Preparation of Heavy Fermion Superconductor $CeRu_2$

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Introduction

The heavy Fermion system presented different electronic ground states at low temperature due to the competition of Kondo effect and RKKY (Ruderman-Kittel-Kasuya-Yosida) interaction, such as superconductors, paramagnets, HF band magnets and local moment magnets. Among these different electronic ground states, many researchers believe that the study of heavy fermion superconductors can help to understand the mechanism of unconventional superconductors. Most heavy fermion superconductors are Ce-based or U-based. In this paper, we are trying to prepare single crystal samples of $CeRu_2$ and provide more experimental basis for the magnetic and superconductivity of this material.

Experiments

We used traditional arc-melting methods to prepare $CeRu_2$ polycrystalline samples, and explored the best preparation conditions for $CeRu_2$ single crystal samples which were grown in four arc draw-up single cryst al furnace using Czochralski method. The purity of these samples was verified by powder X-ray diffraction and DC magnetic susceptibility.

Substrate shaft for pulling

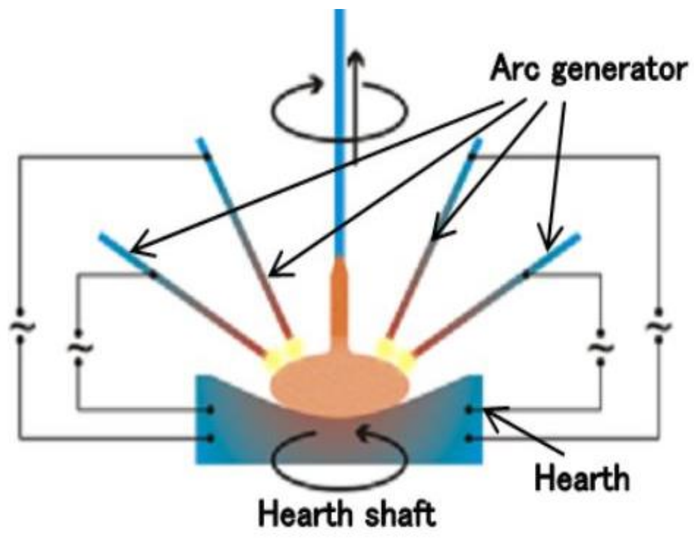

Figure 1 | During the growth process, the raw materials are placed in a rotating copper crucible, and the four electrodes are simultaneously discharged to form a high-temperature melting the raw materials, and the precisely controlled pulling rod is used to pull the molten raw materials into a single crystal by the Czochralski method. The sample chamber has a vacuum of 10^{-6} Torr and can also be filled with a protective gas.

EPS-modulated MR response in the LPCMO-OSV device

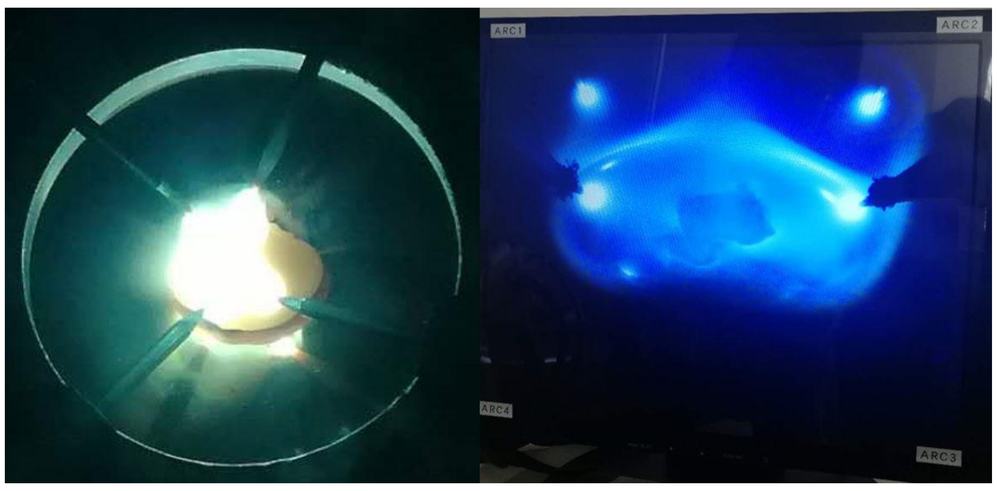

Figure 2 | Arc-melting photographed with a mobile phone (left) and CCD (charge coupled device, right).

Results & Discussion

Rod Crystals Obtained by Czochralski Method

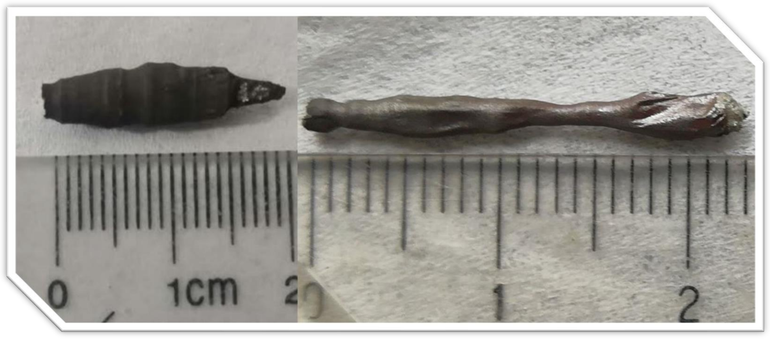

Figure 3 | Rod Crystals Obtained by Czochralski Method.

