Capability study of resonant x-ray magnetic scattering from NiO

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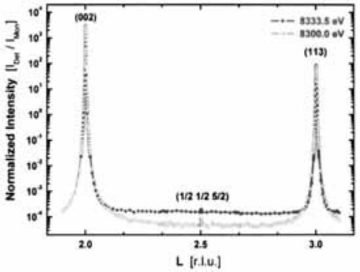
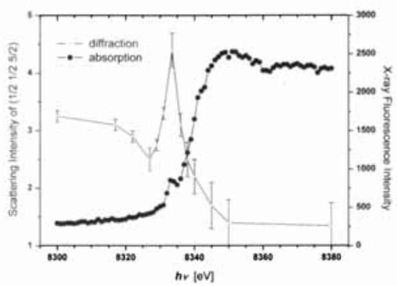
As started from the mid-2004, we formed a new beamline working team to support the general operation of BL12B2. Beside the staff mission to serve users' demands, we initiated a task force for research-oriented mission on the resonant x-ray magnetic scattering to meet our emerging request in Taiwan. This experiment report is a short summary of the capability test performed on x-ray magnetic scattering from the antiferromagnetic structure of NiO single crystal at the room temperature.

Figure 1 is a comparison of scan profiles along the (002) toward (113) diffraction at the incident x-ray energy of 8300.0 eV, below the K-edge of Ni, and at 8333.5 eV of the Ni: 1s→3d resonance. The half-integer diffraction of (1/2 1/2 5/2), accounting for the magnetic superstructure, was evidently observed but in excess of 7 orders of magnitude smaller than the fundamental (002) diffraction peak. After the subtraction of scattering background, which mainly came from the secondary fluorescent x-rays, we observed an expected enhancement at the electric quadrupolar transition of Ni ions as shown in Fig. 2.





X-ray scattering study on semiconductor nanostructures

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As a continuity of the investigation to the thickness dependence of the strain and compositional distribution of quantum wires, we have performed grazing incidence x-ray scattering measurements on GaAs anti-wires grown by depositing 3 ML and 4 ML of GaAs on an InP(001) substrate with an InGaAs buffer layer in between. The atomic force microscopy (AFM) images of sample surface morphology are shown in Fig. 1. The length of the wires formed by 3 ML GaAs extends over a few microms but those formed from 4 ML GaAs break down into "rods" of several tens or hundreds nanometers long. Previous study confirmed that the strain was confined to the direction across the wire axes for the 3 ML wires. It is speculated that there could be some lattice relaxation along the rod axes for the 4 ML wires. Figure 2 illustrates the profile of radial scans across the substrate (2 2 0) and (2 -2 0) surface Bragg peaks of 4 ML sample. The presence of two pronounced broad peaks on both sides of the (2 2 0) Bragg peak together with the absence of similar peaks in the radial scan across the (2 -2 0) peak reflect the highly regular arrangement of the rods along the [2 2 0] direction. From the peak position, it is derived that the inter-rod distance is about 23 nm and the rods are aligned with their long side parallel to the [2 -2 0] direction, similar to what observed on the 3 ML wires. In light of the -3.5% lattice mismatch of bulk GaAs with respect to the underneath InP lattice, the prominent asymmetry of the radial scan across the (2 2 0) peak is attributed to the lattice relaxation of GaAs across the rod axes. In contrast to the symmetric profile of the (2 -2 0) radial scan of 3 ML sample, the (2 -2 0) radial scan of 4 ML sample show slight asymmetry; the intensity at high q side is higher than that of the low q side. This indicates the lattice parallel to the rod axes also exhibits relaxation toward the intrinsic GaAs lattice constant.

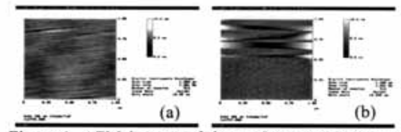

Figure 1. AFM images of the surface morphology of GaAs anti-wires grown by depositing (a) 3 ML and (b) 4 ML of GaAs on substrates, which are InP(001) wafers with lattice matched InGaAs buffer layers.

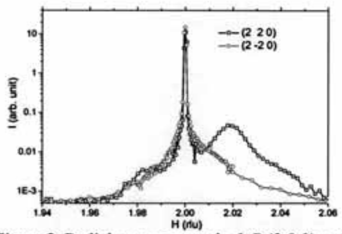

Figure 2. Radial scans across the InP (2 0 0) and (2 –2 0) surface Bragg peaks.

To study the composition distribution within the rods, we also performed energy scans across Ga *K*-edge with scattering vectors, *q's*, fixed at the (2 0 0) Bragg peaks associated with different lattice constants. The spectra are displayed in Fig.3; Δq's mark the deviation of the corresponding scattering vector from the InP(200) surface peak. The drastic difference in profiles demonstrates the high sensitivity of this method to the composition. Comparing the measured spectra with the simulation results, we found that Ga content increases with lattice mismatch. Moreover, the Ga concentration at given lattice mismatch is higher in the 4 ML rods than that of the 3 ML wires, indicative of the coupling of the lattice relaxation with chemical diffusion.

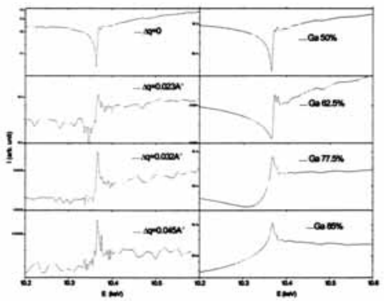

Figure 3. Measured (left panel) and simulated (right panel) spectra with q's fixed at different positions near the InP(200) peak.