Report on superconductivity and magnetotransport measurements in 48nm α-Sn film

Christian Bunker, Logan Riney, Jonathan Liu, B. A. Assaf

Department of Physics, University of Notre Dame, Notre Dame, IN 46556

Summary: Magnetotransport measurements were performed down to 1.5K and up to 16T. The 48nm film goes superconducting at about 3.2K, however the resistance does not fully vanish by 1.55K. The critical field exceeds 1T and is much higher than that of β-Sn. We also find a carrier density closet to 10^{20}cm^{-3} however, it is not clear if this is intrinsic to the α-Sn layer. It may be influenced by the presence of β -Sn islands. Overall, the value of the critical field is unusual and worth comparing to what is observed in the literature for both β-Sn and α-Sn.

48 nm α-Sn

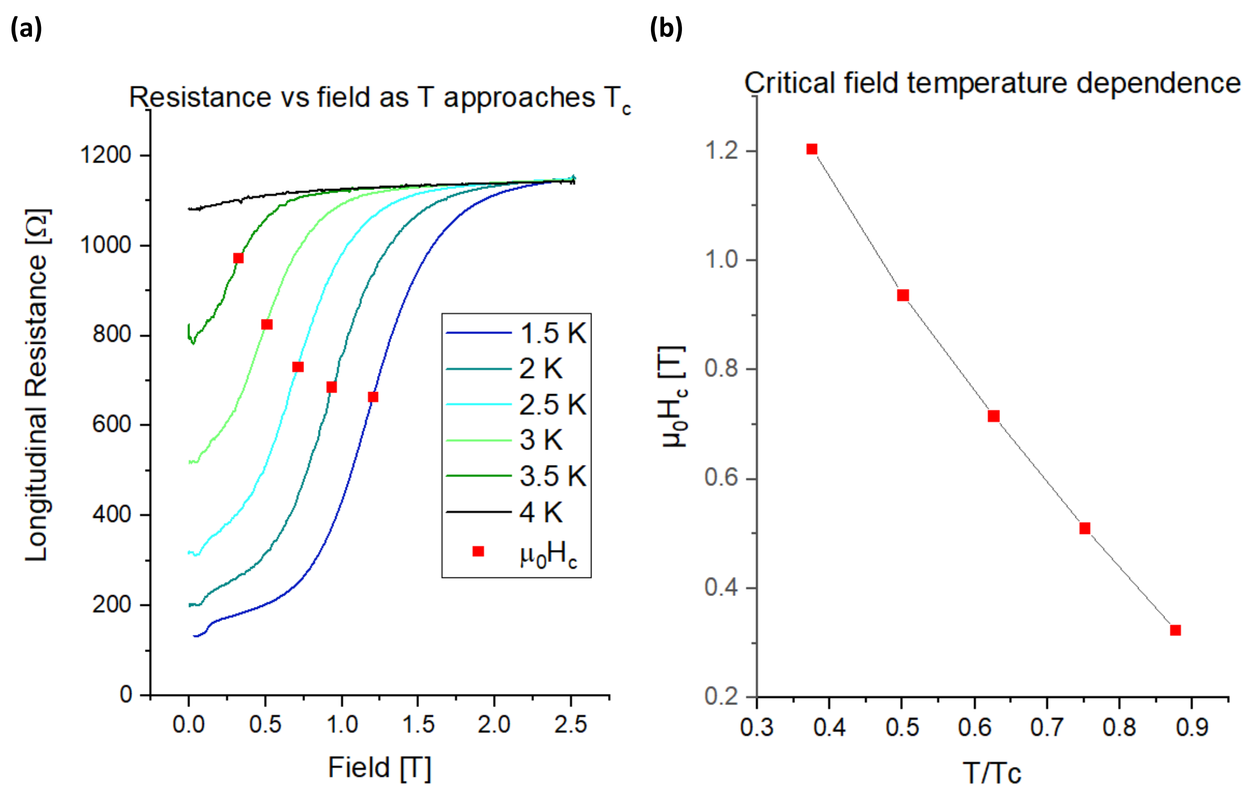

FIG 1. Low field magnetoresistance at different temperatures. (a) Resistance measurements at 1 μA current as a function of magnetic field for the 48 nm α-Sn sample. Curves were fit to a logistic function $f(x) = B + (A-B)/(1+(x/x_0)^p)$ to estimate the midpoint of the drop-off x_0 and thus the critical field. (b) The temperature dependence of the critical field points is plotted. See [1] for a similar plot for β-Sn and [2] for a similar plot for α-Sn. The latter reports critical fields on the order of 0.1

T for a similar temperature range with a 41.6 nm sample but with $\vec{B}$ oriented parallel to the sample instead of perpendicular [2].