Powder X-ray Diffraction

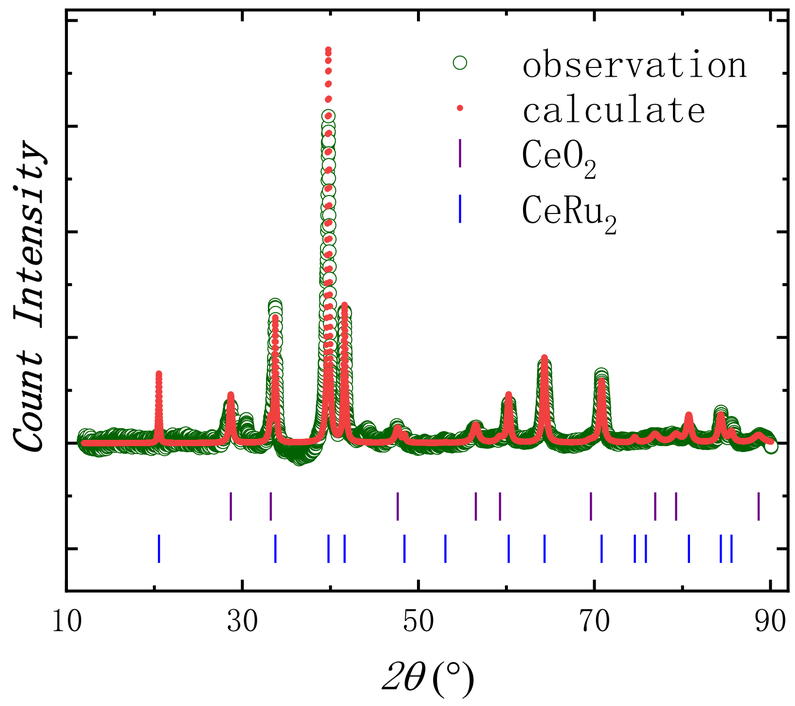

Figure 4 | Using GSAS II to refine the XRD data, we can obtain a $CeRu_2$ content of 61.49% and a CeO_2 content of 38.51% which is too high as an impurity. There are two cases that lead to the production of impurity CeO_2. 1.Oxidation caused by exposure to air for weighing. 2.Oxidation caused by sparks during grinding.

DC Magnetic Susceptibility

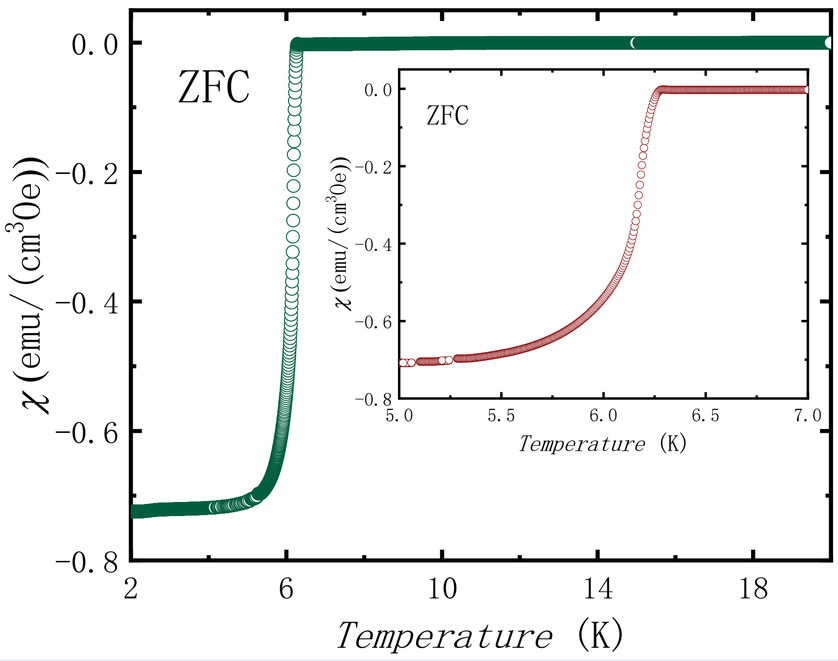

Figure 5 | The magnetic susceptibility of crystal II were measured by SQUID VSM, where the large image shows the data of 2-20K. The small part shows the information of 5-7K. From the small picture, we can clearly see that T_C is 6.28K and ΔT= 1K, which is quite steep, indicating that the high quality of the samples.

Conclusion

From the powder X-ray diffraction spectrum and DC magnetic susceptibility, we claim that we have successfully prepared polycrystalline samples of $CeRu_2$. However further tests are needed in order to check whether the rod-shaped crystal are single crystal samples.

We hope to provide more experimental evidence for judging the magnetic or superconducting transition of $CeRu_2$ near H_a by preparing high quality single crystal samples.

Acknowledgments

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