Magnetic properties of $UCo_{1-x}Os_xAl$ solid solutions: transition from itinerant metamagnetism to ferromagnetism

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UCoAl belongs to a UTX family (T is a late transition metal of 3*d*, 4*d* or 5*d* series, X is a *p*-metal Al, Ga, In or Sn) with the hexagonal crystal structure of the ZrNiAl type. In magnetic field of 0.7 T applied along the *c*-axis, UCoAl undergoes a metamagnetic transition to a forced ferromagnetic state [1]. The ground state of UCoAl is paramagnetic [2], so it has to be classified as itinerant metamagnet with uniquely low critical field H_{cr} of the transition. Due to so low H_{cr} value, UCoAl is extremely sensitive to any influence like dilution of the U sublattice, external pressure or substitution. When Co is substituted by T = Fe, Ru, Rh and Ir in the $UCo_{1-x}T_xAl$ systems, H_{cr} rapidly decreases and already 1-2% doping stabilizes spontaneous ferromagnetism. Opposite, for T = Ni, Pd and Pt, H_{cr} increases and paramagnetism is stabilized.

Influence of only one of late d metal, Os, on the metamagnetism in UCoAl was not studied previously due to metallurgical problems (melting temperature of Os exceeds evaporation temperature of Al). Now we solved these problems, prepared $UCo_{1-x}Os_xAl$ solid solutions and studied their crystal structure and magnetic properties.

Terminal compound UOsAl does not form the ZrNiAl-type structure but hexagonal Laves phase of the $MgZn_2$ type. It is temperature-independent paramagnet, similar to the isostructural compound UFeAl. No field-induced transition is observed in fields up to 60 T. $UCo_{1-x}Os_xAl$ solid solutions with $x < 0.2$ have the ZrNiAl crystal structure. The compound with $x = 0.2$ has traces (~2%) of an impurity phase, so we consider this Os content as a homogeneity limit.

Magnetization measurements performed on single crystals (except for $x = 0.2$, this alloy was studied on isotropic polycrystal) showed that compounds with $x \geq 0.01$ are ferromagnets. Spontaneous moment increases from 0.32 μ_B/f.u. at $x = 0.01$ to 0.55 μ_B/f.u. at $x = 0.20$, which is almost twice larger than the magnetic moment induced at the metamagnetic transition in UCoAl. T_C increases from 16 K at $x = 0.01$ to 54 K at $x = 0.20$. All the compounds within the homogeneity range exhibit strong field and thermal hysteresis. At very low Os content, $UCo_{0.998}Os_{0.002}Al$, the ground state of the compound is still metamagnetic like in UCoAl. Transition field at 2 K is 0.35 T, which is already as twice as lower than that in UCoAl. H_{cr} increases with increasing temperature in the same way as in UCoAl. $UCo_{0.995}Os_{0.005}Al$ has almost purely ferromagnetic ground state with small metamagnetic component. It has $M_s = 0.3$ μ_B and $T_C = 8$ K. The ferromagnetism can be suppressed completely by external hydrostatic pressure of only 0.1 GPa. $UCo_{0.99}Os_{0.01}Al$ is already a pure ferromagnet with $T_C = 16$ K and $M_s = 0.32$ μ_B. All compounds within the homogeneity range exhibit huge uniaxial magnetic anisotropy. The anisotropy field, defined as the field where the hard-axis curve reaches M_s value (or *M* just above metamagnetic transition in the case of metamagnets), is at least 120-130 T.

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