the band edge. We explain the excitation mechanism as a charge transfer process of a hole from a very deep acceptor level into the valence band. The recapture of the hole is followed by a radiant transition via excited Ni^{2+} levels. The distance of the acceptor from the valence band is found to be at 4.2 K 2.19 eV, from the conduction band 0.4 eV.

In the infrared spectral region near 820 nm, the excitation spectroscopy showed unambigously, that the different narrow lines originate all from the same center: A coincidence of the excitation spectrum with the absorption spectrum was found. This explains the observed excitation and emission lines as transitions within Ni^{2+}-states, shifted and split by crystal field and Jahn-Teller interaction. The fine structure of the spectra has been further more elucidated by the study of the influence of temperature and uniaxial stress on the energetic position of the lines.

1) H.A. Weakliem, Journal of Chem. Phys. 36, 2117 (1962)
2) I. Broser, R. Germer, A. Schröder, E. Birkicht, R. Broser Journal of Luminescence 24/25, 225 (1981)
3) I. Broser, R. Germer, H.-J. Schulz, Phys. Stat. Sol. B 101, 181 (1980)