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Fine Structure of the NiO:Co Infrared Absorption Spectrum

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The NiO absorption spectrum in the 1 to 3.5 eV range consists of bands caused by d-d transitions /1/. The NiO absorption bands in the visible spectral region are due to electron magnetic transitions; in the infrared (IR) region they are due to $^3A_{2g} \rightarrow {}^3T_{2g}$ magnetic dipole transitions.

A fine structure of NiO absorption bands caused by d-d transitions was observed in /2/ and the role of phonons and magnons in the fine structure of the NiO absorption spectrum was revealed. It was stated that magnons with K = 0 take part in the formation of the fine structure in the IR absorption band. NiO is an antiferromagnetic of the easy-plane type, that is why there should be two antiferromagnetic resonance (AFMR) modes. One of them is the spin motion from the easy plane. It has a frequency of 36.6 cm^{-1} for NiO and is observed in the far IR spectral region. The AFMR spectra for NiO depending on the cobalt concentration are studied in /3/. It was stated that with growth of the cobalt concentration the absorption band in the far IR region, which is associated with antiferromagnetic resonance, is broadened and shifted towards larger energies. Basing on the results obtained in /3/ one should expect that if magnons (K = 0) take part in the fine structure formation of the absorption band caused by $^3A_{2g} \rightarrow {}^3T_{2g}$ transition, it should be influenced by the cobalt ion impurity.

In order to investigate the fine structure of the absorption bands, NiO:Co single crystals of thickness 50 to 100 μm were used, which had been grown by the chemical transport reaction method. Cobalt ions of proper concentration were incorporated into NiO while producing polycrystalline material by the ceramic technique. For the growth of NiO single crystals doped with cobalt ions MgO single crystals ((100), (110), and (111) cuts) were used as substrates.

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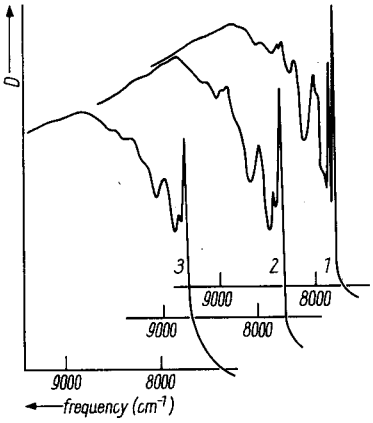

Fig. 1. Infrared absorption spectrum of NiO depending on the cobalt concentration. (1) NiO, (2) 2% Co in NiO, (3) 5% Co in NiO

The X-ray structural analysis shows that the monocrystalline plates obtained are monophase and have the MgO substrate orientation. In the growth process the cobalt concentration does not practically change.

The fine structure of the NiO IR absorption band as a function of cobalt concentration is shown in Fig. 1.

At 80 K there are two zero-phonon peaks: at 7828 and 7864 cm^{-1}, i.e. within experimental accuracy for these bands the energy difference equals the AFMR frequency. The energy difference between these absorption maxima as well as their halfwidth increase and the magnon peak intensity decreases with the cobalt concentration in NiO.

There are also phonon lines in the fine structure of the spectrum. Their dependence on the cobalt concentration in NiO is similar to that of the zero-phonon peaks.

Thus, the fact that magnons with K = 0 take part in magnetic dipole transitions is truthfully proved for NiO.

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