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Single Crystal Growth and Physical Properties of Actinide Compounds

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In recent years, techniques for high-quality single crystal growth of uranium compounds have successfully been expanded to other actinides including Th, Np and Pu. Among them, tetravalent thorium compounds are important related with $4f$-itinerant cerium compounds, since both systems have the same number of valence electrons.

In actinide $AnTX_5$ compounds, there are no reports on $ThTX_5$ compounds so far, although there are many reports on the uranium, neptunium, plutonium compounds with Ga ligands. We tried to synthesize $ThTGa_5$ and $ThTIn_5$. The growth of $ThTGa_5$ was unsuccessful, but we have succeeded in growing high-quality single crystals of $ThRhIn_5$. This may indicate that the ionic radius of Th is close to those of rare earth elements. Single crystals of $ThRhIn_5$ was grown by the In self-flux method. Figure 1 shows a typical single crystal of $ThRhIn_5$. The flat plane corresponds to the (001) plane. We have checked the stoichiometry in the crystals by using an electron probe micro-analysis (EPMA). All the data were consistent with the formula of $ThRhIn_5$, without any trace of impurities. The lattice parameters, positional parameters and thermal parameters for $ThRhIn_5$ with $HoCoGa_5$-type crystal structure were determined at room temperature. We also measured the dHvA effect and succeeded to observed the de Haas-van Alphen signal. Figure 2(a) shows the typical dHvA oscillation in the field range from 100 to 169 kOe at 32 mK and the corresponding fast Fourier transform (FFT) spectrum for the magnetic field H along the [100] direction. Several dHvA branches are clearly observed, ranging from 4.87×10^7 Oe for branch α_3 to 7.54×10^7 Oe for branch β_2. These main dHvA branches named $\alpha_1, \alpha_2, \alpha_3, \beta_2$ follow approximately the $1/\cos\theta$ dependence, indicating cylindrical Fermi surfaces, where θ is a tilted field angle from [001] to [100] or [110].

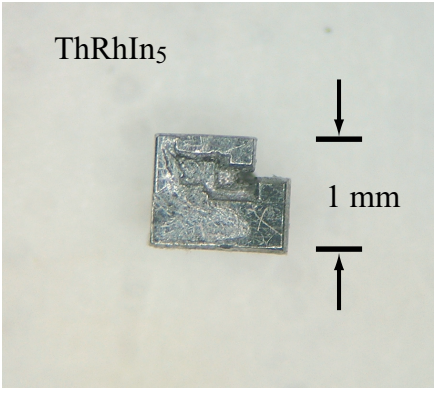

Fig.1 Single crystal of $ThRhIn_5$.

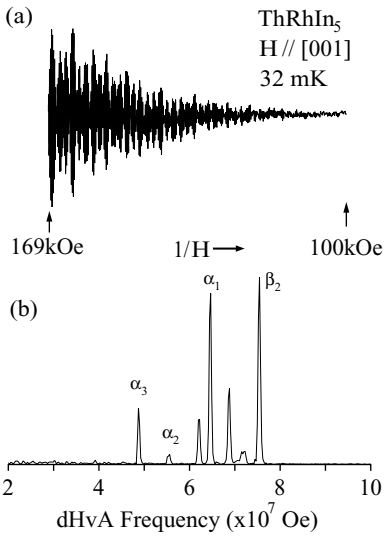

Fig. 2 (a) dHvA oscillation and (b) the corresponding FFT spectrum for the field along [001] in $ThRhIn_5$.