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Expected Semester of Graduation: Spring 2018

Prospectus

Presently, the application of superconductivity is limited by the low temperatures at which the phenomenon occurs. Little progress has been made towards high temperature superconductivity since the 1980s, until magnetic measurements of potassium doped p-terphenyl by Wang *et al.* suggested superconductivity at temperatures possibly as high as 123 K. However, resistance measurements of p-terphenyl have this far been prevented by imperfections in the bulk structure, likely a result of the production methods. This project will be an investigation into the growth of thin films of doped p-terphenyl in ultra-high vacuum (UHV), and the characterization of relevant properties of the produced materials.

An attachment has been built onto Dr. Dessau's UHV photoemission chamber that has samples of p-terphenyl and potassium in separate arms, each with a heat source. The main part of the attachment houses two temperature controlled extensions, one with a piezoelectric crystal and the other with a substrate with pre-made electrical contacts. By sublimating the two components and allowing them to deposit on the cryogenically cooled extensions, doped material of varying composition can be grown. The piezoelectric crystal measures the frequency of oscillation, which is directly dependent on mass, allowing us to calibrate the deposition rates of each component. The substrate has electrical contacts for taking four-point resistance measurements, so we can monitor the resistance as a film is either grown or cooled past its critical temperature. Further, a sample can easily be transferred into the main part of the instrument for spectroscopic characterization. Together these techniques provide a promising method for growing and characterizing superconducting material with a continuous conducting path.

Timeline

Some tasks will likely be done throughout the project. These include purification of terphenyl via zone refinement and sublimation, glovebox maintenance, and writing portions of the thesis. The timing on other elements will depend on other components of the experiment. For instance, resistivity will need to be measured via different tools, one for high resistance and one to measure the low resistances if superconducting material is made. The latter will only become relevant later in the project if at all, so the timing given here is an optimistic projection.

- October- Start growing thin films of doped material. Begin by measuring transport via resistivity, looking for a sudden drop in resistance. Vary parameters as time permits
- November- Focus more intensely on varying parameters, including which material is deposited first, the substrate used, the ratio, deposition temperature and deposition rate. If low resistivity is observed, begin measuring via a DC bridge for zero resistance
- December-February Test more parameters, hopefully measuring for zero resistance. Depending on the success of the growths, potentially start doing photoemission spectroscopy. Focus increasingly on writing the thesis.
- March- Focus on writing thesis as needed to ensure that it is ready to submit. Collect final data.
- April- Finalize and defend thesis.

Works Cited

Baskaran, G. (2017). Two Mott Insulator Theory of Superconductivity in K$_3$X (X: picene,p-terphenyl, .. C$_{60}$). *arXiv:1704.08153 [Cond-Mat]*. Retrieved from http://arxiv.org/abs/1704.08153

Birch Reduction - Chemgapedia. (n.d.). Retrieved August 15, 2017, from http://www.chemgapedia.de/vsengine/vlu/vsc/en/ch/12/oc/vlu_organik/radikale/birch_red.vlu.html

Carriers - The Fermi Function. (n.d.). Retrieved July 29, 2017, from http://www.ece.utep.edu/courses/ee3329/ee3329/Studyguide/ToC/Fundamentals/Carriers/fermi.html

Koralek, J. D. (2006). *Laser based angle-resolved photoemission spectroscopy and high-temperature superconductivity* (Ph.D.). University of Colorado at Boulder, United States -- Colorado. Retrieved from http://search.proquest.com.colorado.idm.oclc.org/docview/305354949/abstract/57F91C45203E4C14PQ/1

Li, H., Zhou, X., Parham, S., Nummy, T., Griffith, J., Gordon, K., … Dessau, D. S. (2017). Spectroscopic Evidence of Pairing Gaps to 60 Kelvin or Above in Surface-Doped p-Terphenyl Crystals. *arXiv:1704.04230 [Cond-Mat]*. Retrieved from http://arxiv.org/abs/1704.04230

Liu, W., Lin, H., Kang, R., Zhang, Y., Zhu, X., & Wen, H.-H. (2017). Magnetization of potassium doped p-terphenyl and p-quaterphenyl by high pressure synthesis. *arXiv:1706.06018 [Cond-Mat]*. Retrieved from http://arxiv.org/abs/1706.06018

Peres, L., Spisser, M., & Froyer, G. (2005). Reduction of p-terphenyl, p-quaterphenyl and p-sexiphenyl using alkali metal in liquid ammonia: Process and characterization of the reduced compounds.

Superconductor Uses. (2015). Retrieved August 9, 2017, from http://superconductors.org/Uses.htm

Wang, R.-S., Gao, Y., Huang, Z.-B., & Chen, X.-J. (2017). Superconductivity at 43 K in a single C-C bond linked p-terphenyl. *arXiv:1703.05804 [Cond-Mat]*. Retrieved from http://arxiv.org/abs/1703.05804

Wang, R.-S., Gao, Y., Huang, Z.-B., & Chen, X.-J. (2017). Superconductivity above 120 kelvin in a chain link molecule. *arXiv:1703.06641 [Cond-Mat]*. Retrieved from http://arxiv.org/abs/1703.06641