Brock University

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PhD Thesis Defense

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Wednesday February 5, 2025
2pm, CRN207

Discovery of a Pseudogap Attributed to Charge Density Wave Order at the β- β' Phase Transition in As2Te3 and the Influence of Cu and Ge Doping on its Properties

In this work, the origin and driving mechanism of the β to β ' phase transition of As2Te3 is investigated through primarily resistivity, optical reflectance and heat capacity measurements. From optical reflectivity we identify the formation of a pseudogap concomitant to the β-As2Te3 to β'-As2Te3 transition. Based on this observation, in addition to a fourfold modulation of the b-axis as reported in the literature, as well as a resistivity anomaly and corresponding hysteresis associated with the phase transition, we propose that this β-As2Te3 to β'-As2Te3 phase transition is due to charge density wave order.

This charge density wave transition is observed to be tunable with both Ge and Cu doping, with evidence indicating that the increase in the number of charge carriers due to doping drives the transition temperature lower until, with Ge doping, the transition is entirely eliminated. Optical reflectivity was used to determine the plasma frequency (assumed proportional to the number of charge carriers) as a function of dopant concentration for both dopants. Copper doping was found to add charge carriers in two regimes, with lower dopings adding more charge carriers proportionally up to around Cu0.1As2Te3 beyond which the increase in charge carriers per dopant added decreases. Ge adds substantially more charge carriers per stoichiometric dopant amount added and thus influences the transition temperature more than copper as doping is increased. Utilizing DSC and heat capacity measurements, a phase diagram was created for doped β-As2Te3. It was found that at higher germanium doping concentration, the β-As2Te3 structure could be stabilized, and oriented samples were obtained via slow cooling.

Lastly, properties of the pseudogap as doping was varied were investigated. It was found that the pseudogap exhibits a non-BCS-like behaviour with a sharp onset and weak temperature dependence, with doping increasing the characteristic gap energy despite the associated transition temperature decreasing. Predicated by these results we argue that β-As2Te3 may be a member of a group of short coherence length charge density wave materials.