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Identifizierung von Donatoren in ZnO

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The identification of residual donors in ZnO is a very important aspect. Only for very low background concentrations of the donors one can expect to achieve carrier type conversion towards controllable p-type doping. It was, therefore, our interest to identify the chemical nature of the donors and to determine precisely their binding energies.

The optical properties of excitonic recombinations in bulk, n-type ZnO are investigated by photoluminescence (PL) and spatially resolved cathodoluminescence (CL) measurements. At liquid helium temperature in undoped crystals the neutral donor bound excitons dominate in the PL spectrum. Two electron satellite transitions (TES) of the donor bound excitons allow to determine the donor binding energies ranging from 45 to 74 meV. These results are in line with the temperature dependent Hall effect measurements. In the as-grown crystals a shallow donor with an activation energy of 30 meV controls the conductivity. Annealing annihilates this shallow donor which has a bound exciton recombination at 3.3628 eV. Correlated by magnetic resonance experiments (EPR/ENDOR at 9 and 90 GHz) we attribute this particular donor to Hydrogen. For the bound exciton lines which were correlated with Li and Na by doping experiments we offer a different interpration. Li and Na do not introduce any shallow acceptor level in ZnO which otherwise should show up in donor-acceptor pair recombinations. The Al, Ga and In donor bound exciton recombinations are identified based on doping and diffusion experiments and using secondary ion mass spectroscopy.