4-Point Resistivity Measurements of Silicon-Carbide Nanowires

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The Purpose

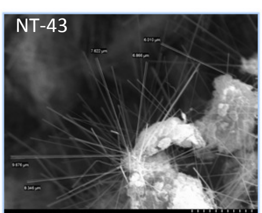
Current technology is limited by size and electrical properties because wires cannot currently be fabricated with diameters on the nano scale with high durability. Therefore, new ways to produce nanowires and facilitate smaller electrical systems are being explored.

Why SiC?

Silicon Carbide (SiC) is a semiconductor that has high thermal stability, mechanical strength, chemical inertness, high electron mobility and a large band cap. It is therefore an ideal choice for use in nanoscale technology, as an optimal switch in transistors.

The Goal

Study the electrical properties of silicon carbide nanowires, specifically resistivity. Then be able to control the resistivity of the wires to make electrical devices.



SiC nanowire sample

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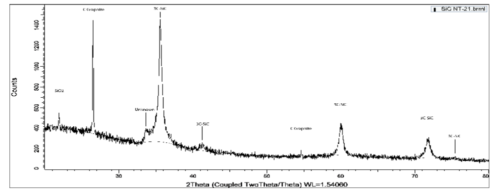
Sample Preparation

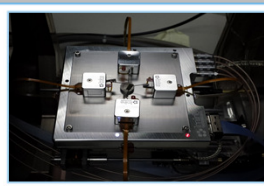
Multi-walled Carbon Nanotubes (CNTs) are reacted with Silicon Monoxide (SiO) using a Vapor-Liquid-Solid deposition method in an alumina crucible. The CNTs are dispersed in methanol and a small amount is dropped onto a polished graphite planchet in the crucible. The reactants are placed in a crucible unmixed and heated to 1450 °C for 4 hours.



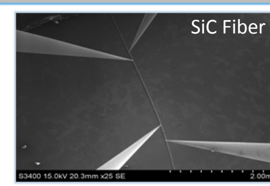
X-Ray Diffraction (XRD) results show 3C-SiC as the main component..

Four-Point Measurements

Four-point probe MiBots were recently purchased by the Materials Science Center and are being used in conjunction with a high precision source meter to test electrical properties of the produced nanowires. The MiBots are placed directly in a Scanning Electron Microscope to attach the probes to the nanowires. Two of the probes are used to run a current and voltage through a wire and the other two probes are used to measure some parameter of interest. These can be resistance, voltage, or current. The resistivity was found to be between 6.62×10^{-4} to 9.66×10^{-4} Ωm for a single SiC fiber.

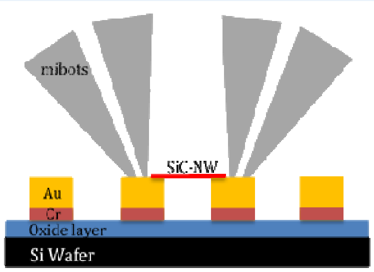


Newly installed 4-point probe system in a Hitachi 3400 N Scanning Electron Microscope



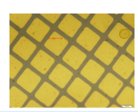
Creation of the Grid

One problem we have run into is that it is very hard to attach the probes to just one SiC nanowires as shown in the middle picture above . To test the resistivity of a single SiC-NW we have created a method for laying a single SiC-NW on a conductive grid and then using the Mibots to attach to the grid. To create such a grid Transmission electron microcopy (TEM) grids are glued to a silicon wafer that will contain an oxide layer. Then they are placed in an evaporator and coated with Cr and gold. Once the layer of gold is applied the TEM grids are removed what is left is a grid pattern of gold columns that the SiC-NW can lay across. The layer of oxide on the silicon wafer provides electrical insulation between the columns. The conductive gold allows us to attach the probes to the grid and test the wire that lays across the columns. The grid has to be tested to make sure that it has a high resistance from one column to the next.

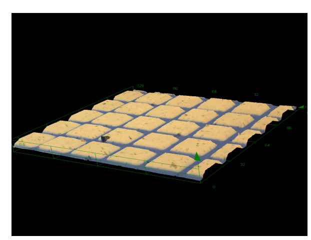


Shown above is a representation of a grid that can be made with the different layers. The SiC-NW can lay across the columns and the Mibot probes can be attached to the columns.

Above is an optical image of the TEM grid super glued to a silicon wafer.



Above is an optical image after the Silicon wafer has been coated with Cr and Au and the TEM grid has been removed.



A confocal image was taken of the grid. It is seen how there are distinct gold columns that are raised in a pyramid shape.

Doping SiC Nanowires

We are doping SiC wires to figure out what makes SiC a better Semiconductor and to control their resistivity and electrical properties. We will be testing different dopants to figure out the best one. There are two types of doping: N-type and P-type. We are currently doping SiC fibers with P and N type dopants. After we can successfully dope the SiC the next step is to create fibers with both N and P dopants and then work our way down to the SiC nanowires.