ESRF	**Experiment title:** A structural study of the ruthenocuprates $RuSr_2(RE_{1.1-x}Ce_{0.9}Y_x)Cu_2O_{10}$(RE = Nd, Sm, Eu, Gd) which show a crossover from large negative to positive magnetoresistance.	**Experiment number**: HS-3215
Beamline:	**Date of experiment**: from:20/09/06 to: 25/09/06	**Date of report**: 03/08/08
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Report:

In order to further investigate the large negative magnetoresistances (MR) observed in $RuSr_2Nd_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$ a series of materials $RuSr_2RE_{1.1-x}Y_xCe_{0.9}Cu_2O_{10}$ (RE = Nd, Sm, Eu, Gd) were synthesized. The magnetotransport results show an unusual crossover from negative to positive magnetoresistance as the rare earth size decreases (Figure 2). The magnetoresistance increases linearly from -34% to 11% as <R> decreases from 1.042 Å to 1.012 Å. Positive magnetoresistance is observed for $RuSr_2RE_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$ (RE = Eu and Gd, <R> = 1.018 Å and 1.012 Å respectively). In order to ascertain if this crossover between negative and positive magnetoresistance arises due to a change in crystal structure I performed variable temperature synchrotron X-ray diffraction experiments on a series of materials with different <R>, $RuSr_2RE_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$ (RE = Nd, Eu, Gd) and $RuSr_2Sm_{1.1}Ce_{0.9}Cu_2O_{10}$. Samples were contained in 0.5 mm borosilicate capillaries and a wavelength of 0.40025 Å was used. Data was collected from 5 K – 40 K (approximately every 4 K), 45 K – 150 K (every 5 K) and at 160, 170, 180, 200, 250 and 290 K. Excellent fits were obtained for all samples using the tetragonal *I4/mmm* structural model and there was no evidence of a structural transition at any temperature for any of the samples which agrees with recent results which have demonstrated that the crossover from negative to positive MR arises due to a change in the electronic transport from two-dimensional to three-dimensional variable range hopping at 30 K [1].

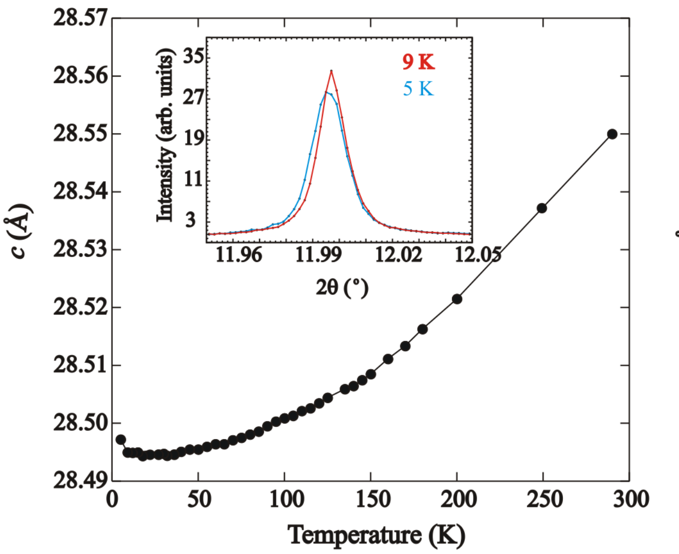

Fig. 1. Variation of c cell parameter with temperature for $RuSr_2Gd_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$, showing a small negative thermal expansion below 9 K. The inset shows the (2 0 0) peak at 5 K and 9 K.

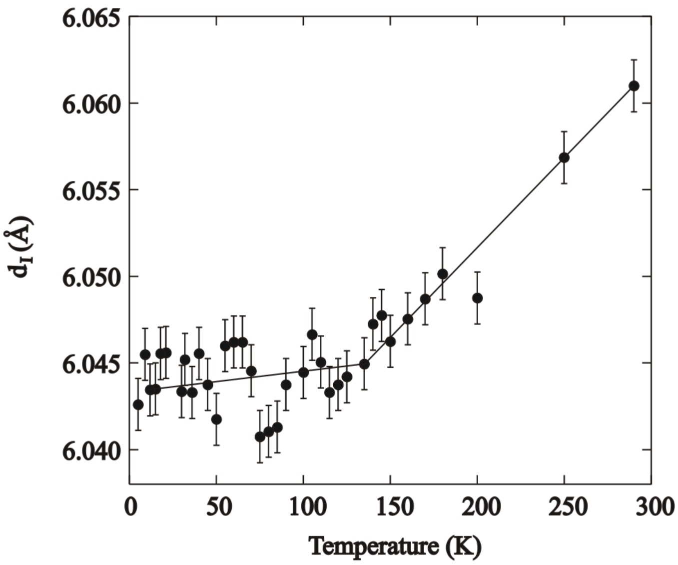

Fig. 2 Temperature variation of the interplanar CuO_2 seperation, d_i, for $RuSr_2Gd_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$.

A small negative thermal expansion (NTE) is observed in all samples below 9 K (Fig. 1); the origin of the NTE is as yet unknown and more data will be required at lower temperatures in order to investigate this further. The NTE is observed in both c and a. A structural anomaly is observed at the Ru spin ordering temperature in all samples where a change in slope in the variation of the interplanar CuO_2 separation,d_i, with temperature is observed at T_{Ru} (Fig 2). This structural anomaly has been observed previously for $RuSr_2Nd_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$ [2]. However an expansion in the Cu-O in plane bond is also observed below T_{Ru} for $RuSr_2Gd_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$. A magnetostriction in the Cu-O bond has not been observed previously for $RuSr_2Nd_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$ [2]. This suggests that the magnetic coupling between RuO_2 layers becomes stronger as the thickness of the $(R,Ce)_2O_{2-\delta}$ block is decreased on changing from larger Nd^{3+} to smaller Gd^{3+} so that a greater magnetostriction is observed in the CuO_2 layers. Surprisingly upon cooling $RuSr_2Gd_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$ in the beam to 5 K, phase segregation is observed. The phase segregation disappears upon warming the sample back to 150 K and was not present if the sample was cooled without the beam on. A similar photoinduced phase segregation has been observed in the CMR manganites as a result of strong electron lattice interactions [3]. There was no time to study this effect within the current experiment and further beamtime will be requested. It will be important to determine if the observed phase segregation conincides with one of the several magnetic or electronic transitions observed in $RuSr_2Gd_{0.9}Y_{0.2}Ce_{0.9}Cu_2O_{10}$ [1, 2].

References

1) A. C. Mclaughlin, L. Begg, C. Harrow, S. A. J. Kimber, F. Sher and J. P. Attfield, *J. Am. Chem. Soc.,* **128**, 12364 (2006).
2) A. C. Mclaughlin, F. Sher, S. Kimber and J. P. Attfield, *Phys. Rev. B* **76**, 094514 (2007).
3) Y. Kiryukhin *et al*, *Nature*, **813**, 386 (1997).