

Large enhancement of critical temperature in the van der Waals superconductor 4Hb-TaS₂ induced by in-plane uniaxial strain

P. Mówiński¹, J. Juraszek¹, Ł. Bochenek¹, M. Konczykowski², Y. Thiebes³, R. Niewa³, and T. Cichorek¹

¹Institute of Low Temperature and Structure Research, Polish Academy of Sciences, 50-422 Wrocław, Poland

²Laboratoire des Solides Irradiés, CEA/DRF/IRAMIS, École Polytechnique, CNRS, Institut Polytechnique de Paris, F-91120 Palaiseau, France

³Institute of Inorganic Chemistry, University of Stuttgart, 70569 Stuttgart, Germany

Micro-Hall probe magnetometry enables the accurate detection of the vector magnetic field with subgauss sensitivity and micrometer spatial resolution. In superconductors, this technique minimizes disadvantages caused by surface barriers and sample geometry. This allows a precise determination of the lower critical field $H_{c1}(T)$ [1,2]. $H_{c1}(T)$ is related to the superfluid density, and thus valuable information about the symmetry of the underlying order parameter can be achieved.

Application of the uniaxial strain can narrow down the possible scenarios for the symmetry of the order parameter by lifting the specific crystal symmetries. To this end, we built a differential thermal contraction strain rig capable of applying uniaxial compression of $\sim 0.6\%$ to the sample. The original design [3,4] was adapted to allow mounting of a micro-Hall sensor. The sensor was placed on a specially designed arm, positioning its active area of $40 \times 40 \mu\text{m}^2$ close to the center of the crystal surface. A thin sample was glued to the sample platform made of beryllium copper.

We performed first measurements of critical temperature under uniaxial strain of the van der Waals heterostructure 4Hb-TaS₂, a putative chiral superconductor ($T_c \approx 3$ K) with hexagonal structure. Interestingly, its unconventional superconducting state is likely driven by Ising type spin-orbit interaction. With strain along the crystallographic direction [110], for a sample with thickness $d \approx 18 \mu\text{m}$, we observed the formation of Cooper pairs at T_c^{onset} of around 3.25 K. More remarkably, when the sample thickness was reduced ($d \approx 4 \mu\text{m}$), the influence of strain was very strong, resulting in $T_c^{\text{onset}} \approx 7.5$ K, which was the highest value recorded. Subsequent measurements with strain applied along the [120] direction revealed an even larger enhancement up to $T_c^{\text{onset}} \approx 9$ K ($d \approx 10 \mu\text{m}$) suggesting possible anisotropy between different in-plane strain directions and influence on Ising pairing mechanism. Our results demonstrate potential of in-plane uniaxial strain in studying the unconventional superconductivity in 4Hb-TaS₂ and related systems.

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Reference

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