Nano-X-ray Absorption Spectroscopy of Single Co-Implanted ZnO Nanowires

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Co-doped ZnO nanowires (NWs) offer unique advantages for spintronics applications owing to their large geometrical aspect ratio and predicted room-temperature ferromagnetism. However, controlled doping of semiconductor NWs with transition metals (TM) during growth remains a challenge. Ion implantation is an alternative that allows a better control of both concentration and distribution of TM ions. Determining the doping homogeneity and local order of individual nanostructures is crucial to understand their behavior in nanodevices. The average local atomic structure and secondary phases in ensembles of NWs have already been studied by X-ray absorption near edge structure (XANES) and extended X-ray absorption fine structure (EXAFS). However, the examination of single NWs remains an experimental challenge mainly due to the beam instability during the energy scan, and chromaticity of the nanofocusing lens.

In this work, we report on the local structure of single Co-implanted ZnO nanowires studied using a hard X-ray nanoprobe at station ID22NI of the ESRF. X-ray fluorescence maps show uniform Zn and Co distributions along the wire within the length scale of the beam size. The X-ray fluorescence data allow the estimation of the Co content within the nanowire. Polarization dependent X-ray absorption near edge structure shows no structural disorder induced neither in the radial nor axial directions of the implanted nanowires after subsequent annealing. Co^{2+} ions occupy Zn sites into the wurtzite ZnO lattice. Extended X-ray absorption fine structure data reveal high structural order in the host lattice without distortion in their interatomic distances, confirming the recovery of the radiation damaged ZnO structure through thermal annealing.