Characterization and Fabrication of V_xNbS_2

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Abstract

Transition metal dichalcogenides (TMDs) such as Fe_xNbS_2, an antiferromagnet, have demonstrated electrical switchability. In this study we will present findings of V_xNbS_2, a TMD, to show its antiferromagnetic transitions and the possibility of electrical switchability through transport, magnetization on nanofabricated devices.

Background

Transition Metal Dichalcogenides (TMDs) are studied in particular for their characteristics that include superconductivity, magnetism, charge density waves (CDW), and Mott Physics [1]. The band gap within these Van der Waals layered materials provides the opportunity for the creation of new applications such as memory based devices [2].

Fe_xNbS_2, an antiferromagnet, has shown switching properties that allows the manipulation of spin information [3]. These results are the motivating factor to find a transition metal dichalcogenide that switches at higher temperatures. For this reason we have switched Fe for V.

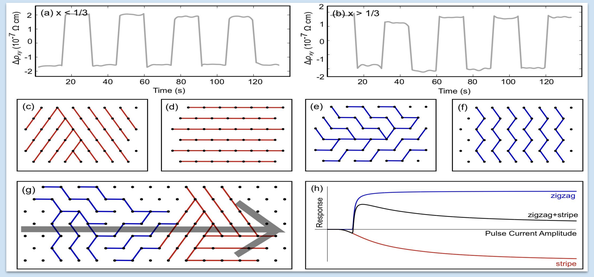

Figure 1
These images show the switching properties of Fe_xNbS_2.

Methods

Synthesis of V_xNbS_2

- Precursor made by sealing a quartz tube filled with Ar and placed within a box furnace. Precursor was made with stoichiometric amounts of vanadium, niobium and sulfur
- The precursor would next be transferred into a new quartz tube with iodide to be placed within a two zone furnace for chemical vapor transport (CVT).

Characterization

Figure 3
Thermo Scientific Scios 2. Used for Energy Dispersive Spectroscopy (EDS/EDX) and Focused Ion Beam (FIB). [4]

Figure 4
Quantum Design Physical Property Measurement System (PPMS). Used for transport measurements. [5]

Results and Discussion

Synthesis Results

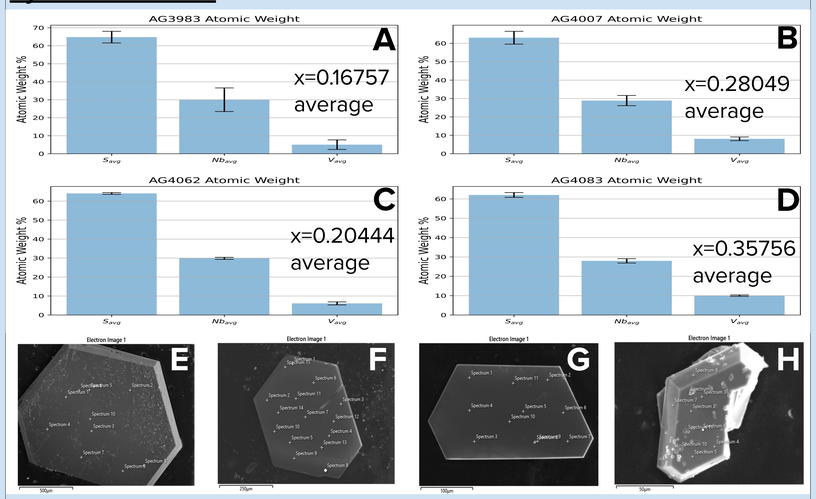

Figure 5
(A-D) Bar graphs showing the stoichiometric measurements of the given sample. (E-H) Example crystal growth of the given sample. [E:AG4083, F:AG4007, G:AG4062, H:AG3983]

Characterization

AG4007

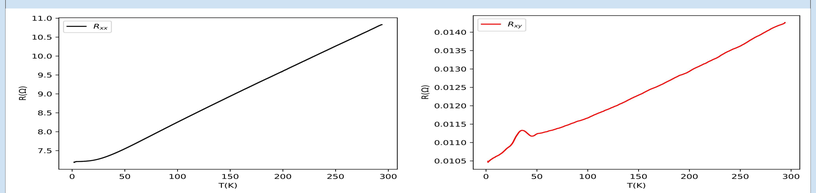

Figure 6
These graphs show the Resistance vs Temperature for the two channels of AG4007.

AG4083

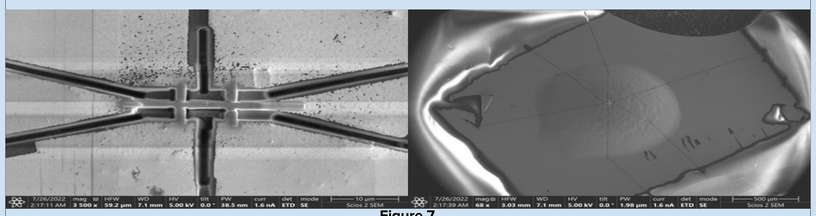

Figure 7
These two photos display the nanofabricated device created using the Focused Ion Beam (FIB).

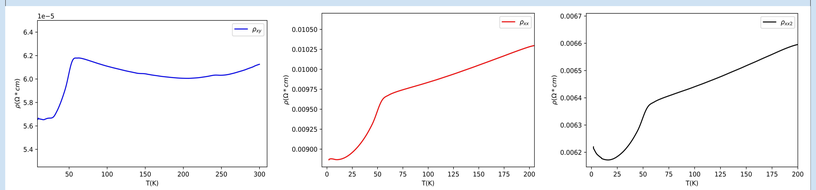

Figure 8
These graphs show the Resistivity vs Temperature for the three channels of AG4083.

Results and Discussion Cont.

Characterization

AG4083

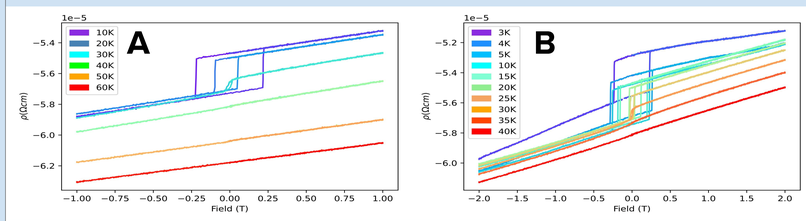

Figure 9
These graphs show the Resistivity vs Magnetic Field for channel Rxy at varying temperatures for AG4083. [A: 10-60K, B:3-40K]

Discussion

- Able to synthesize versions of V_xNbS_2 above and below $V_{1/3}NbS_2$. This gives us insight into what may be the necessary steps to synthesize crystals close to $V_{1/3}NbS_2$
- We were able to see signatures related to a transition through transport measurements in V_xNbS_2
- Based on both the Resistance v Temperature and the Resistivity vs Temperature data we were able to verify previous studies that demonstrate that V_xNbS_2 is an antiferromagnet
- Figure 9 displays a hysteresis and anomalous hall effect at varying temperatures

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References

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