MERIT Internship Report

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【Implementation period】

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【Host organization】

Strong Correlation Quantum Transport Research Team, Center for Emergent Matter Science (CEMS), RIKEN

Dr. Ryutaro Yoshimi

【Research theme】

Synthesis of superconductor PdTe2 thin films by molecular beam epitaxy

【Contents】

The topology in materials and novel physical properties caused by it have been one of the central themes in condensed matter physics today. Superconductivity accompanied by nontrivial topology has been also intensively studied, which is represented by the detection and manipulation of novel Majorana fermions in topological superconductors.

Strong Correlation Quantum Transport Research Team (Center for Emergent Matter Science (CEMS), RIKEN) has been investigated novel physical phenomena caused by nontrivial topology in materials such as the quantum Hall effect and the quantum anomalous Hall effect. In this internship, the research was carried out under the guidance of Dr. Ryutaro Yoshimi, a researcher in Strong Correlation Quantum Transport Research Team.

The target material studied in the internship is a superconductor $PdTe_2$. $PdTe_2$ is a layered material consisting of two-dimensional $PdTe_2$ layers bonded by van der Waals force, and it is known that bulk $PdTe_2$ crystals exhibit superconducting transition at 1.7 K. A few-layer-thick thin samples have been attracting great interest as a platform to study two-dimensional superconductivity, in which typical phenomena of two-dimensional superconductors such as Berezinskii-Kosterlitz-Thouless (BKT) transition and Ising superconductivity are observed. Moreover, by preparing heterostructures consisting of $PdTe_2$ and topological insulators such as $(Bi,Sb)_2Te_3$, superconducting gap is expected to be induced in the surface Dirac state of the topological insulator, which will leads to the realization of interfacial topological superconductivity.

In this research, we tried the synthesis of $PdTe_2$ thin films by means of molecular beam epitaxy. InP(111) substrate was set in the ultra-high vacuum chamber and heated at 300 ºC. Elemental Pd and Te were supplied from Knudsen cells onto the substrate. As shown in Fig. 1(a), the result of the X-ra diffraction measurement demonstrates that the single-phase $PdTe_2$ thin films was successfully obtained. The topography obtained by the atomic force microscopy also confirms that the films have flat surfaces. The charge transport property of the film was measured by the Physical Property Measurement System (Quantum Design) using the adiabatic demagnetization refrigerator option. Figure 1(b) shows the sharp superconducting transition at T = 1.7 K, which is as high as that in bulk crystals, demonstrating that superconducting $PdTe_2$ thin films can be synthesized by molecular beam

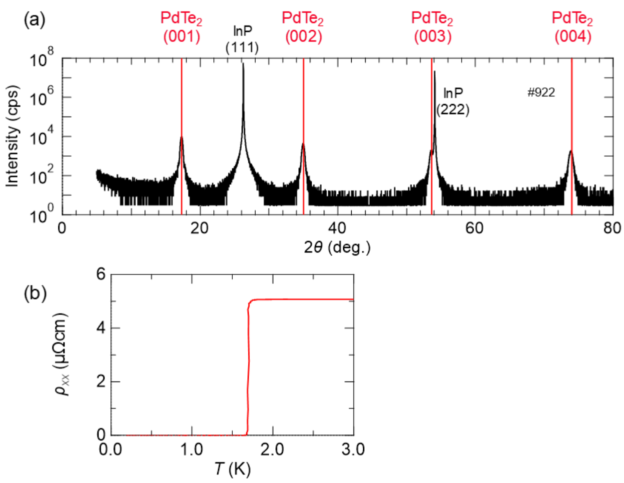

Fig. 1. (a) X-ray diffraction 2θ-ω scan and (b) temperature dependence of resistivity of a $PdTe_2$ / InP(111) thin film.

epitaxy. Moreover, it was also confirmed that the heterostructures with a topological insulator $(Bi,Sb)_2Te_3$ can be also prepared and those heterostructures also show superconductivity. In such a system, topological superconductivity is expected at the interface of a superconductor and topological insulator. We had discussion about possible experimental techniques to detect these states.

【Acknowledgements】

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