Study of dynamic behaviour of CDW using x-ray scattering

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The layered ruthenate compounds have attracted a great of attention because of the discovery of the many unusual physical properties, such as the superconductivity in Sr_2RuO_4, and bad metallic non-Fermi-liquid behaviour in $SrRuO_3$. More recently, the other family compound $BaRuO_3$ have been observed to show the unusual transport behaviour, a metallic-insulator transition at T≈100 K due to the formation of a pseudo-gap, which has been suggested to be due to the formation of a charge-density waves (CDWs) at low temperature. Previously, using an *in-vacuum* camera on beamline BL201, we located some weak spots at T=30 K, which were observed to double the unit cell along the C^*-axis. The further confirmation was done on beamline BL12B2 using x-ray scattering.

The tiny crystal was glued on the cold head of a cryostat mounted on a 6-circle diffractometer. The use of the multi-circle diffractometer allows us to perform scans along the any axis on the reciprocal space. The crystal was first cooled down to T=10 K, and CDW satellites were located at positions (0 0 7.5), (0 0 10.5), (0 0 13.5), (0 0 12.5), and (0 1 15.5), and so on.

Cares were pied to track the evolution of the peak intensity as a function of temperature. The satellite reflections almost disappeared at T_{C2} ≈ 84 K, which is in agreement with the transport measurement. Figure 1 shows the plot of the integrated intensity versus temperature. The CDW was observed to be a second order phase transition just below T_{C2}≈ 50 K, while the host structure did not show any change. Further cooling, we observed that the transition curve was not monotonic change with temperature, instead of, the curve indicates that $BaRuO_3$ undergoes a second phase transition at T_{C2}. In order to understand this transition, we also measured the Bragge peak (0 0 15). As shown in figure 1, the Bragg peak which reflects the behaviour of the host structure also shows a transition at T_{C2}. From the susceptibility measurement, R. J. Cava et al. observed a ferromagnetic transition at 50 K as the field was applied along c-axis. We did not expect to see this ferromagnetic phase transition using x-ray scattering. One possibility for explaining the transition as we observed at T_{C2} is that the existence of a strong spin-phonon interaction due to the ferromagnetic transition causes the lattice distortion along the c-axis. However, this is still of need to be further studied.

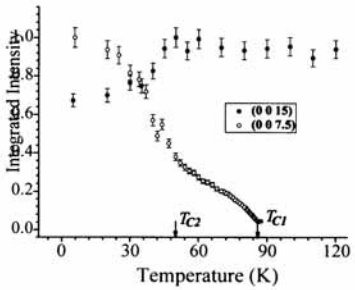

Figure 1 Evolution of the integrated intensity of CDW satellite reflection and Bragg reflection versus temperature. Longitudinal scans through both CDW satellite reflection (0 0 7.5) and Bragg peak (0 0 15) as a function of temperature.

Phase Determination of Charge-Density-Wave material: $K_{0.3}MoO_3$ with Varying Electric Field

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The incommensurately modulated structure of the isostructureal blue bronze of $K_{0.3}MoO_3$ with modulation wave vector q=a*+0.748b*+0.5c* at 100k has been determined by x-ray diffraction. And the transition at 10K is the Peierls transition temperature leading to an incommensurate semiconducting charge-density-wave state. As a consequence of the electron-phonon interactions the electronic density $n(\vec{r})$ of a CDW acquires a small sinusoidal component superimposed on its normal state distribution:

$n(\vec{r}) = n_0[1 + p\cos(\vec{q}\cdot\vec{r} + \phi)]$,

where p, ϕ, and q are the fractional amplitude, phase, and wave vector of the CDW. This kind of structure modulation can be easily observed by x-ray diffraction of CDW satellite reflection while temperature is lower than transition temperature. The irrational component of modulation wave vector is along the b*. If we consider a transformation of lattice: A=a, B=b, C=2c giving q=0.748b*.

The indices of reflections hklm then transformed to H=h, K=k, L=2l+m. The main structure modulation appears in b* only. The additional electron density distribution also would affected by the electric field. And what kind of structure information will come out, if we apply the electric field along b*, is our main propose. We can observe the phase change with varying E-field by using the multiple x-ray diffraction. Fig. 1 shows the I-V curves at different temperatures. The threshold voltage of $K_{0.3}MoO_3$ increased with lowering temperature, and the current jump became steeper and steeper.The asymmetry profiles of azimuthal scan along primary diffraction (13, 0.75, -6.5) at temperature = 50K are shown in Fig. 2. Apparently, the triplet-phase changed after external voltage applied on it. The peak profiles could be fitted according to a model of multiple diffraction result from the interference effect between the CDW modulation and the host lattice, the collective phases of CDW are therefore determined. There is no obvious change of the peaks' intensity below threshold voltage. However, we observed that CDW peaks displaced with varying current, the larger the current, the lower the θ, as shown in Fig.3.