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Impurity effects on spinel-type vanadium oxide MnV_2O_4

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Introduction

MnV_2O_4 is a spinel ferrimagnet with Mn^{2+} ($3d^5$) and V^{3+} ($3d^2$). This compound has been studied owing to the collinear-to-noncollinear magnetic-phase transition accompanied by a cubic-to-tetragonal structural transition. In addition, it has orbital order phase below structural transition temperature because V^{3+} ion has orbital degrees of freedom of t_{2g} electrons [1,2]. We investigated impurity doping effects of Cr^{3+} ($3d^3$) and Mo^{3+} ($4d^3$), which have no orbital degrees of freedom, for the V^{3+} site.

Experiments

$Mn(V_{1-x}M_x)_2O_4$ (M=Cr, Mo) single crystals were grown by a floating-zone method. Magnetization measurements were carried out with a SQUID magnetometer. The powder X-ray scattering with the energy of 15keV were carried out at BL-8A. Resistivity was measured by a standard four-probe method.

Results and discussion

Figure 1 shows the phase diagram of $Mn(V_{1-x}M_x)_2O_4$ (M=Cr, Mo) determined by the results of temperature dependence of magnetic susceptibility. The orbital ordering temperature (T_{OO}) is suppressed with increasing impurities and disappears over than x=0.1 in both impurity doped samples. On the other hand, the transition temperature from paramagnetism to collinear ferrimagnetism (T_N) slightly increase with increasing impurity doping levels.

Figure 2 represents the results of powder X-ray scattering of $Mn(V_{0.95}M_{0.05})_2O_4$ (M=Cr, Mo). It shows a cubic-to-tetragonal structural transition and the transition temperature is consistent with the T_{OO} defined by magnetic measurement. The variations of transition temperature are almost same in both impurity doped samples but resistivity increase with Cr substitution and decrease by Mo substitution.

These results indicate that the substitution of the impurities with no orbital degree of freedom suppress the V orbital order but the changes of electronic structure are different. Electrons are localized in Cr-doped samples and itinerant in Mo-doped ones respectively.

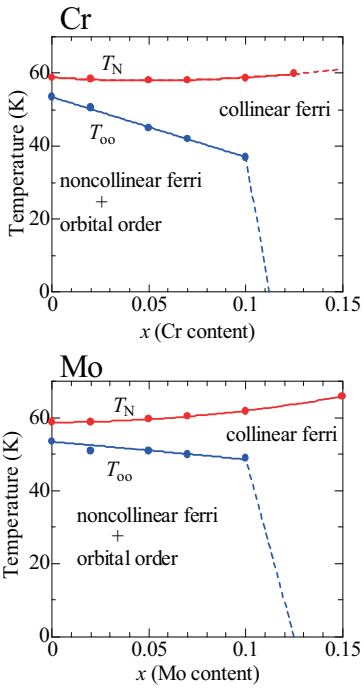

Fig.1 Phase diagram of $Mn(V_{1-x}M_x)_2O_4$ (M=Cr, Mo).

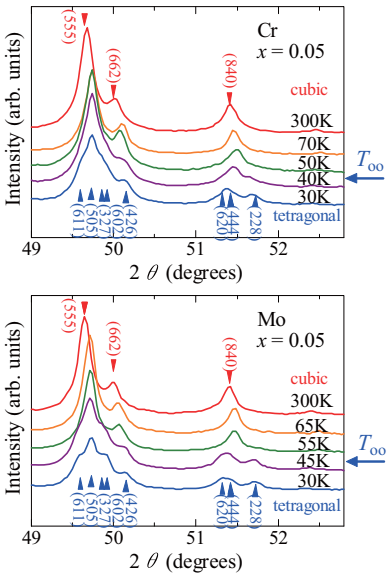

Fig.2 Powder X-ray profiles of $Mn(V_{1-x}M_x)_2O_4$ (M=Cr, Mo) with x=0.05 at various temperatures.

References

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