Thin-Film Hydride Superconductors: A New Platform to Study Near-Room-Temperature Superconductivity at Megabar Pressures

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Abstract

The discovery of hydride superconductors has opened a new route towards room-temperature superconductivity [1-5]. Among those materials, LaH_{10} has attracted considerable interest due to its superconducting transition temperature around 250 K. However, hydride superconductors can only be synthesised at megabar pressures, making their study challenging and limiting the range of experimental techniques that can be applied. In particular, electrical transport measurements require electrodes integrated into a diamond anvil cell (DAC) that can survive both extreme pressures and laser-heating synthesis conditions whilst maintaining sufficiently low contact resistance with the sample for sensitive measurements.

To overcome some of these challenges, we have developed a method for synthesising hydride superconductors from elemental thin films deposited directly onto diamond anvils and using ammonia borane (NH_3BH_3) as a hydrogen source [6]. This approach led to the discovery of superconductivity in La_4H_{23} [7] and, more recently, enabled the synthesis of the first LaH_{10} thin films [8].

In this talk, I will present the methods used in our laboratory to synthesise and characterise high-T_c hydride superconductors. I will focus on thin-film LaH_{10} and its structural and superconducting properties, characterised using synchrotron X-ray powder diffraction and electrical transport measurements in magnetic fields. We find that thin-film LaH_{10} exhibits properties consistent with bulk samples. By combining high-resolution diffraction mapping with transport measurements, we can assign superconducting transitions to specific structural phases and distinguish between contributions from different phases. Finally, I will discuss the stability of both the structural and electronic properties of LaH_{10} thin film, based on measurements we carried out over almost a year.

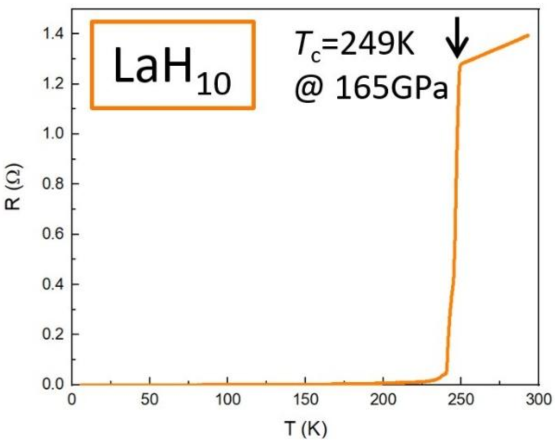

Figure 1: Electrical resistance in LaH_{10} film.

The thin-film approach provides a practical route to facilitate electrical measurements at extreme pressures and significantly improves the success rate of our transport experiments. Furthermore, the development of hydride superconductor thin films opens new possibilities for fabricating devices directly within DACs, enabling more advanced electrical and spectroscopic studies of superconductivity at ultrahigh pressures.

References
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