Investigation of the Low-Temperature High-Magnetic-Field Phase Diagram of $URu_{2-x}Re_xSi_2$, $x \leq 0.30$

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Introduction

URu_2Si_2 is an antiferromagnetic (AF) heavy fermion compound ordering at 17 K into a hidden order (HO) phase and at 1.2 K into a superconducting state. Its low-temperature high-magnetic-field phase diagram is characterized by the formation of multiple ordered phases in the 30 to 42 T magnetic field range around a putative quantum critical point (QCP) located at 38 T **[1]**. Rhenium doping yields a heavy fermion compound $URu_{2-x}Re_xSi_2$ with other intriguing electronic and magnetic properties below 14 K **[2]**. The HO phase is suppressed at x = 0.10; from x = 0.30, ferromagnetism develops and, for 0.10 < x < 0.50, the electronic liquid is not Fermi liquid-*like*. In the present work, we aim at determining the consequences of a rhenium doping on the QCP and on the ordering at the QCP in URu_2Si_2. Previous pulsed field magnetization (x = 0.02, 0.04, 0.10, 2006-269 NHMFL report) and magnetoresistance (x = 0.08, 2006-272 NHMFL report) measurements have suggested that rhenium doping contributes at weakening the ordering around the QCP and at making this metamagnet more itinerant. Here we report on complementary results from magnetization measurements in $URu_{2-x}Re_xSi_2$ for x = 0.08, 0.20, 0.30, from four-wires magnetoresistance measurements for x = 0.20, 0.30 and from Tunnel Diode Oscillator (TDO) magnetoresistance measurements for x = 0.02, 0.04, 0.30.

Experimental

The magnetization and four-wire magnetoresistance measurements were carried out up to 55 T between 0.5 and 30 K in the 65T short-pulse magnet whereas the TDO measurements were carried out up to 42 T between 0.5 and 11 K in the 50 T mid-pulse magnet and up to 55 T in the 60 T long-pulse magnet at the NHMFL Los Alamos Facility. For the magnetization and TDO measurements, the single-crystal samples have a cut ~ 0.8 x 0.2 x 1.7 mm^3 plane-parallel shape with the longer edge along *c*. For the four-wire resistance measurements, the samples have a ~ 0.2 x 0.3 x 1 mm^3 plane-parallel shape, the longer edge being along *a*. The resistance at 10 K is 49 mΩ in $URu_{1.80}Re_{0.20}Si_2$ and 13 mΩ in $URu_{1.70}Re_{0.30}Si_2$. All measurements were carried out so that the easy magnetization axis *c* and the magnetic field are aligned. The value of the rhenium doping was checked in each sample either prior or posterior to the pulsed field measurements by measuring the resistance in a 14T PPMS and tracking the temperature positions of known features in the R vs. T curves.

Results and Discussion

The different ordered phases around the QCP are shown to be suppressed at x = 0.05. The metamagnetic magnetization jump survives up to x = 0.30. However, an important increase of its width Γ_M and shift to higher field of its position B_M occur as the rhenium content increases. In $URu_{1.80}Re_{0.20}Si_2$, as shown **Fig.1,** B_M ~ 40.5 T and Γ_M ~ 17 T *vs.* B_M ~ 37.5 T and Γ_M ~ 8 T in $URu_{1.92}Re_{0.08}Si_2$ (not shown) On the other hand, the magnetoresistance maximum associated with the disordered quantum critical region is shifted to lower field. Both trends suggest a detuning of the QCP. A data analysis is underway to make clear this scenario.

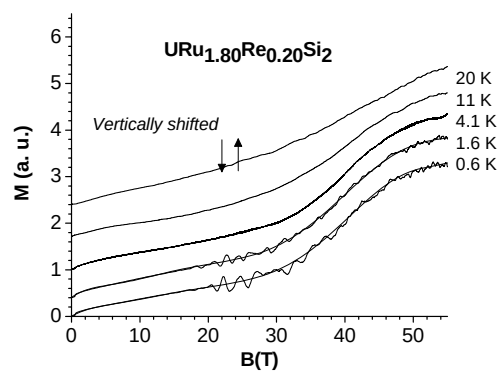

Fig.1. Magnetization curves at several different temperatures in $URu_{1.80}Re_{0.20}Si_2$

Acknowledgements

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References

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[2] Bauer E. D. *et al.*, Phys. Rev. Lett. 94, 046401 (2005)