Polarized neutron powder diffraction studies of antiferromagnetic order in bulk and nanoparticle NiO

In many materials it remains a challenge to reveal the nature of magnetic correlations, including antiferromagnetism and spin disorder. Revealing the spin structure in magnetic nanoparticles is further complicated by the large incoherent neutron scattering cross section from water adsorbed at the particle surfaces and by the broadening of diffraction peaks due to the finite crystallite size. Moreover, the spin structure in magnetic nanoparticles may deviate significantly from that of the corresponding bulk material because of the low-symmetry surroundings of surface atoms and the large relative surface contribution to the magnetic anisotropy. Here we explore the potential use of polarized neutron diffraction to reveal the magnetic structure in NiO bulk and nanoparticle powders by applying the XYZ-polarization analysis method. Our investigations address in particular the spin orientation in bulk NiO and platelet-shaped NiO nanoparticles with thickness from greater than 200 nm down to 2.0 nm. The advantage of the applied method is that it is able to clearly separate the structural, the magnetic, and the spin-incoherent scattering signals for all particle sizes. For platelet-shaped particles with thickness from greater than 200 nm down to 2.2 nm we find that the spin orientation deviates about 16° from the primary (111) plane of the platelet-shaped particles. In the smallest particles (2.0 nm thick) we find the spins are oriented with a 30° average angle to the primary (111) plane of the particles. The results show that polarization analyzed neutron powder diffraction is a viable method to investigate magnetic order in powders of antiferromagnetic nanoparticles.

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