# Probing the local structural and magnetic properties of dilute magnetic semiconductors using hard x-ray absorption spectroscopy

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## Abstract

Dilute magnetic semiconductors (DMS) are envisioned as sources of spin-polarized carriers for future semiconductor devices which simultaneously utilize spin and charge of the carriers. The hope of discovering a DMS with ferromagnetic order up to room temperature (RT) still motivates research on suitable DMS materials. Two candidate wide-band gap DMS are Gd:GaN and Co:ZnO.

We have used hard x-ray absorption spectroscopy (XAS) and in particular x-ray linear dichroism (XLD) and x-ray magnetic circular dichroism (XMCD) to study both DMS materials with element specifity. The results for Gd:GaN will be briefly reviewed demonstrating that the Gd atoms are located predominantly on Ga substitutional sites [1]. Further, the element specific magnetic properties as measured with XMCD significantly deviate from the integral SQUID measurements [1] and the Gd sublattice behaves purely paramagnetic [2]. Using XMCD we also tried to probe the magnetic polarization at the Ga K-edge. However the polarization was at least two orders of magnitude too small to explain the colossal magnetic moments reported before [2].

For Co:ZnO films grown by pulsed laser deposition or reactive magnetron sputtering we could demonstrate by means of XLD that more than 95% of the Co dopant atoms occupy substitutional Zn lattice sites [3]. The M(H) curves recorded by SQUID as well as XMCD at the Co K-edge consistently reveal paramagnetic behaviour [3]. A more quantitative analysis of the curvature of the M(H) curve versus the measured magnetization reveals that the Co-O-Co pairs found in 10%-Co:ZnO couple antiferromagnetically [3]. For a comprehensive set of paramagnetic/ superpara-magnetic pairs of Co:ZnO samples hard XAS was used to identify spectroscopic signatures in the XAS, XLD and XMCD as quality indicators for the absence of phase separation of elemental Co(0) in this DMS material [4].

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