Development of Patterned Electron Beam Image Transfer though a Nanocrystalline Diamond Thin Film Membrane/Window

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In an effort to create an electron transparent vacuum window, we have developed a process to create free standing nanocrystalline diamond thin films which can be used as a pressure separating membrane to separate regions of UHV from higher pressure or "dirty" volumes. Preliminary results show pressure separation of greater than four orders of magnitude using these diamond membranes. In addition, while not truly electron transparent, these thin film diamond membranes (100nm to 800nm thick) are capable of electron beam pattern transfer by emission of backside secondary electrons with similar pattern to the incident electron beam. Due to the negative electron affinity of the nanocrystaline diamond [1], amplification of the secondary beam was expected and a gain of greater than 2x the incident beam current was observed.

This work describes the experimental setup used to validate the pattern transfer through these thin film diamond membranes, and the simulation methodology used during system design. A combination of charged particle optics simulations and monte-carlo based beam sample interaction modeling was utilized to predict the image blur that occurs from the secondary-emission-image-transfer-process. The process involves simulating an incident beam's trajectories using SIMION [2], exporting the SIMION output data into a Monte-Carlo program and then exporting trajectory data back into SIMION for simulation of secondary election trajectories. This simulation process allows calculation of output pattern versus the incident optics and the sample material characteristics, resulting in faster design turns for process optimization. Experimental results of this optimization will also be presented.

[1] I. L. Krainsky, V. M. Asnin, G. T. Mearini, and J. A. Dayton, Jr., Phys. Rev. B 53, (1996)
[2] D. A. Dahl, "SIMION for the personal computer in reflection," Int. J. Mass Spectrom. 200 (2000)

This work was supported by the U.S. Department of Homeland Security, Science and Technology Directorate sponsored this work under contract: HSHQDC-12-C-00002

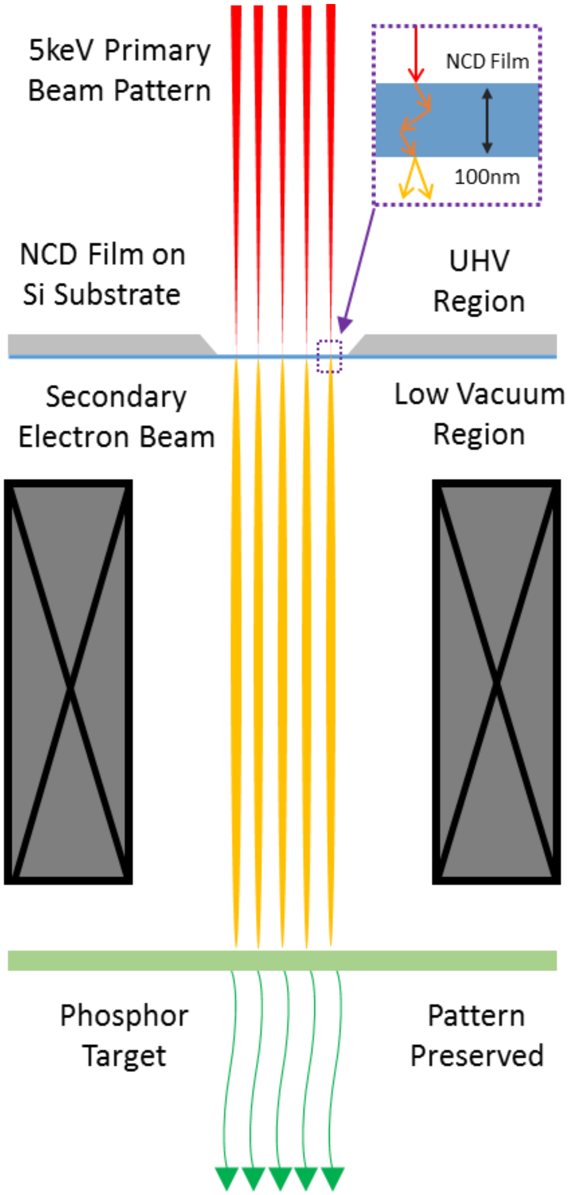

Figure 1: The image transfer system used to test electron beam pattern transfer through a nanocrystaline diamond (NCD) thin film membrane/window. A 5keV primary patterned beam illuminates the NCD film. The secondary electron beams are magnetically focused onto target for pattern transfer. Film thickness is adjusted so predominantly secondary electrons exit the backside.

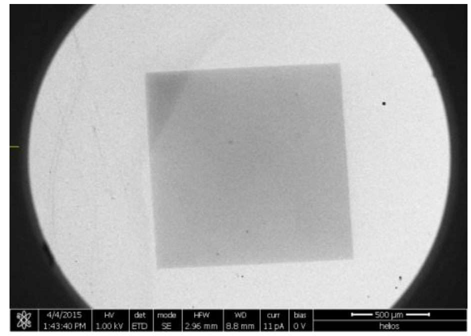

Figure 2: Low magnification micrograph of a processed diamond window used for pressure separation.

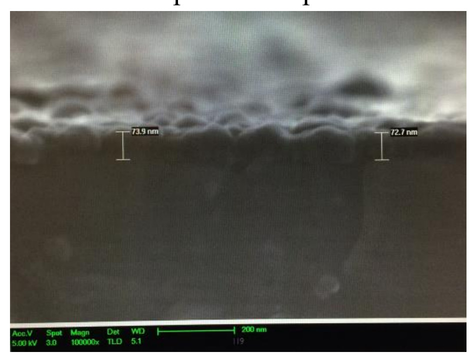

Figure 3: Micrograph of diamond film cross section. The substrate is removed leaving a freestanding film.

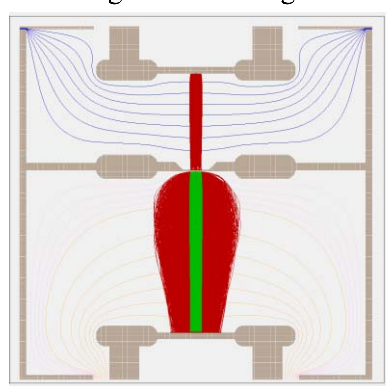

Figure 4: SIMION Model of electron beam transport through a membrane. Secondary electrons (green) are focused while higher energy (red) forward scattered or transmitted electrons are highly defocused (low dose).