Magnetic properties of $R_2T_{13.6}Si_{3.4}$ single crystals (R = U, Lu, T = Fe, Co)

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In contrast to rare-earth metals, uranium does not form the binary intermetallic compounds with 3d metals having the 2-17 stoichiometry. Nevertheless, this structure can be stabilized by relatively small amount of a third element (Si, Ge). We have grown single crystals of the $U_2T_{13.6}Si_{3.4}$ (T = Fe, Co) compounds and the corresponding analogues with Lu and measured the magnetization along the main axes as a function of magnetic field and temperature.

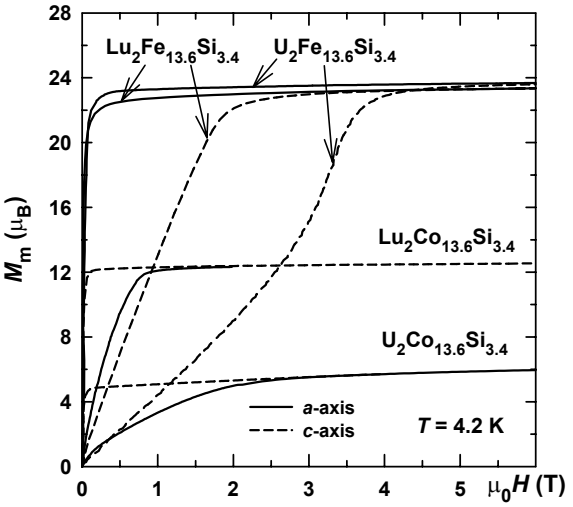

Fig. 1. Magnetization curves along the main axes of the $R_2T_{13.6}Si_{3.4}$ single crystals.

In $U_2Fe_{13.6}Si_{3.4}$, U strongly influences the magnetic properties. A considerable U spin moment is clear from the enhanced T_C of $U_2Fe_{13.6}Si_{3.4}$ (530 K) compared to that of $Lu_2Fe_{13.6}Si_{3.4}$ (470 K). A considerable U orbital moment is manifest by the much larger magnetic anisotropy in $U_2Fe_{13.6}Si_{3.4}$ than in $Lu_2Fe_{13.6}Si_{3.4}$ (Fig. 1). Both the Fe and the U sublattices provide the easy-plane type of magnetic anisotropy. The Fe sublattice is characterized by the first anisotropy constant K_1 = -0.84 MJ/m^3 at 4.2 K. The U sublattice exhibits nearly the same contribution to K_1 and gives rise to a large negative K_2 = -0.47 MJ/m^3 (<0.06 MJ/m^3 in $Lu_2Fe_{13.6}Si_{3.4}$), which is manifest by a strong non-linearity of the magnetization curve and a field-induced transition with critical field μ_0H_c = 3.3 T (determined as a field of maximal differential susceptibility).

In compounds with Co, the situation is completely different. $U_2Co_{13.6}Si_{3.4}$ has much lower magnetic moment (Fig. 1) and T_C (210 K and 415 K, respectively) compared to the Lu analogue. Both compounds exhibit the uniaxial magnetic anisotropy with identical K_1 = 0.2 MJ/m^3 at 4.2 K (Fig. 2), which is much weaker than the easy-plane anisotropy of the Fe counterparts. No field-induced transition is observed for $U_2Co_{13.6}Si_{3.4}$.

Thus, all the features pointing to the magnetic state of U in $U_2Fe_{13.6}Si_{3.4}$ are absent in $U_2Co_{13.6}Si_{3.4}$. U atoms do not carry a magnetic moment and the compound behaves as an analogue of $Lu_2Co_{13.6}Si_{3.4}$ with reduced magnetic moment and exchange interaction. In both compounds, K_1 decreases with temperature somewhat faster than M^3 similar to other R-T intermetallics with a non-magnetic R sublattice.

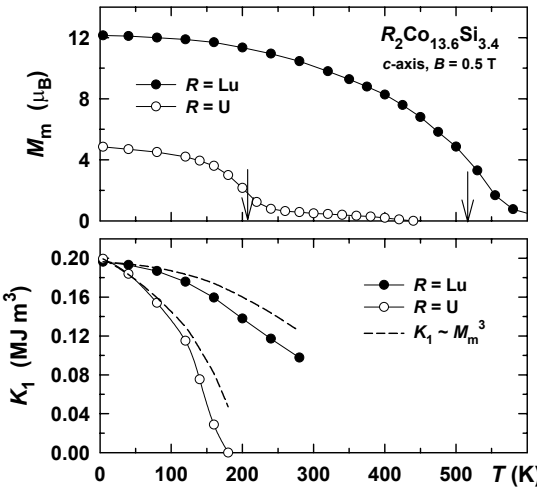

Fig. 2. Temperature dependences of M_m and K_1 of the $R_2Co_{13.6}Si_{3.4}$ single crystals. The arrows indicate T_C.