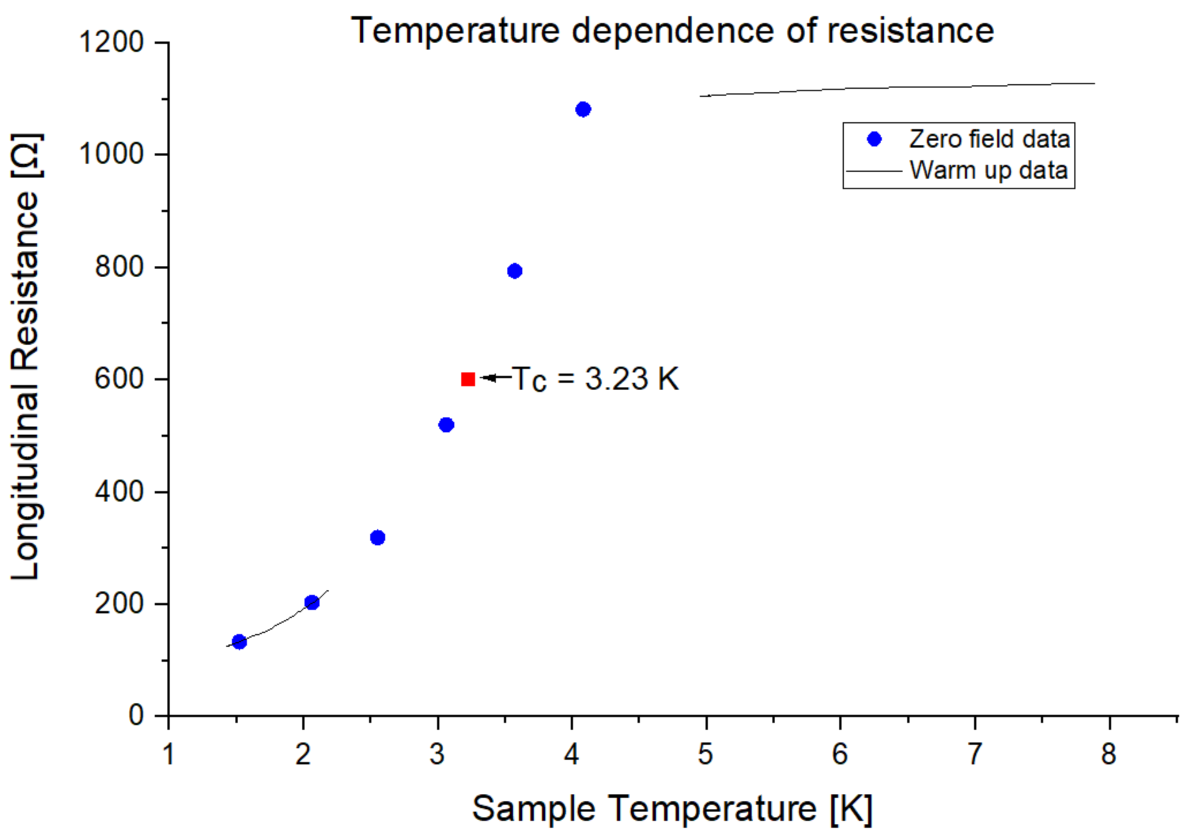

FIG 2. Zero field resistance as a function of temperature at 1 μA current. Using the same logistic fit method as above, T_c was estimated to be 3.23 K. For reference, the critical temperature of bulk β-Sn is 3.722 K [1] while that of a 50 nm thick β-Sn sample is 3.71 K [3]. Previous investigations into superconductivity in α-Sn thin films suggests the formation of islands of the β-Sn phase at thicknesses above 180 monolayers or 41.6 nm with larger island size at higher thickness [2]. They found that when this occurred, T_c was significantly reduced compared to the bulk case, which is exactly what we see, although they reported a lower value (T_c = 2.54 K) for the 41.6 nm sample than we saw [2].

