Low-temperatures High-magnetic-fields Phase Diagram of $URu_{2-x}Re_xSi_2$, x ≥ 0.20

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Introduction

URu_2Si_2 is a heavy fermion compound ordering into a Hidden Order (HO) phase at 17 K and supraconducting below 1.2 K. Its low-temperature high-magnetic-field phase diagram is characterized by the formation of multiple ordered phases between 30 and 42 T around a putative metamagnetic Quantum Critical Point (QCP) located at 38 T **[1]**. Rhenium doping suppresses the HO at x ~ 0.12 and brings ferromagnetism (FM) from x ~ 0.30 **[2]**. In the present project, we study the consequences of Re doping on the Itinerant Electron Metamagnetism (IEM) and on the ordering at high fields. Previous magnetization and magneto-transport measurements in pulsed fields on $URu_{2-x}Re_xSi_2$ single crystals for x ≤ 0.20 (2007 NHMFL reports) have shown that the field-induced reentrant ordering is suppressed at x = 0.05, that the QCP is detuned and that the metamagnetic transition field B_{MM} goes to higher fields with x. Here we report on the measurements for the higher doping contents x ≥ 0.20.

Experimental

The four-wire magnetoresistance measurements were carried out up to 42 T at several different temperatures below 100 K in the mid-pulse magnet at the NHMFL Los Alamos Facility and the magnetization measurements up to 60 T below 30 K in a short-pulse magnet. The samples for transport have a ~ 0.15 x 0.4 x 2.5 mm^3 needle shape, the longer edge being along *a*. The samples for magnetization have a ~ 0.2 x 0.8 x 1.0 mm^3 cut plane-parallel shape with the longer edge along *c*. For the purpose of absolute measurements, resistivity and magnetization was measured on each sample in a 14T PPMS using the transport and VSM options. All measurements were carried out so that the easy magnetization axis *c* and the magnetic field are aligned.

Results and Discussion

On Fig.1, we show the magnetoresistance drop from 41 T at several different temperatures up to 42 T in $URu_{2-x}Re_xSi_2$ for x = 0.20 (left panel) and x = 0.50 (right panel). For x = 0.20, the change from positive to negative magnetoresistance behavior at low fields marks the transition from the spin-compensated Kondo-lattice regime to the Kondo single impurity regime. Ferromagnetism for x ≥ 0.30 is shown to alter the low fields behavior bringing a steep negative magnetoresistance in a wide temperature range as much as down to 1.5 K for x = 0.50. The magnetoresistance maximum is present up to x = 0.50, yet visible at the lowest temperatures only and quite broadened. Its position in field $B_{\rho max}$ moves to lower fields with x as was observed already for x ≤ 0.20. From the magnetization measurements (not shown), the IEM transition is shown to survive deep inside the FM state up to x = 0.50. Interestingly, B_{MM} keeps on moving to higher fields with x as x ≥ 0.30 where a shift to lower fields could have been expected considering the early proposal of band FM triggered by a spontaneous spin-splitting of the heavy bands **[3]**. Trends for B_{MM} and $B_{\rho max}$ as a function of x support the scenario of a detuning of the QCP under Re doping.

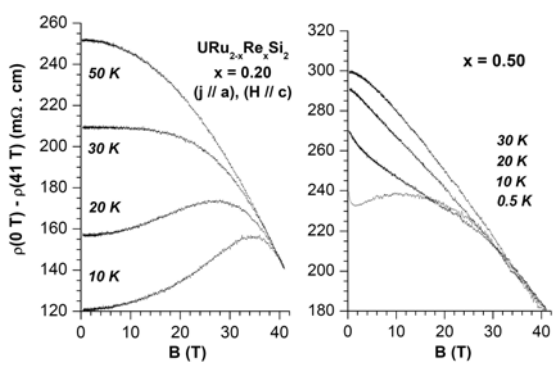

Fig.1. Magnetoresistance drop from 41 T at several different temperatures in $URu_{2-x}Re_xSi_2$ x = 0.20 (left panel) and x = 0.50 (right panel). Curves have been shifted vertically for clarity.

Acknowledgements

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References

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