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Crystal Growth and Superconducting Properties of a Chiral Compound $TaSi_2$

*Yuta Hoshidoh[1], Kaito Koyanagi[1], Takao Sasagawa[1]

MSL, Tokyo Institute of Technology[1]

Superconductivity was reported, long time ago, in MX_2 (M = Nb, Ta; X = Si, Ge) [1,2]. Though the reported superconducting transition temperature, T_c, was as high as 16 K for $NbGe_2$, there have been only a few follow-up experiments. It is noted that the measurements of superconducting properties under magnetic fields are lacking, and T_c for each compound remains controversial. The difficulty of establishing the superconductivity in these compounds may be attributed to the fact that it is difficult to synthesize single-phase pure samples. This is because high purity Nb and Ta are not readily available and the melting-points (T_m) and reaction-temperatures of the raw materials are very high (e.g. T_m ~ 3000°C for Ta).

We are interested in these compounds from the viewpoint of electronic structures. As shown in Fig. 1 (a), MX_2 has a hexagonal crystal structure with the space group $P6_222$, which belongs to the chiral symmetry. It is expected that the spin band splitting occurs in the electronic states when strong spin-orbit interaction (SOI) is present in the chiral symmetry. In fact, by the first principles calculations, we confirmed such spin band splitting in these compounds. Therefore, it became increasingly important to examine and establish the superconductivity in these chiral compounds.

Using Ta (6N) and Si (5N) grains, single-phase polycrystalline samples of $TaSi_2$ were successfully synthesized by the arc-melting method in a tetra-arc furnace (Fig. 1 (b)). Residual resistivity at 2 K and residual resistivity ratio of the obtained $TaSi_2$ pellet were 0.22 μΩcm and 143, respectively, indicating the high quality of the sample. The temperature dependence of resistivity was measured using a dilution refrigerator down to 55 mK. Below 0.7 K, the resistivity suddenly dropped, indicating a superconducting transition. Although the onset T_c ~ 0.7 K is lower than the previously reported value (4.4 K [1], which is very close to T_c for Ta), we believe this is the intrinsic superconductivity in $TaSi_2$.

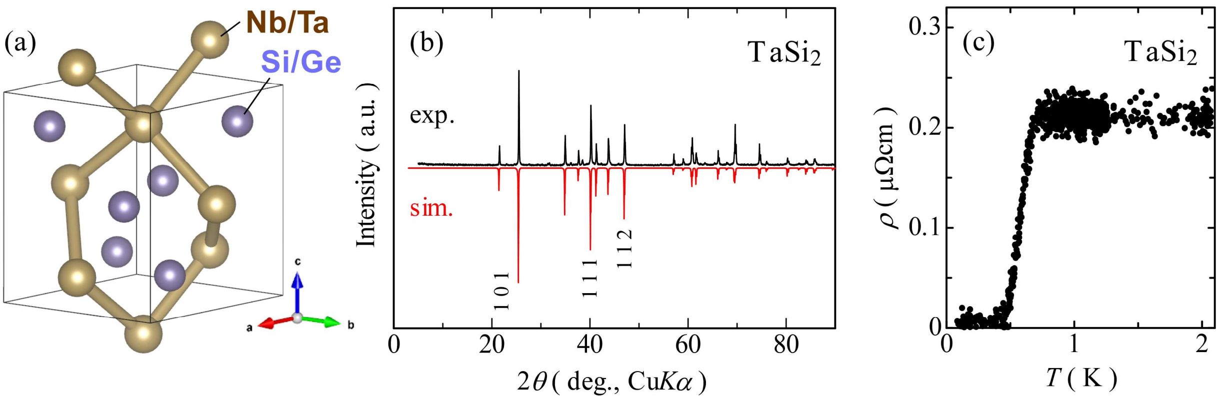

Fig. 1 (a) Crystal structure of MX_2 (M = Nb, Ta; X = Si, Ge). (b) XRD patterns of $TaSi_2$ (experiment vs. Simulation). (c) Temperature dependence of resistivity in the $TaSi_2$ pellet.

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