

Charge stripe order in $\text{Pr}_{1.67}\text{Sr}_{0.33}\text{NiO}_{4+\delta}$.

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Beamline: X22C

Introduction: In $\text{La}_{2-x}\text{Sr}_x\text{NiO}_4$ it was found that below a critical temperature $T_c(x)$ the charge carriers in the NiO planes segregate into charge stripes for Sr concentrations $0.13 \leq x \leq 0.5$. The stripes run diagonally relative to the square lattice defined by the Ni-O-Ni bonds. A maximum T_c of 240K was observed for $x=0.33$, where the stripe order is commensurate to the lattice and therefore seems to be most stable. In $\text{La}_{2-x}\text{Sr}_x\text{NiO}_4$ stripe order occurs in the HTT phase ($I4/mmm$) with flat NiO_2 planes. In contrast in the cuprates with stripe order the CuO_2 planes are buckled, and there is some evidence that the buckling influences the stripe direction, depending on whether the structure is of the LTO type ($Abma$) or the LTT type ($P4_2/nm$).

At high temperatures $\text{Pr}_{1.67}\text{Sr}_{0.33}\text{NiO}_4$ is isostructural to $\text{La}_{1.67}\text{Sr}_{0.33}\text{NiO}_4$. However, at room temperature the structure of the Pr-based nickelate is LTO and at about 150K it changes from LTO to the less orthorhombic LTO2 phase ($Pccn$), which is an intermediate phase between the LTO and the LTT phase (so far this was checked only for polycrystalline samples). In $\text{Pr}_{1.67}\text{Sr}_{0.33}\text{NiO}_4$ it is therefore possible to study whether the formation of charge stripes (T_c , stripe direction) is influenced by the buckling of the NiO_2 planes.

Methods and Materials: The $\text{Pr}_{1.67}\text{Sr}_{0.33}\text{NiO}_{4+\delta}$ single crystal has been grown by the travelling solvent floating zone method using an image furnace. The (010) direction of the crystal was normal to the reflecting surface. The mosaic width was found to be $\sim 0.03^\circ$. The photon energy was set to 8.1 keV, which is 0.233 keV below the Ni-K edge.

Results: Charge stripe peaks have been detected below $T_c \sim 240\text{K}$ at positions $(0, 2n \pm 2\varepsilon, 1)$ and $(0, 2n \pm 2\varepsilon, 3)$. The parameter ε is weak temperature dependent: It decreases from $\varepsilon \approx 0.36$ at 10K to $\varepsilon \approx 0.34$ at T_c which is close to the commensurate value of $1/3$ (see Fig. 1). The slightly larger ε could mean that the crystal contains a small amount of excess oxygen ($\delta \neq 0$). No clear orthorhombic splitting of the (040) reflection could be resolved down to 10K. However, the (032) reflection (which is not allowed in the HTT phase) indicates that the structure changes from HTT to LTO at $T \sim 375\text{K}$ (see Fig. 2, upper plot). Below 250K the intensity of the (032) reflection starts to decrease. This unusual behavior was also observed for the reflections (-232) , (-142) , and (-342) . Whether this effect is related to the charge stripe formation below 240K has to be checked in more detail (see Fig. 2, lower plot). No reflections have been detected at positions (130) and (241), which are only allowed in the LTT and LTO2 phases. In recent measurements with analyzer diffuse scattering was observed in the diagonal hk -directions around the (040) reflection, indicating local orthorhombic strain. This feature was temperature independent between 10K and room temperature.

Acknowledgements: The work at Brookhaven was supported by the U.S. Department of Energy, Division of Material Science, under Contract No. DE-AC02-98CH10886.

References: [1] H. Yoshizawa et al., Phys. Rev. B 61, R854 (2000).

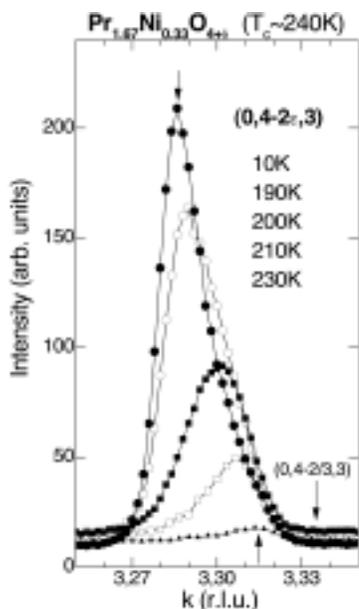


Fig. 1: k-scans through $(0, 4-2\varepsilon, 3)$ charge stripe peak.

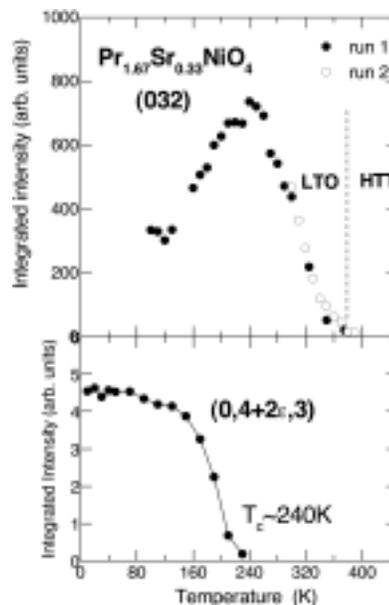


Fig. 2: Top: Integrated intensity of (032) reflection. Bottom: Integrated intensity of the $(0, 4+2\varepsilon, 3)$ charge stripe peak.