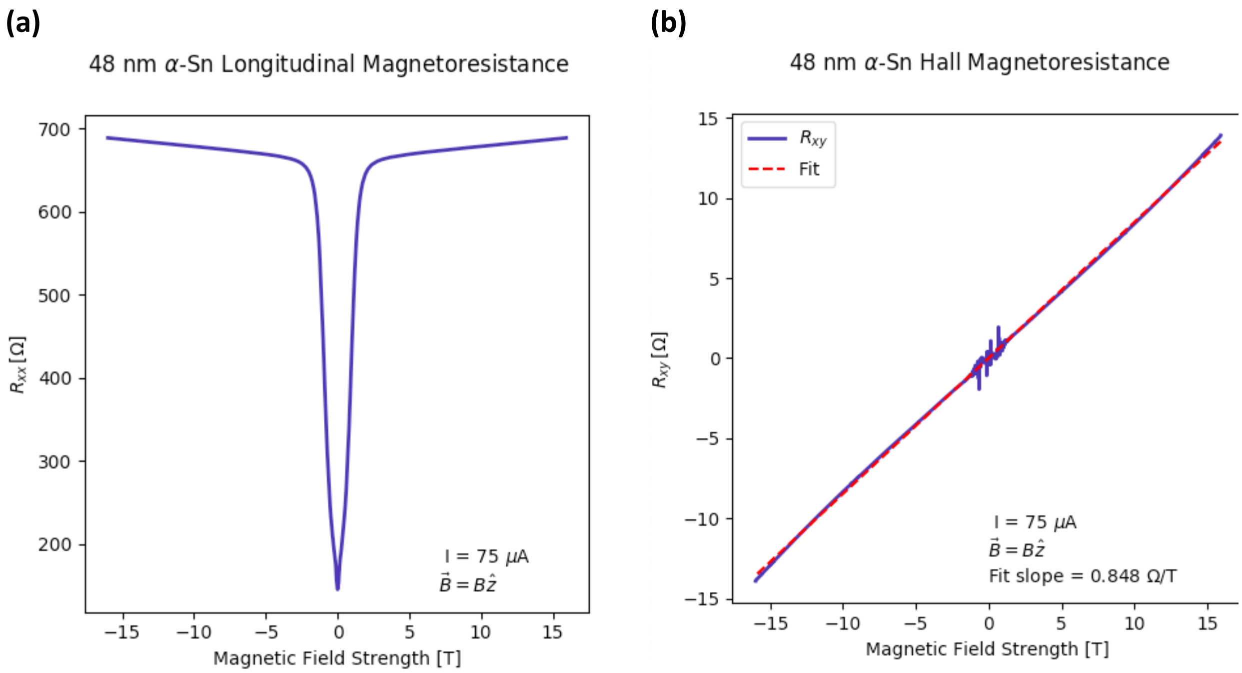

FIG 3. Magnetotransport data at 75 μA current and 1.5 K. (a) Longitudinal resistance data. (b) Hall resistance data. The slope of the linear fit can be used to calculate the density of the charge to be $n = 1.51 * 10^{20}\ \mathrm{cm}^{-3}$. We did not observe any sizable Shubnikov-de-Haas oscillations at high magnetic fields.

1. Bang, Morrison, Rathnayaka, Lyuksyutov, Naugle, and Teizer. Characterization of superconducting Sn thin films and their application to ferromagnet-superconductor hybrids. *Thin Solid Films* **676,** 138-143 (2019).
2. Didschuns, Fleischer, Schilbe, Esser, Richter, and Luder. Superconductivity in Sn films on InSb(110) taking into account of the film morphology and structure. *Physica C* **377,** 89-95 (2002).
3. Matthias, Geballe and Compton. Superconductivity. *Reviews of Modern Physics* **35,** 1-22 (1963).