Correlation of ferromagnetic-like signatures in cobalt-doped ZnO with metallic cobalt precipitations

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A comprehensive set of experimental techniques such as transmission electron microscopy (TEM) and synchrotron-based x-ray absorption spectroscopy (XAS) and the respective linear and magnetic circular dichroism was used to study the structural, chemical and magnetic properties of Co-doped ZnO epitaxial films. Samples of good structural quality grow in a columnar nanostructure with point defects within the columns. These are found to be paramagnetic [1]. Samples of lesser quality exhibit a globular nanostructure. For these it can be shown that the ferromagnetic-like behavior observed by integral superconducting quantum interference device magnetometry is not an intrinsic property of the material [2]. Here we will directly evidence their presence by TEM as well as XAS to clarify the microscopic origin of the ferro-magnetic-like signal. We can directly show, that the SQUID magnetization curve at 300 K stems from metallic Co inclusions found in these samples. In addition, we can correlate the observed changes in the magnetic properties upon annealing procedures with a reduction or oxidation of the metallic Co species, respectively.

[1] A. Ney et al., Phys. Rev. Lett. 100, 157201 (2008)
[2] A. Ney et al., New J. Phys. 12, 013020 (2010)