Low Resistivity in Silver Complexes

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Abstract

The chalcogenide compounds $Ag_2Te(MS_2)_3$ (M=V,Nb), first synthesized by the Kanatzidis' group, are of interest because of their unique properties. These two crystals exhibit low resistivity and may give access to other types of transport. We synthesized and characterized the two crystals to henceforth better understand transport at lower temperatures, where classical transport theories break down. A solid state method was used to synthesize both crystals. This work added to the characterization work of the Kanatzidis' Group including calculating the RRR and the Hall Effect. The RRR values of the V and Nb sample are 19.73 and 44.22 respectively. Hall bar measurements of the Vanadium crystal reveal the predominant charge carriers are holes.

Introduction

Layered transition metal dichalcogenides (TMDCs) are of interest due to their unique magnetic and structural properties. Their low resistivity may give access to other types of transport. Northwestern University presented two new compounds in the form of $Ag_2Te(VS_2)_3$ and $Ag_2Te(NbS_2)_3$ [1]. The Kanatzidis group did x-ray diffraction studies, measured magnetic susceptibility, spectroscopy measurements and other tests. It was reported that, at low temperatures $Ag_2Te(VS_2)_3$ behaves like an antiferromagnet and at higher temperatures it shows paramagnetic properties. In this paper we continued to characterize the transport properties of these chalcogenide compounds by measuring the Hall effect.

Methods

Solid State Growth of $Ag_2Te(VS_2)_3$

Amounts of 0.644g (6 mmol) Ag , 0.378 (3 mmol) Te, 0.454g (9 mmol) V, and 0.665g (20 mmol) S were added and mixed into an alumina crucible. It was then placed in a quartz tube. The tube was then evacuated to $1x10^{-3}$ mbar, flame sealed, and placed in the furnace. It was heated to 600 °C for 12 hours, held for 6 hours, heated to 800 °C in 6 hours then held for 6 days. It was then cooled to 50 °C over 7 days.

Solid State Growth of $Ag_2Te(NbS_2)_3$

Amounts of 0.084g (0.7 mmol) Ag, 0.051 (0.04 mmol) Te, 0.109 (1.2 mmol) Nb, and 0.088 (2.7 mmol) S were mixed and added into an alumina crucible and placed in a quartz tube. The tube was then evacuated to $1 x10^{-3}$ mbar, flame sealed, and placed in the furnace. It was heated to 600 °C for 12 hours, held for 6 hours, heated to 800 degrees celsius, held for 6 days, cooled to 425 °C for 100 hours and cooled again to 50 °C for 100 hours.

Transport methods

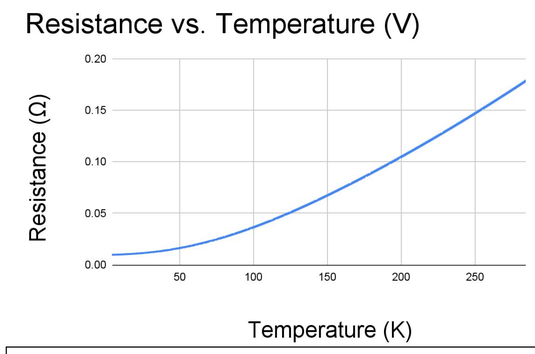
Transport measurements performed on the crystal using a 14 Tesla PPMS system. Five probes were attached with a layer of gold in between as a conductor. The temperature was sweeped from 300K to 5K using 1 mA. The potential difference between the probes were measured in the V_{xx} and V_{xy} direction.

Ongoing Efforts

- Analyzing the charge density of the Niobium crystal
- Designing experiments to find the cause of the resistance bump in the Niobium Sample
- Creating complex geometries with crystals to explore hydrodynamics writhin crystal

Results

The RRR value of the crystals were calculated from the resistances at 300K and 5K. The RRR values of the Vanadium and Niobium crystal are 19.73 and 44.22 respectively.



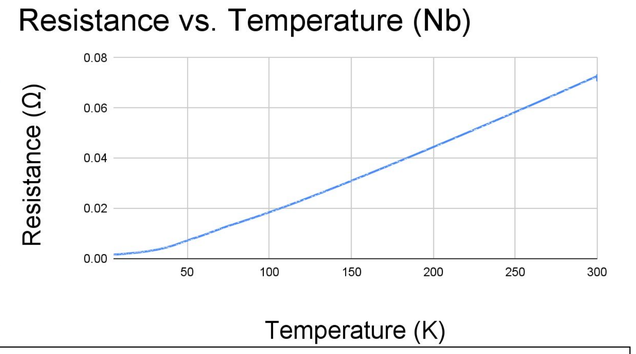


Fig 1 (left) Resistance vs. Temperature of the Vanadium Crystal
Fig 2 (right) Resistance vs. Temperature of the Niobium Crystal

The charge density of the Vanadium crystal was calculated using the Hall voltage formula with measurements taken from the PPMS in the Vxy direction.

Temperature	Charge Density (carriers/m^3)
5K	1.43094E+27
10K	1.44722E+27
15K	1.44538E+27
20K	1.44851E+27
25K	1.45001E+27
30K	1.45632E+27
35K	1.46184E+27
40K	1.47193E+27

Fig 3. The charge density of the vanadium sample taken at various temperatures

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References

[1] Nguyen, Sandy L., Christos D. Malliakas, Melanie C. Francisco, and Mercouri G. Kanatzidis. "Lattice-Matched Transition Metal Disulfide Intergrowths: The Metallic Conductors $Ag_2Te(MS_2)_3$ (M = V, Nb)." *Inorganic Chemistry* 52, no. 11 (June 3, 2013): 6520–32. https://doi.org/10.1021/ic400483d.

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