313c Corrugated Nanodiamond Films as Stripping Foils for the Spallation Neutron Source

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A thin carbon stripping foil is an integral component of the Spallation Neutron Source (SNS) currently under construction in Oak Ridge, TN. The function of the stripper foil is conversion of H^- to H^+ at the injection point of the accumulator ring; collision of H^+ with a mercury target ultimately yields neutrons by the spallation process in the facility. The operational lifetime of the carbon stripping foils is a concern, especially considering the H^- beam current (26 mA) and energy (1.0 GeV) they must withstand. Even higher currents and energies are included in proposed upgrades to SNS and are integral to future accelerator facilities under consideration.

Thin films of chemical vapor deposited (CVD) diamond have shown promise for providing ca. 10X increased lifetime over traditional carbon foils made by evaporation and arc discharge methods. The preferred foil geometry for SNS is 10 to 12 mm by 20 mm at a thickness of 350 microgram/cm^2 (~ 10^{-6}m) mechanically supported on preferably one, but no more than two adjacent edges. However, the lack of support on two or more edges can lead to film curling due to the high stress in CVD diamond films. We have addressed that problem by adding corrugations in the films to increase mechanical strength. Films with the required thickness uniformity (10%) and largely free of pinholes requires growth of fine-grained diamond at high nucleation densities. Nanocrystalline diamond is therefore an excellent candidate for this application.

We have prepared and tested corrugated, thin diamond foils for use in stripping the SNS H^- Linac beam. The foils are prepared by conformal CVD diamond growth on a photolithographically patterned silicon substrate, followed by chemical removal of the silicon. This yields a foil with trapezoidal corrugations to enhance mechanical strength and foil flatness. L-bracket foils, ones with silicon support retained on two adjacent edges, are very robust and can be prepared with high success rate. Both micro- and nano-crystalline diamond foils have been grown. Microwave plasma CVD methods that incorporate high argon gas content were used to produce the latter. Sixteen foils of a variety of characteristics have been tested using the BNL 750 keV RFQ H^- beam at a current scaled to simulate the energy deposition in the SNS foil. Long foil lifetimes, up to more than 130 hours, have been demonstrated. Characterization of the foils after beam testing indicates creation of sp^2 defects within the ion beam spot. Current efforts are centered on further testing of nanocrystalline diamond and development of corrugation patterns that will enhance flatness of single-edge supported foils.

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