TECHNIQUES FOR THE FABRICATION OF GRAPHENE DEVICES

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Motivation

The goal of this project is to measure a \( \pi \) -junction through an SNS Josephson junction by applying an external magnetic field. In superconductors, electrons couple into Cooper pairs. In a Josephson junction, the Cooper pairs separate as they pass through the normal metal, and reconnect once across so that the junction has zero resistance. The introduction of a magnetic field in the normal metal pushes the electrons out of phase and stops their re-coupling. However, it is predicted that at large enough fields supercurrent can reform, in what is called a \( \pi \) -junction. To see this effect, the normal channel must be very thin, so we have chosen to use graphene as the metal. Graphene is a single atomic layer of carbon, and methods exist that allow us to consistently create and deposit graphene on a silicon substrate. We explored the methods of the creation of graphene devices.

Graphene Visibility

Due to interference effects, graphene is visible through an optical microscope when on top of Si with 300 nm SiO\(_2\). The technique of mechanical exfoliation (Scotch tape method) was used to separate layers of graphite and then to transfer them to a silicon chip. The transfer is completed by placing the piece of tape on the silicon chip, lightly rubbing the tape for several minutes with tweezers, and then peeling away the tape very slowly.

Results and Conclusions

• The transfer of graphene can leave behind large amounts of tape residue. This residue was removed by soaking the chips in acetone, or baking the chips at 400˚C in an argon environment.

• The surface of the chips were scanned for graphene deposits using an optical microscope, then coated in e-beam resist.

• Thermal evaporation and sputtering were both used to deposit electrical leads (5nm Ti / 50 nm Al) for measurements.

• Sputtering metal contacts, rather than thermally evaporating, reduced contact resistance; however, even this resistance was too high to have a working device. The high temperatures required to evaporate titanium created impurities in the aluminum.

Future Work

Future work could include the further exploration of these methods, in hopes of creating a working device. To create such a device, the contact resistance must be reduced. Other research groups have used e-beam evaporation to create contacts, which may have contributed to their lower contact resistances. Another proposed change is to bake the device a second time after lithography and before sputtering or evaporation. The exposed edges of graphene may be covered in a residue layer after developing the pattern.