NOTE: Single-spaced for sample purposes only; yours must be double-spaced.

Analysis and fabrication of carbon micro-ribbon targets for proton polarimetry studies at the Relativistic Heavy Ion Collider

Author (Intern and Mentor) Information

The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory requires a highly polarized proton beam for spin-polarization studies. During each experimental run, 250 GeV protons are elastically scattered from a carbon micro-ribbon target 10 μm wide and 50 nm thick to monitor the degree of proton beam polarization. Experiments have shown that the amorphous carbon targets have poor electrical conductivity, limiting their lifetime. Since RHIC operates continuously for several months at a time under ultra-high vacuum, it is costly and inefficient to use carbon targets with short lifetimes. Our study has examined the few micro-ribbons that serendipitously survived a recent RHIC experimental run. Transmission electron microscopy diffraction pattern analysis of the micro-ribbons shows that heating from the RHIC beam has crystallized the amorphous carbon into graphite. In addition to examining micro-ribbons fabricated by Collider-Accelerator Department staff, we are exploring new methods of micro-ribbon fabrication that will have superior material properties. One possible approach consists of depositing thin films of nickel and carbon on a silicon wafer through an anisotropically-etched silicon wafer mask. By annealing amorphous carbon micro-ribbons, we consistently achieve conductivity and crystallinity results similar to those found in the surviving RHIC micro-ribbons. When annealed at 700 °C, a 10 nm thick amorphous carbon layer forms a solid solution within the 50 nm thick nickel layer before recrystallizing as graphene on the surface of the nickel. Graphene is well known to have superior electrical conductivity and tensile strength, and may well prove to be an ideal material for the next generation of micro-ribbon targets for RHIC during its next proton polarimetry experiments in 2015. As a result of this summer, I have added electron microscopy to my repertoire of materials characterization techniques. Additionally, I am now familiar with microfabrication processes and several software programs including DesignCAD, NPGS, MathCAD, and Scandium.