The Ru Electron Configuration of $RuSr_2EuCu_2O_8$

B.-C. Chang (張炳章)[1], C.-Y. Yang (楊致芸)[1], H.-C. Ku (古煥球)[1], and L.-Y. Jang (張凌雲)[2]

[1]Department of Physics, National Tsing Hua University, Hsinchu, Taiwan
[2]National Synchrotron Radiation Research Center, Hsinchu, Taiwan

The ac electrical resistivity r(T) and volume magnetic susceptibility c_V (T) are shown in Fig. 1 for $RuSr_2EuCu_2O_8$ under 1 G field-cooled (FC) and zero-field-cooled (ZFC) conditions. The resistivity shows a non-Fermi-liquid linear T-dependence behavior down to the weak-ferromagnetic ordering temperature T_{Curie} of 133 K, and changes to a T^2-dependence below T_{Curie} due to the magnetic order. [2]

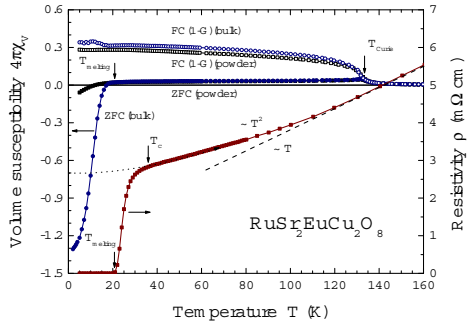


Figure 1. Electric resistivity r(T) and volume magnetic susceptibility c_V(T) under 1 G field-cooled (FC) and zero-field-cooled (ZFC) conditions for $RuSr_2EuCu_2O_8$.

The normalized Ru L_3-edge (2p-4d dipole transition) XANES at 300 K for $RuSr_2EuCu_2O_8$ and $RuSr_2GdCu_2O_8$ as well as for two standards, $SrRuO_3$ (Ru^{4+}) and Sr_2GdRuO_6 (Ru^{5+}), were shown in Fig. 2. The almost identical threshold energy E_o for the two Ru-1212 samples, as compared with $RuSr_2GdO_6$ standard, indicate that Ru valence is close to 5+ with a similar RuO_6 environment. Peak A is the transition form $2p_{3/2}$ to 4d-t_{2g} and peak B is the transition form $2p_{3/2}$ to 4d-e_g. The energy separation E = 2.6 eV for $RuSr_2GdCu_2O_8$ and smaller than 3.2 eV for Sr_2GdRuO_6, which indicates a mixed-valence $Ru^{4/5+}$ character. The Ru self-doping with anisotropic hybridization may drive the resulting Ru^{4+}/Ru^{5+} mixed-valent system metallic and ferromagnetic via a double exchange interaction. [1, 2]

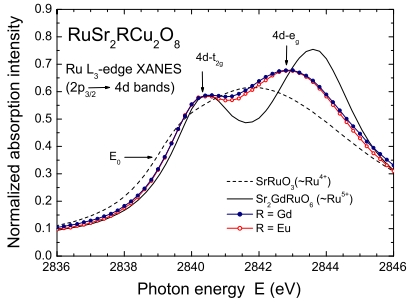
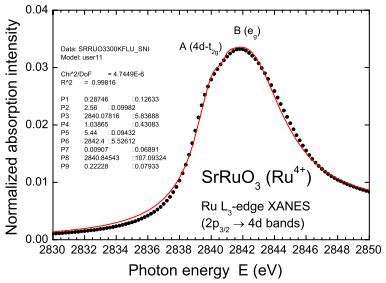


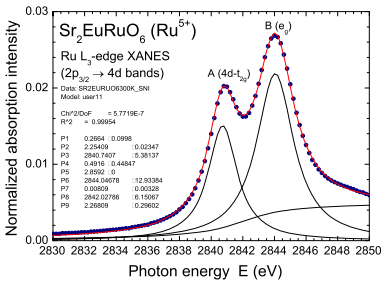
Figure 2. Ru L_3-edge XANES for $RuSr_2GdCu_2O_8$ and $RuSr_2EuCu_2O_8$.

The Ru electron configuration of $SrRuO_3$ (Ru^{4+}), Sr_2EuRuO_6 (Ru^{5+}) and $RuSr_2EuCu_2O_8$ was analysis, and the XANES spectra was fitted by the following equation.
$I_AL(E_{oA},W_A)+ I_BL(E_{oB},W_B)+I_tArctan(Eo,W)$,
where L(x, y) was Lorentz equation.

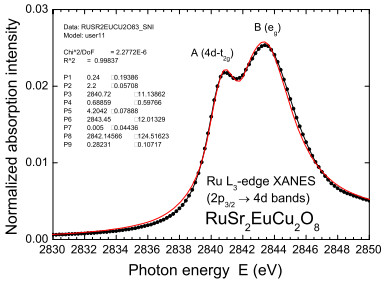
(1) SrRuO3
$I_A : I_B = 0.59 : 1$, DE = 2842.4-2840.07 = 2.33 eV
$W_A = 2.56$ eV, $W_B = 5.44$ eV



(2) Sr_2EuRuO_6
$I_A : I_B = 0.75 : 1$, DE = 2844.05-2840.73 = 3.28 eV
$W_A = 2.25$ eV, $W_B = 2.86$ eV



(3) $RuSr_2EuCu_2O_8$
$I_A : I_B = 0.666 : 1$, DE = 2843.45-2840.72 = 2.73 eV
$W_A = 2.2$ eV, $W_B = 4.2042$ eV



Intensity I_A and I_B were the empty t_{2g} and empty e_g bands. The empty $t_{2g} : e_g = 2.4 : 4$ for $SrRuO_3$, 3 : 4 for Sr_2EuRuO_6, and 2.67 : 4 for $RuSr_2EuCu_2O_8$. The 3.33 electrons in t_{2g} band indicate 33% Ru^{4+} and 67% Ru^{5+}, and imply the mixed valence of Ru^{4+} and Ru^{5+}.

REFERENCES

1. R. S. Liu, L.-Y. Jang, H.-H. Hung, and J. L. Tallon, Phys. Rev. B **63**, 212507 (2001).
2. C. Y. Yang, B. C. Chang, H. C. Ku, and Y. Y. Hsu, Phys. Rev. B **72**, 174508 (2005).