Synthesis and magnetic properties of the Au-(Al, In)-Gd 1/1 approximants

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Tsai type 1/1 approximants have been reported to exhibit various magnetic orders [1, 2]. Figure 1 shows the dependence of the paramagnetic Curie temperature on the average electron-per-atom(*e/a*) ratio for the Au-Al-Gd 1/1 approximant [2]. This indicates that the net interaction between spins oscillates from positive values to negative values with increasing the e/a ratio, showing that the e/a ratio is one of the key parameters for the magnetic order of the 1/1 approximants. In this work, we have synthesized In-substituted Au-(Al, In)-Gd 1/1 approximants in order to investigate the relationship between the chemical disorder and the magnetic property, which has not been well understood up to date.

Polycrystalline alloys were prepared by arc-melting and annealing at 973K for 50h under Ar atmosphere. The phase purity of the samples was examined by powder X-ray diffraction (XRD) using CuKα radiation. The temperature dependence of the magnetization was measured using a vibrating-sample magnetometer (VSM).

The powder X-ray diffraction patterns show that single 1/1 approximant phase is obtained from x=0 to 13 in the $Au_{64}Al_{22-x}In_xGd_{14}$. The lattice parameter is found to increase with increasing In/Al ratio. Figure 2 shows the magnetic susceptibility of the $Au_{64}Al_{22-x}In_xGd_{14}$ below 50K as a function of temperature. A rapid increase of the magnetization, indicative of a ferromagnetic transition, is observed for all the samples. Moreover, the Curie temperature is found to increase systematically with increasing the amount of In. Here we note that the obtained Curie temperature in the $Au_{64}Al_9In_{13}Gd_{14}$, i.e., 36.7K, is the highest value ever reported in 1/1 approximants. Since the e/a ratio does not change with the substitution of In for Al, such a trend of the Curie temperature might be attributed to the introduction of chemical disorder. Details will be presented in the presentation.

[1] R.Tamura, et al. *Phys. Rev. B* **82** (2010) 220201
[2] A. Ishikawa, et al. *Phys. Rev. B* **98** (2018) 000400

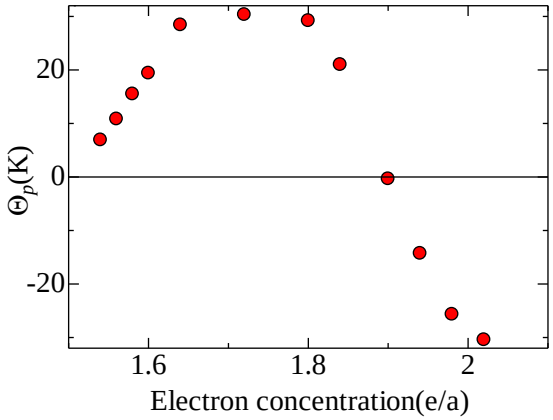

Fig.1: The paramagnetic Curie temperature θ_p vs the average electron-per-atom(e/a) ratio for the Au-Al-Gd approximant [2]

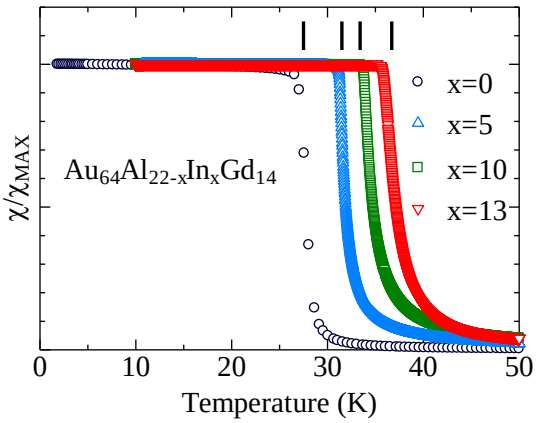

Fig.2: Temperature dependence of the magnetic susceptibility of $Au_{64}Al_{22-x}In_xGd_{14}$